10TH EUROPEAN PALAEOBOTANY & PALYNOLOGY CONFERENCE

University College Dublin, Ireland
12-17 August 2018

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10TH EUROPEAN PALAEOBOTANY & PALYNOLOGY CONFERENCE

PROGRAM & ABSTRACTS

EPPC2018
University College Dublin, Ireland
12-17 August 2018

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The University of Dublin

UCD Earth Institute

national botanic gardens of Ireland

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Bianca O'Connor
Lisa Ashton

EPPC 2018 FIELDTRIP LEADERS

MID-CONFERENCE TOURS

Dublin Botanical Gardens Trip

Colin Kelleher, The National Botanic Gardens of Ireland, Ireland
The staff at The National Botanic Gardens of Ireland, Ireland

Historical Dublin Walking Tour

Approved Tourist Guides of Ireland

Glaciation and Palaeoecology of the Wicklow Mountains

Fraser Mitchell, Trinity College Dublin, Ireland
Gayle McGlynn, Trinity College Dublin, Ireland

POST-CONFERENCE TOURS

The Kerry Tour (the Ring of Kerry, the Unesco World Heritage Site of Scelig Mhichíl (Skellig Michael) and the Environs of Valentia Island)

Hidden Ireland Tours, Ireland
Cormac Foley, The Office of Public Works (Historic Parks & Gardens), Ireland

Palaeozoic Rocks and Fossils of the Hook Head Peninsula, County Wexford

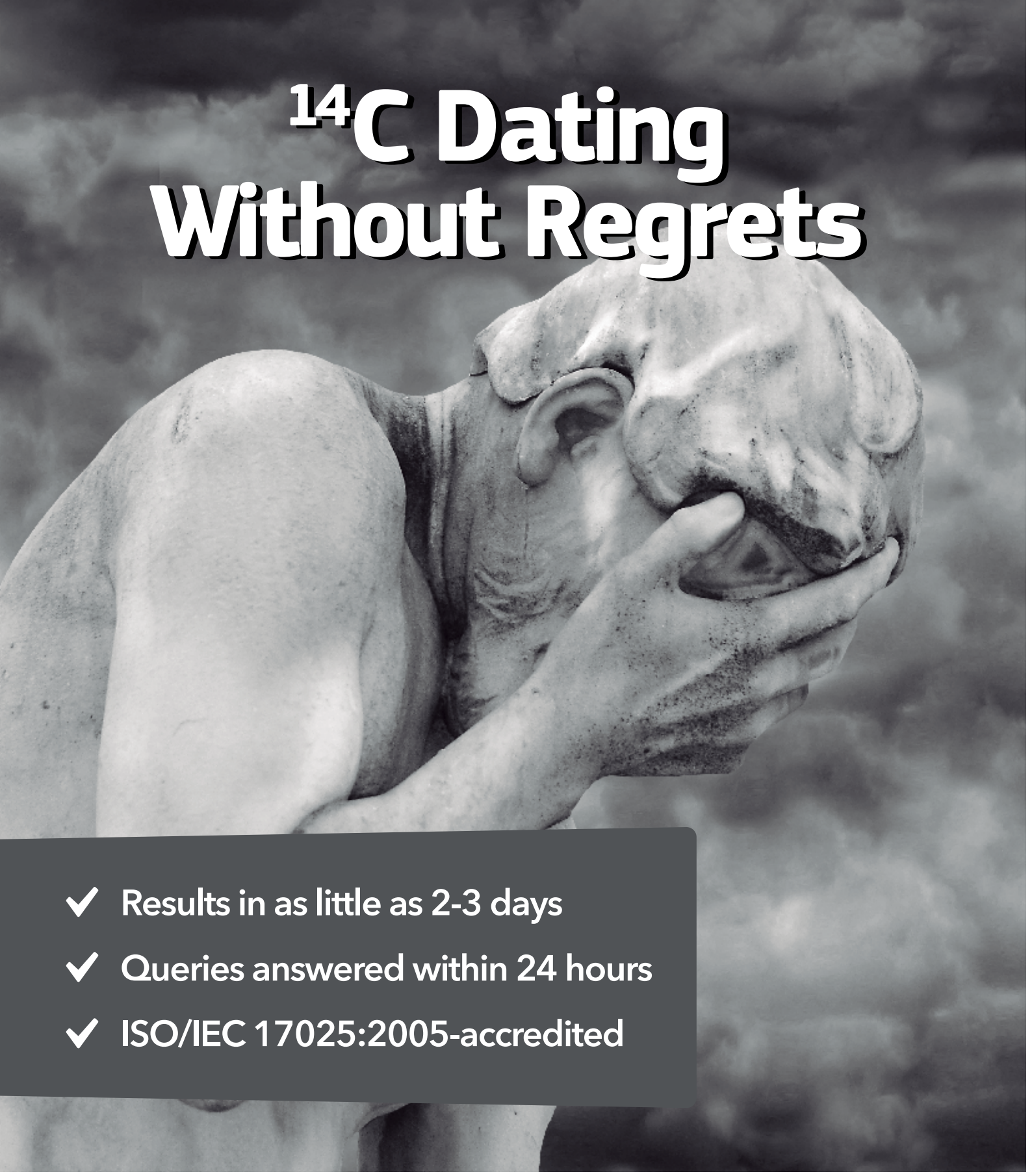
Ken Higgs, University College Cork, Ireland
Geoffrey Clayton, Trinity College Dublin, Ireland
Robbie Goodhue, Trinity College Dublin, Ireland

Botany and Landscape of the Burren

Stephen Waldren, Trinity College Dublin, Ireland
Michael Simms, National Museums, Northern Ireland
Jenny McElwain, Trinity College Dublin, Ireland

Paleozoic Palaeobotany – Kiltoran and Castlecomer

Matthew Parkes, National Museum of Ireland, Ireland



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International Organisation of Palaeobotany

The Palaeontological Association

International Association of Wood Anatomists

The Paleontolological Society

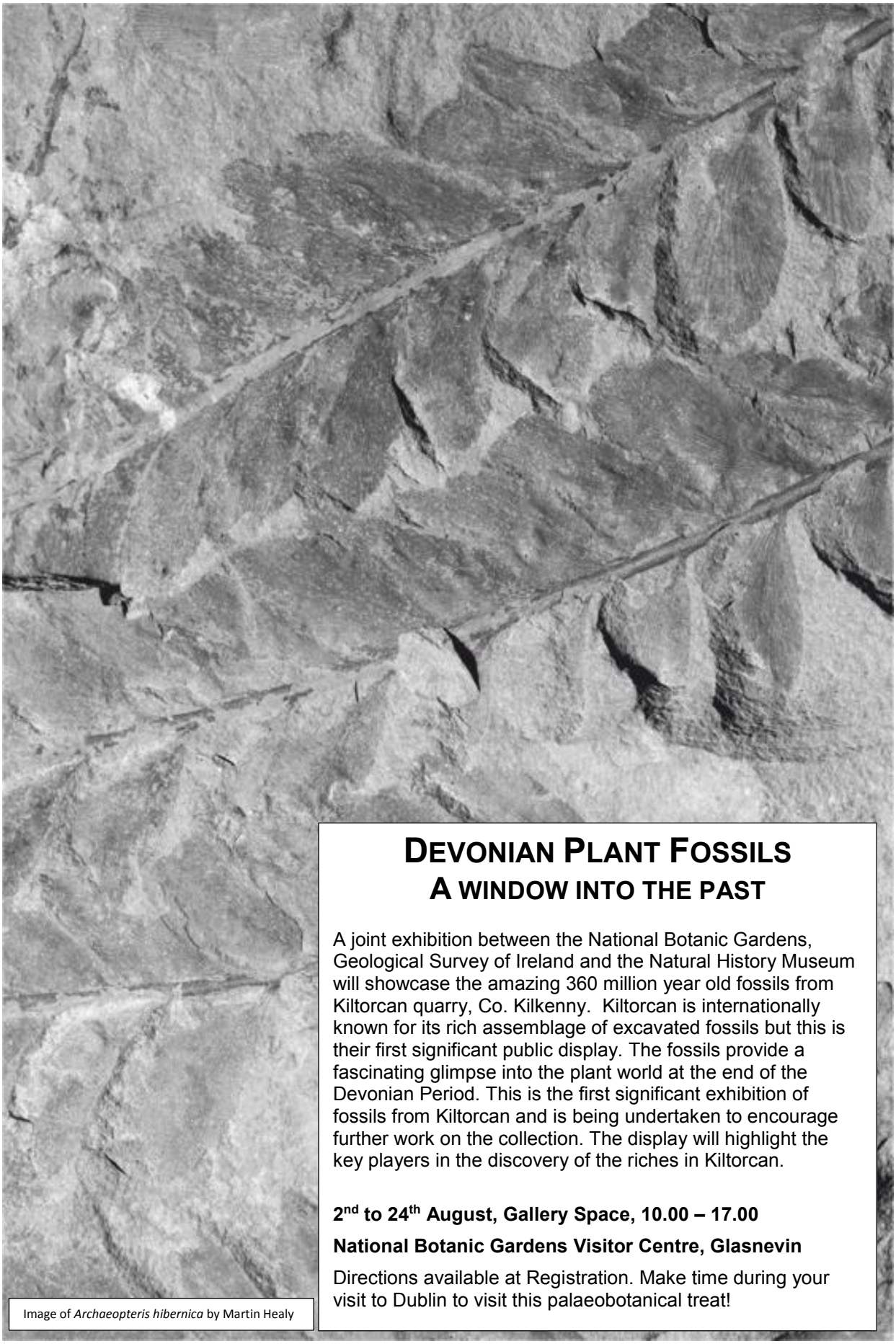

Image of *Archaeopteris hibernica* by Martin Healy

DEVONIAN PLANT FOSSILS
A WINDOW INTO THE PAST

A joint exhibition between the National Botanic Gardens, Geological Survey of Ireland and the Natural History Museum will showcase the amazing 360 million year old fossils from Kiltorcan quarry, Co. Kilkenny. Kiltorcan is internationally known for its rich assemblage of excavated fossils but this is their first significant public display. The fossils provide a fascinating glimpse into the plant world at the end of the Devonian Period. This is the first significant exhibition of fossils from Kiltorcan and is being undertaken to encourage further work on the collection. The display will highlight the key players in the discovery of the riches in Kiltorcan.

2nd to 24th August, Gallery Space, 10.00 – 17.00

National Botanic Gardens Visitor Centre, Glasnevin

Directions available at Registration. Make time during your visit to Dublin to visit this palaeobotanical treat!

national botanic gardens

museum
National Museum of Ireland
Ard-Mhúsaem na hÉireann

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

OPW

CONTENTS

WELCOME TO EPPC 2018

10TH EUROPEAN PALAEOBOTANY AND PALYNOLOGY CONFERENCE

12TH-17TH AUGUST, 2018

On behalf of the organization committee I would like to extend a warm welcome and invite you to Dublin to attend the 10th European Palaeobotany and Palynology Conference. The disciplines of palaeobotany and palynology are integrative and multidisciplinary by nature. As a community we are constantly seeking new tools and techniques to answer both long-standing and new questions. Palaeobotanists and palynologists demonstrate a strong history of partnership with disciplines that are outside our core biological and geological fields of research such as with chemistry, physics, maths and computer science. Our community have been early adopters of state-of-the- art technology in visualization, experimentation and chemical analyses to name but a few.

The theme for EPPC 2018 'A Multidisciplinary Science' seeks to highlight multi- and inter-diciplinarity in palaeobotanical and palynological research, past, present and future. We aim to showcase disciplinary diversity in palynological and palaeobotanical research through themed and open sessions, via demonstrations of new technology platforms in a dedicated exhibition space and during post-conference field excursions.

We have planned exciting cultural activities and field trips for you to explore the great botanical, archaeological and geological richness that the island of Ireland has to offer. These include the famous karst landscapes and flora of the Burren in County Clare and a world heritage site of immense geological and archaeological interest; Skellig Michael, islands within the Atlantic Ocean off the west coast of County Kerry. Mid-conference day trips will showcase the Viking history and building stones of Dublin city and natural heritage of surrounding counties including blanket bogs and oak forests.

Céad Míle Fáilte! We look forward to welcoming you to EPPC Dublin in 2018.

Yours sincerely,

Jennifer C. McElwain

Chair of Botany, Trinity College Dublin

Chair, Organization Committee

10TH EUROPEAN PALAEOBOTANY & PALYNOLOGY CONFERENCE

PROGRAM

EPPC2018
University College Dublin, Ireland
12-17 August 2018

PROGRAM IN BRIEF

Sunday 12th August			
14:00 - 19:00	Registration Ground Floor Foyer of the O'Brien Centre, UCD		
18:00 - 20:00	The Dining Hall, Trinity College Dublin.		
Monday 13th August			
Room	**O'Reilly Hall**		
09:00 - 11:00	Plenary Speakers		
11.30 - 12.30	Keynote Speakers		
Room	**George Moore Auditorium**	**Intel (Theatre E)**	**ICON (Theatre D)**
13.30 - 14.50	**Special Session 1** ADVANCES AND APPLICATIONS OF PALEOZOIC PALYNOLOGY AND PALYNOSTRATIGRAPHY IN THE ARABIAN PLATE AND ADJOINING REGIONS	**Special Session 23** GEOCHEMICAL AND MOLECULAR PROXIES FROM FOSSIL PLANTS AND PALYNOMORPHS: NEW TECHNIQUES, NEW CHALLENGES	**Special Session 12** PALEOBOTANY AND PALYNOLOGY OF THE DECCAN INTERTRAPPEAN BEDS, LATE CRETACEOUS TO PALEOCENE OF CENTRAL INDIA
15.20 - 17.00	**Special Session 1** CONT...	**Special Session 23** CONT...	**Special Session 12** CONT...
17.00 - 18.00	Poster Session		
17.30 - 18.30			
Tuesday 14th August			
9:00 - 10:40	**Special Session 22** CELEBRATING THE CAREER OF BILL CHALONER - FROM PALAEOPROXIES TO NOMENCLATURAL ISSUES	**Special Session 2** PALAEOZOIC PALYNOLOGY – PRESENT AND FUTURE RESEARCH DIRECTIONS	**Special Session 7** MELISSOPALYNOLOGY POLLEN MORPHOLOGY AND DISPERSAL
11:10 - 12:30	**Special Session 22** CONT...	**Special Session 2** CONT...	**Special Session 26** QUATERNARY VEGETATION, CLIMATE, FIRE, AND PLANT RESILIENCE IN EUROPE AND THE NEAR EAST
13:30 - 14:50	**Special Session 22** CONT...	**Special Session 2** CONT...	**Special Session 26** CONT...
15:20 - 17:40	**Special Session 22** CONT...	**Special Session 2** CONT...	**Special Session 26** CONT...
17:00 - 18:00	Poster Session		
17:30 - 18:30	International Organization of Palaeobotany (IOP) AGM		
Wednesday 15th August			
9:00 - 10:40	**Special Session 33** PALEOZOIC PALAEOBOTANY	**Special Session 11** A WORLD FULL OF AMBER	**Special Session 24** CAN THE PAST UNLOCK THE FUTURE? USING PALAEOBOTANY & PALAEOECOLOGY TO PREDICT FUTURE ECOLOGICAL TRENDS
11:10 - 12:30	**Special Session 33** CONT...	**Special Session 11** CONT...	**Special Session 24** CONT...
13:30 - 18:00	Mid-Conference Excursions: Botanic Gardens / Dublin / Wicklow		

ALE (E1.17)	ALE (H1.49)	H1.51
Special Session 17 BOUNDARIES, TRANSITIONS AND EXTREME ENVIRONMENTS OF THE CENOZOIC	**Special Session 32** TRIASSIC AND JURASSIC TERRESTRIAL ECOSYSTEMS	**Special Session 27** WORK VERTICALLY, THINK 3-DIMENSIONALLY: PALAEOCOLOGY IN TOPOGRAPHICALLY COMPLEX MOUNTAIN SETTINGS
Special Session 17 CONT...	**Special Session 32** CONT...	**Special Session 35** LATE QUATERNARY PALAEOECOLOGY
Agora Paleobotanica AGM		
Special Session 20 PLANT EVOLUTION AND GEOBIOSPHERE INTERACTIONS AS A DRIVER OF EARTH SYSTEM	**Special Session 13** BIOGEOGRAPHIC RELATIONSHIPS OF NORTHERN HEMISPHERIC CENOZOIC FLORAS	
Special Session 20 CONT...	**Special Session 13** CONT...	
Special Session 10A FOSSIL WOODS - NEW RESULTS AND PERSPECTIVES	**Special Session 13** CONT...	
Special Session 10A CONT...	**Special Session 21** EARLY EVOLUTION OF SOILS AND THEIR BIOLOGICAL COMPONENTS	
CIMP Buisness Meeting	Collegium Palynologicum Scandinavicum	
Special Session 14 CENOZOIC PLANT DIVERSITY OF TIBET, HIMALAYAS AND HENGDUAN MOUNTAINS	**Special Session 10B** FOSSIL WOODS - NEW RESULTS AND PERSPECTIVES	
Special Session 14 CONT...	**Workshop 19** DATABASES, ONLINE SERVICES AND DIGITAL LITERATURE: RESPONSE TO CHALLENGES OF PALAEOBOTANY IN XXI CENTURY	

Thursday 16th August			
Room	**George Moore Auditorium**	**Intel (Theatre E)**	**ICON (Theatre D)**
9:00 - 10:40	**Special Session 8** TRANSFORMATIVE PALEOBOTANY: COMMEMORATING THE LIFE AND LEGACY OF THOMAS N. TAYLOR	**Special Session 18** PLANT EVOLUTION; FLORAL DIVERSITY AND THE RESPONSE OF PLANTS TO ENVIRONMENTAL STRESS FROM DEEP TIME	**Special Session 5** HIGH TEMPORAL RESOLUTION PALYNOLOGY AND PALAEOECOLOGY – FROM CENTENNIAL TO DECADAL VEGETATION CHANGE, TO YEARLY FLOWERING CYCLES AND SEASONAL INSIGHTS FROM STRATIFIED QUATERNARY DEPOSITS
11:10 - 12:30	**Special Session 8** CONT...	**Special Session 18** CONT...	**Special Session 5** CONT...
13.30 - 14.50	**Special Session 8** CONT...	**Special Session 18** CONT...	**Special Session 5** CONT...
15.20 - 17.00	**Special Session 15** THE TIMING AND PHYLOGENY OF FUNCTIONAL TRAITS IN WOOD	**Special Session 18** CONT...	**Special Session 6A** QUANTITATIVE POLLEN-BASED RECONSTRUCTIONS OF PLANT COVER FOR ENVIRONMENTAL AND ARCHAEOLOGICAL RESEARCH
17.00 - 18.00	Poster Session		
19:00 - Late	Gala Dinner		
Friday 17th August			
9:00 - 10:40	**Special Session 31** PLANT EVOLUTION IN THE CRETACEOUS	**Special Session 28** PFILLING THE GAPS ABOUT NON-POLLEN PALYNOMORPH ECOLOGICAL SIGNIFICANCE	**Special Session 6B** QUANTITATIVE POLLEN-BASED RECONSTRUCTIONS OF PLANT COVER FOR ENVIRONMENTAL AND ARCHAEOLOGICAL RESEARCH
11:10 - 12:30	**Special Session 31** CONT...	**Special Session 28** CONT...	**Special Session 6B** CONT...
12:30 - 13:00	Closing Remarks and Prizes		
13:30 - 14:00	Lunch and Posters		
Saturday 18th - Monday 20th August			
Post Conference Field Trips			
18th - 20th	KERRY INCLUDING THE RING OF KERRY, THE UNESCO WORLD HERITAGE SITE OF SCELIG MHICHÍL (SKELLIG MICHAEL) AND THE ENVIRONS OF VALENTIA ISLAND		
18th - 19th	PALAEOZOIC ROCKS AND FOSSILS OF THE HOOK HEAD PENINSULA, COUNTY WEXFORD		
18th - 20th	BOTANY AND LANDSCAPE EVOLUTION OF THE BURREN, COUNTY CLARE		
18th	PALEOZOIC PALAEOBOTANY – KILTORCAN AND CASTLECOMER FIELD TRIP		

ALE (E1.17)	ALE (H1.49)	H1.51
Special Session 3 ASPECTS OF UPPER PALAEOZOIC TO MESOZOIC PALAEOBOTANICAL BIOSTRATIGRAPHY	**Special Session 25** CENOZOIC PLANT DIVERSITY GRADIENTS IN TIME AND SPACE AND THEIR IMPACT ON EARLY HUMANS (ROCEEH/NECLIME)	
Special Session 3 CONT...	**Special Session 25** CONT...	
Special Session 3 CONT...	**Special Session 25** CONT...	
Special Session 9A EXPERIMENTAL PALEOBOTANY: ILLUMINATING THE PAST USING EXPERIMENTS AND MODELLING	**Special Session 16A** ORIGINATIONS, EXTINCTIONS AND SPECIES TURNOVER IN PLANT HISTORY	
Special Session 9B EXPERIMENTAL PALEOBOTANY: ILLUMINATING THE PAST USING EXPERIMENTS AND MODELLING	**Special Session 4** CRETACEOUS AND CAINOZOIC PALAEOPALYNOLOGY SEEN THROUGH THE ELECTRON MICROSCOPY	**Special Session 16B** ORIGINATIONS, EXTINCTIONS AND SPECIES TURNOVER IN PLANT HISTORY
Special Session 9B CONT...	**Special Session 22** CONT...	**Special Session 16B** CONT...

SPECIAL SESSIONS LIST

No.	Titles	Convenors
Public	Fabulous Fossil Talks/Plenary and Keynote Talks	Jennifer McElwain
1	Advances and Applications of Paleozoic Palynology and Palynostratigraphy in the Arabian Plate and Adjoining regions	Marco Vecoli Charles Wellman
2	Palaeozoic Palynology – Present and Future Research Directions (CIMP Sponsored)	Reed Wicander Hartmut Jäger
3	Aspects of Upper Palaeozoic to Mesozoic palaeobotanical biostratigraphy	Ellen Stolle José Bienvenido Diez Ferrer
4	Cretaceous and Cainozoic palaeopalynology seen through the electron microscopy	Friðgeir Grímsson Christa-Charlotte Hofmann Reinhard Zetter
5	High temporal resolution Palynology and Palaeoecology– From centennial to decadal vegetation change, to yearly flowering cycles and seasonal insights from stratified Quaternary deposits	Jean Nicolas Haas Benjamin Dietre
6	Quantitative pollen-based reconstructions of plant cover for environmental and archaeological research	Marie-José Gaillard Furong Li Ralph Fyfe
7	Melissopalynology pollen morphology and dispersal	Irina Delusina Tiiu Koff Elena Severova
8	Transformative Paleobotany: Commemorating the Life and Legacy of Thomas N. Taylor	Carla J. Harper Michael Krings Gar Rothwell
9	Experimental Paleobotany: Illuminating the Past Using Experiments and Modelling	Cindy V. Looy Claire M. Belcher Jonathan P. Wilson
10	Fossil woods - New results and perspectives	Anaïs BOURA Anne-Laure DECOMBEIX
11	A world full of amber	Guido Roghi Leyla Seyfullah Jacopo Dal Corso
12	Paleobotany and Palynology of the Deccan Intertrappean beds, late Cretaceous to Paleocene of Central India	Steven Manchester Bandana Samant Selena Smith
13	Biogeographic relationships of northern hemispheric Cenozoic floras	Thomas Denk Johannes Bouchal
14	Cenozoic Plant Diversity of Tibet, Himalayas and Hengduan mountains	Zhe-kun Zhou Tao Su Lutz Kunzmann
15	The timing and phylogeny of functional traits in wood	Lisa BOUCHER Elizabeth Wheeler
16	Originations, extinctions and species turnover in plant history	Evelyn Kustatscher Niall W. Paterson Benjamin Bomfleur
17	Boundaries, transitions and extreme environments of the Cenozoic	Matthew Pound Ulrich Salzmann
18	Plant evolution; floral diversity and the response of plants to environmental stress from deep time	Wolfram M. Kürschner Heather Pardoe Christopher Cleal
19	Databases, online services and digital lterature: response to challenges of palaeobotany in XXI century	Jiri Kvacek

20	Plant evolution and geobiosphere interactions as a driver of Earth System	Borja Cascales-Miñana José B. Diez Xin Wang Charilaos Yiotis Joseph D. White Jennifer C. McElwain
21	Early evolution of soils and their biological components	Paul Kenrick Christine Strullu-Derrien Chris Berry
22	Celebrating the career of Bill Chaloner - from palaeoproxies to nomenclatural issues	Margaret E. Collinson Andrew C. Scott
23	Geochemical and molecular proxies from fossil plants and palynomorphs: new techniques, new challenges	Barry Lomax Phillip Jardine Daniela Festi Keith Bennett William Fletcher Alistair Seddon Wesley Fraser
24	Can the past unlock the future? Using palaeobotany & palaeoecology to predict future ecological trends	Karen Bacon Claire M. Belcher
25	Cenozoic plant diversity gradients in time and space and their impact on early humans (ROCEEH/NECLIME)	Alexandra-Jane Henrot Louis François Torsten Utescher Angela A. Bruch Natalia Rudaya Dimitrios Velitzelos Peta Hayes
26	Quaternary vegetation, climate, fire, and plant resilience in Europe and the Near East	Andrea Miebach Nadine Pickarski Laura Sadori Angelica Feurdean Walter Finsinger Graciela Gil Romera Lyudmila Shumilovskikh
27	Work vertically, think 3-dimensionally: palaeocology in topographically complex mountain settings	Walter Finsinger Eniko Magyari Konstantinos Panagiotopoulos
28	Filling the gaps about Non-Pollen Palynomorph ecological significance	Benjamin Dietre Fabienne Marret-Davies Havandanda Ombashi
31	Plant evolution in the Cretaceous	Jiri Kvacek Ruth Stockey
32	Triassic and Jurassic terrestrial ecosystems	Dieter Uhl Maria Barbacka
33	Paleozoic Palaeobotany	Hans Kerp Patricia Ryberg
35	Late Quaternary Palaeoecology	Fraser Mitchell Jennifer C. McElwain

PROGRAM IN FULL

Sunday 12th August			
14:00 - 19:00	Registration Ground Floor Foyer of the O'Brien Centre, UCD		
18:00 - 20:00	The Dining Hall, Trinity College Dublin.		
Monday 13th August [09:30 - 12:30]			
Room	**O'Reilly Hall**		
09:00 - 11:00	Plenary Speakers	Plen01	**Pete Coxon** - The Tertiary and Quaternary vegetation history of Ireland
		Plen02	**Jane Stout** - Palynology from the perspective of a pollination biologist
		Plen03	**Caroline Stromberg** - The evolution of grasses and grasslands
11:00 - 11:30	Refreshments		
11.30 - 11:50	Keynote Speakers	Key01	**Leyla Seyfullah** - A world full of amber
11:50 - 12:10		Key02	**Benjamin Bomfleur** - Expeditions to the Antarctic
12:10 - 12:30		Key03	**Claire Belcher** - Maintaining the air that we breathe: Why we need to understand long-term fire-feedbacks to the Earth system in order to manage our future
12:30 - 13:30	Lunch		

Monday 13th August [13:30 - 15:20]

Room	George Moore Auditorium	Intel (Theatre E)	ICON (Theatre D)	ALE (E1.17)	ALE (H1.49)	H1.51
	Special Session 1 ADVANCES AND APPLICATIONS OF PALEOZOIC PALYNOLOGY AND PALYNOSTRATIGRAPHY IN THE ARABIAN PLATE AND ADJOINING REGIONS	**Special Session 23** GEOCHEMICAL AND MOLECULAR PROXIES FROM FOSSIL PLANTS AND PALYNOMORPHS: NEW TECHNIQUES, NEW CHALLENGES	**Special Session 12** PALEOBOTANY AND PALYNOLOGY OF THE DECCAN INTERTRAPPEAN BEDS, LATE CRETACEOUS TO PALEOCENE OF CENTRAL INDIA	**Special Session 17** BOUNDARIES, TRANSITIONS AND EXTREME ENVIRONMENTS OF THE CENOZOIC	**Special Session 32** TRIASSIC AND JURASSIC TERRESTRIAL ECOSYSTEMS	**Special Session 27** WORK VERTICALLY, THINK 3-DIMENSIONALLY: PALAEOCOLOGY IN TOPOGRAPHICALLY COMPLEX MOUNTAIN SETTINGS
13.30 - 13:50	O001 Paleozoic Palynology of the Arabian Plate: a synopsis and historical perspective **Said Al-Hajri**	O005 An experimental evaluation of the use of Δ13C as a proxy for paleoatmospheric CO_2 **Barry Lomax**	O009 Review of Angiosperm flowers and fruits from the classic Mohgaonkalan chert of Central India. **Dashrath Kapgate**	O013 Late Cretaceous to Paleogene vegetation and terrestrial climate change of the Amundsen Sea Embayment, West Antarctica **Ulrich Salzmann**	O017 A modern revision of the Upper Triassic flora from the Tatra Mts, Poland. **Zuzanna Wawrzyniak**	O021 Late Glacial and Holocene vegetation history of south Balkan: a comparison between the new pollen archives of Lakes Ohrid and Prespa **Styliani Kyrikou**
13:50 - 14:10	O002 Cambrian and Ordovician acritarchs from Saudi Arabia **Stewart Molyneux**	O006 Towards the development of a Holocene proxy for UV-B radiation using *Pinus* spp. pollen grains **Alistair Seddon**	O010 Fruit, pollen and wood remains of Malvaceae from the Maastrichtian-Paleocene Deccan Intertrappean Beds of India **Steven R. Manchester**	O014 Rapid floral change in diverse early Paleocene fossil flora from the San Juan Basin, New Mexico, USA **Andrew Flynn**	O018 Succession in cycadophyte-dominated Jurassic plant community as a consequence of paleoenvironmental changes in the Cianowice area, southern Poland. **Maria Barbacka**	O022 Long-term disturbance dynamics of mountain spruce forests inferred from pollen records **Petr Kuneš**
14:10 - 14:30	O003 Ordovician cryptospores from Saudi Arabia as a record of early embryophyte evolution **Paul Strother**	O007 Towards chemical identification of Quaternary pollen grains:Drivers of chemical variation in fresh and degraded *Quercus* spp.and *Eucalyptus* spp." **Florian Muthreich**	O011 Fossil palm reading: a morphological survey of modern and fossil palm fruits, and recommendations for recognizing fossilized palm reproductive structures **Kelly Matsunaga**	O015 The late Paleocene and early Eocene Arctic megaflora of Ellesmere and Axel Heiberg islands, Nunavut, Canada. **Christopher West**	O019 New data on Lower Jurassic plants from the Holy Cross Mountains (Central Poland) **Grzegorz Pacyna**	O023 Towards a more detailed disturbance history in montane spruce forests: Integration of dendrochronological and palaeoecological records **Niina Kuosmanen**
14:30 - 14:50	O004 Chitinozoan biostratigraphy in the Silurian of Saudi Arabia **Anthony Butcher**	O008 An 1800-year Stable Carbon Isotope Chronology from Austrian Alps **Marzena Kłusek**		O016 A multi proxy atmospheric CO_2 reconstruction of the early Paleocene from the San Juan Basin, New Mexico, USA **Joseph Milligan**	O020 Recognising the range of morphological variation in microspores produced by a single fossil plant species in dispersed assemblages; new observations from the Sleipner Formation (Middle Jurassic) of the North Sea. **David Bailey**	O024 Towards an integrated understanding of montane spruce forest disturbance dynamics in central Europe **Jennifer Clear**
14:50 - 15:20	Refreshments					

Monday 13th August [15:20 - 18:30]

Room	George Moore Auditorium	Intel (Theatre E)	ICON (Theatre D)	ALE (E1.17)	ALE (H1.49)	H1.51
	Special Session 1 ADVANCES AND APPLICATIONS OF PALEOZOIC PALYNOLOGY AND PALYNOSTRATIGRAPHY IN THE ARABIAN PLATE AND ADJOINING REGIONS	**Special Session 23** GEOCHEMICAL AND MOLECULAR PROXIES FROM FOSSIL PLANTS AND PALYNOMORPHS: NEW TECHNIQUES, NEW CHALLENGES	**Special Session 12** PALEOBOTANY AND PALYNOLOGY OF THE DECCAN INTERTRAPPEAN BEDS, LATE CRETACEOUS TO PALEOCENE OF CENTRAL INDIA	**Special Session 17** BOUNDARIES, TRANSITIONS AND EXTREME ENVIRONMENTS OF THE CENOZOIC	**Special Session 32** TRIASSIC AND JURASSIC TERRESTRIAL ECOSYSTEMS	**Special Session 35** LATE QUATERNARY PALAEOECOLOGY
15:20 - 15:40	O025 Silurian acritarchs and prasinophyte algae from the subsurface of Saudi Arabia **Marco Vecoli**	O030 Pollen eDNA metabarcoding from ice cores as a tool for reconstructing plant biodiversity dynamics. A case study from the largest and deepest southern Alps glacier: Adamello, Italy. **Alexis Marchesini**	O035 Using three-dimensional shape analysis of phytoliths to test the taxonomic affinities of grass fossils from the Late Cretaceous Lameta Formation, Central India **Caroline Strömberg**	O040 Global vegetation and terrestrial climate of the super-warm Early Eocene **Stephanie Strother**	O045 Dispersed gymnosperm cuticles from the Mukheiris Formation of Jordan – a glimpse into Anisian (Middle Triassic) phytodiversity at the northern margin of Gondwana **Dieter Uhl**	O050 Persistence of temperate trees during the Late Glacial period in the central-eastern Europe (Czechia and Slovakia). **Eva Jamrichová**
15:40 - 16:00	O026 Silurian dispersed spore assemblages from the Arabian Plate: A synthesis **Charles Wellman**	O031 Using stable isotope ecology of historical *Thuja* (Cupressaceae) specimens as a tool to identify carbon sources in deep time **Rebekah Stein**	O036 Re-investigation of conifer ovulate cones from the Maastrichtian-Danian Deccan Intertrappean Beds of India **Selena Smith**	O041 Oligocene climate signals and forcings in Eurasia revealed by plant macrofossil and modelling results **Shufeng Li**	O046 A new record of Bennettitalean flower (*Williamsonia*) from the Lower Jurassic in southern China **Yongdong Wang**	O051 Neolithic landscape and people in central Europe, unique perspective from paleobotanical evidence of two wooden well in Czech republic **Libor Petr**
16:00 - 16:20	O027 Devonian palynology of Saudi Arabia: review and synthesis **Pierre Breuer**	O032 Chemical classification of grass pollen: a new tool for palynologists and archaeologists to study crop domestication **Phillip Jardine**	O037 Palynoflora across Late Cretaceous-Early Paleogene in Deccan volcanic associated sediments of India **Bandana Samant**	O042 The role of grasses in the East African vegetation across the Oligocene-Miocene boundary: new results and perspectives from plant silica (phytolith) analyses at Chilga and Mush Valley (Ethiopia). **Alice Novello**	O047 Late Triassic floral diversity of the central Transantarctic Mountains: Re-investigating the fossil flora of "Alfie's Elbow". **Patricia Ryberg**	O052 Looking at the Byzantine Resilience using palaeoclimate proxies: pollen, geochemistry and biomarkers analyses from Lake Dojran (Greece, F.Y.R. of Macedonia) **Alessia Masi**
16:20 - 16:40	O028 Mississippian palynology of Saudi Arabia: review and synthesis **Pierre Breuer**	O034 Palaeoecological reconstruction of high-mountain peat bog communities based on classical and molecular methods: a comparative synthesis. **Sandra Garcés-Pastor**	O039 Fine-tuning the position of paleobotanical localities within the Deccan basalt stratigraphy of India relative to the K-Pg boundary **Mike Widdowson**	O043 Assessing Pliocene palaeoclimate variability with high-resolution pollen records from the Asian interior (Kunlun Pass and Qaidam Basin) **Florian Schwarz**	O048 Cuticular analysis of mummified plant remains from the Triassic Leigh Creek Coal Measures of South Australia **Jan Unverfärth**	O053 Agropastoral Activities In Lake Maharlou Basin (SW Iran), During The Achaemenid Persian Empire, With Introduction Of New Arboricultural Elements **Sara Saeedi**
16:40 - 17:00	O029 Palynology of Pennsylvanian to Permian successions in Saudi Arabia (Juwayl, Nuayyim and Khuff formations) **Hani Boukhamsin**			O044 Quantitative reconstructions of palaeoclimate in Altai-Sayan mountain area (south Siberia, Russia) in Late Glacial and Holocene time based on pollen data from five sections of peat and lake sediments. **Tatiana Blyakharchuk**	O049 The palaeoecological implications of megaherbivore coprolites from the Upper Triassic of Poland. **Zuzanna Wawrzyniak**	O054 Carpological analysis of the Santi Quattro Coronati pit (Rome, Italy) **Claudia Moricca**
17:00 - 18:00	Poster Session					
17:30 - 18:30				Agora Paleobotanica AGM		

Tuesday 14th August [09:00 - 11:10]

Room	George Moore Auditorium	Intel (Theatre E)	ICON (Theatre D)	ALE (E1.17)	ALE (H1.49)
	Special Session 22 CELEBRATING THE CAREER OF BILL CHALONER - FROM PALAEOPROXIES TO NOMENCLATURAL ISSUES	**Special Session 2** PALAEOZOIC PALYNOLOGY – PRESENT AND FUTURE RESEARCH DIRECTIONS	**Special Session 7** MELISSOPALYNOLOGY POLLEN MORPHOLOGY AND DISPERSAL	**Special Session 20** PLANT EVOLUTION AND GEOBIOSPHERE INTERACTIONS AS A DRIVER OF EARTH SYSTEM	**Special Session 13** BIOGEOGRAPHIC RELATIONSHIPS OF NORTHERN HEMISPHERIC CENOZOIC FLORAS
09:00 - 09:20	O055 Snapshots from the life and times of William G. Chaloner FRS – pioneering palaeobotanist and palynologist. **Andrew Scott and Margaret Collinson**	O060 Acritax: A new online taxonomic database of acritarchs **Brian E. Pedder**	O065 The Power of Melissopalynology: Review and new Challenges **Irina Delusin**a	O070 Eoembryophytic evolution of plant life: new megafossil data and perspectives **Borja Cascales-Miñana**	O075 Historical biogeography of the Icacinaceae Miers during the PETM **Cédric Del Rio**
09:20 - 09:40	O056 The family Chaloneriaceae 35 years on, and its influence on isoetalean lycopsid phylogeny. **Patricia Gensel**	O061 Revision of the Cambrian–Ordovician acritarch genus *Vulcanisphaera Deunff*, 1961 - Ecophenotypism in early Palaeozoic acritarchs? **David Kroeck**	O066 The Online Pollen Catalogue Network (RCPol): subsides to melissopalynology studies **Cláudia Inês Silva**	O071 Assessing the role of [O_2] and [CO_2] in driving physiological convergence/divergence among higher plants: Implications for palaeo-physiology and macroevolutionary patterns. **Charilaos Yiotis**	O076 Fossil Fruit (*Lagokaopos*) from Tibet Reveals the Floristic Linkage of the Northern Hemisphere During Paleogene **He Tang**
09:40 - 10:00	O057 Three aspects of the chaloneresque approach. **Hugh Pearson**	O062 Peri-Gondwanan Ordovician acritarchs from the Llanos Orientales Basin (Colombia, NW South America) **Thomas Servais**	O067 Pollen development across the pollen lifecycle in *Ruppia maritima* (Alismatidae): Insight into the consequences of the ecological transition to hydrophily. **Mackenzie L. Taylor**	O072 Testing the impact of changing atmospheric composition on vascular plant reproduction **Caroline Elliott-Kingston**	O077 Biogeographic patterns in the history of Trochodendraceae **Steven Manchester**
10:00 - 10:20	O058 Studies of fossil and modern spore wall sporopollenins using FTIR. **Barry Lomax**	O063 New data on Upper Ordovician acritarch assemblages from the Kalpin area, northwest Tarim Basin, China **Jun Li**	O068 Loss and re-gain of pollen apertures: steps towards omniapertuate condition in aquatic basal monocots (Alismatales) **Elena Severova**	O073 Bridging the Gap Between Fossil Evidence and Theories in Angiosperm Systematics **Xin Wang**	O078 Biogeographic History of Fagaceae (Oak Family) **Thomas Denk**
10:20 - 10:40	O059 Experimentally generated charcoals: implications for recognition and interpretation of fossil and modern wildfire charcoal **Margaret Collinson**	O064 Ultrastructural study confirms that, yes, *Moyeria* is a euglenoid. **Wilson Taylor**	O069 The importance of tree pollen in supporting crop pollinators: Pollen preferences among the bee species visiting apple (*Malus pumila*) in New York **Laura Russo**	O074 Paleoclimate variations and palae-CO_2 change during the Toarcian (Early Jurassic) based on South China floras **Ning Zhou**	O079 Analyses of the global macrofossil record of palms: environmental and paleoclimatic insights **David Sunderlin**
10:40 - 11:10	Refreshments				

Tuesday 14th August [11:10 - 13:30]

Room	George Moore Auditorium	Intel (Theatre E)	ICON (Theatre D)	ALE (E1.17)	ALE (H1.49)
	Special Session 22 CELEBRATING THE CAREER OF BILL CHALONER - FROM PALAEOPROXIES TO NOMENCLATURAL ISSUES	**Special Session 2** PALAEOZOIC PALYNOLOGY – PRESENT AND FUTURE RESEARCH DIRECTIONS	**Special Session 26** QUATERNARY VEGETATION, CLIMATE, FIRE, AND PLANT RESILIENCE IN EUROPE AND THE NEAR EAST	**Special Session 20** PLANT EVOLUTION AND GEOBIOSPHERE INTERACTIONS AS A DRIVER OF EARTH SYSTEM	**Special Session 13** BIOGEOGRAPHIC RELATIONSHIPS OF NORTHERN HEMISPHERIC CENOZOIC FLORAS
11:10 - 11:30	O080 *Cymastrobus*, a new Paleozoic lycopsid from Australia investigated through a combination of old (thin-sections), less old (SEM), and new approaches (X-Ray Synchrotron microtomography) **Brigitte Meyer-Berthaud**	O084 The Early Devonian alluvial/marginal marine palynofacies from the Bukowa Góra Quarry (Holy Cross Mountains, Poland) **Marcelina Kondas**	O088 Early Pleistocene vegetation and environmental history from Lake Ohrid (SE Europe) **Konstantinos Panagiotopoulos**	O092 Roots, stems, leaves, and communities: a whole plant ecosystem perspective on Late Carboniferous aridification **Joseph White**	O096 Biogeographic Origin of East Asia Flora **Hang Sun**
11:30 - 11:50	O081 Palaeozoic horsetails – How do we assess their taxonomic diversity? **Christopher Cleal**	O085 Palynology of the Middle Devonian of Northern Spain: effects of the Kačák Event on an endemic island biota **Alexander Askew**	O089 Impacts of Climate on the Vegetation and Fire History during the Last Two Interglacial-Glacial Cycles at Lake Van, Turkey **Nadine Pickarski**	O093 Paleobotanical record of a Jurassic volcanic island in the Proto-Ligurian Tethys Ocean (NE Iberian Peninsula). **Artai Antón Santos**	O097 Endocarps of *Parinari* (Chrysobalanaceae) from the Miocene of Thailand **Paul Grote**
11:50 - 12:10	O082 A remarkable mass-assemblage of the lycopsid *Brasilodendron pedroanum* Chaloner et al. 1979 from the Rio Bonito Formation, lower Permian of the Paraná Basin, Rio Grande do Sul, Brazil **Dieter Uhl**	O086 The Terrestrial Record of the End Devonian Mass Extinction Event **John Marshall**	O090 Long-term ecosystem dynamics driven by climate oscillations and fire-regime changes during the last 18k yr cal BP in the Cantabrian region (La Molina peat bog, Puente Viesgo, Spain) **Marc Sánchez-Morales**	O094 Foliar adaptations of a new Oligocene *Rhus* species. Palaeoclimatic implications **Aixa Tosal**	O098 The Pliocene flora of Frankfurt/M (Germany) - novelties and palaeoenvironment **Zlatko Kvaček**
12:10 - 12:30	O083 New insights into the late Mississippian flora from Kingswood Fife, Scotland. **Andrew C Scott**	O087 Post-extinction recovery of terrestrial vegetation following the End Devonian Mass Extinction: integrated palynological and palaeobotanical evidence from the Tournaisian (Early Carboniferous) of the UK **Emma Reeves**	O091 Holocene-scale fire dynamics from spruce-beech temperate forests of central Europe **Alice Moravcová**	O095 Trends in deep-time (Triassic-Jurassic) plant ecological functioning under elevated atmospheric carbon dioxide **Wuu Kuang Soh**	O099 Biogeographic distribution: pattern and process in Rosaceae from the early Eocene Okanogan Highlands flora, British Columbia, Canada, and Washington, USA **Melanie DeVore**
12:30 - 13:30	Lunch				

Tuesday 14th August [13:30 - 15:20]

Room	George Moore Auditorium	Intel (Theatre E)	ICON (Theatre D)	ALE (E1.17)	ALE (H1.49)
	Special Session 22 CELEBRATING THE CAREER OF BILL CHALONER - FROM PALAEOPROXIES TO NOMENCLATURAL ISSUES	**Special Session 2** PALAEOZOIC PALYNOLOGY – PRESENT AND FUTURE RESEARCH DIRECTIONS	**Special Session 26** QUATERNARY VEGETATION, CLIMATE, FIRE, AND PLANT RESILIENCE IN EUROPE AND THE NEAR EAST	**Special Session 10A** FOSSIL WOODS - NEW RESULTS AND PERSPECTIVES	**Special Session 13** BIOGEOGRAPHIC RELATIONSHIPS OF NORTHERN HEMISPHERIC CENOZOIC FLORAS
13:30 - 13:50	O100 Naming of whole plants in palaeobotany – case study from Cretaceous **Jiří Kvaček**	O104 New insight of the morphological variation in miospores with microreticulate-foveolate sculpture **Dmitriy A. Mamontov**	O108 Response of fire activity to Holocene rapid climate changes, inferred from high-resolution European charcoal records **Gabriela Florescu**	O112 Seeing the trees for the woods: diversity vs. disparity in Mississippian lignophyte trees. **Anne-Laure Decombeix**	
13:50 - 14:10	O101 The inevitable seed: A Cretaceous perspective **Else Marie Friis**	O105 Correlation of Palynomorph Darkness Index (PDI) to other thermal maturation indices such as Vitrinite Reflectance (Ro) and Spore Colour Index (SCI) **Geoff Clayton**	O109 Holocene fire history of the British Isles **Claire Jones**	O113 Affinities and hydraulic properties of Late Devonian archaeopterids from Anti-Atlas, Morocco **Mélanie Tanrattana**	O117 Fossil *Cercis* L. (Leguminosae) from the Eocene of western North America and their phytogeographic and palaeoclimatic implications **Hui Jia**
14:10 - 14:30	O102 Diversity and homologies of corystosperm seed-bearing structures from the Early Cretaceous of Mongolia and China. **Peter Crane**	O106 Changes in sporomorph appearance with increasing maturity: a case study from Southwest Iran. **Francesca Galasso**	O110 Regional, local and anthropogenic vegetation and climate changes in North-Western Russia during the Holocene **Maria Nosova**	O114 ABleS: A database for softwood identification **Boura Anaïs**	O118 Extracting biogeographic/ecological signal from papillate Cupressaceae (former Taxodiaceae) pollen – possibilities and limitations **Johannes M. Bouchal**
14:30 - 14:50	O103 *Frenelopsis*, a Swiss-knife plant proxy of climate and terrestrial ecology during the Cretaceous **Abel Barral**	O107 Biostratigraphy and depositional setting of Permian deposits in Ajabshir area (Central Iran Basin). **Andrea Sorci**	O111 The value of comparing multiple sites in reconstructing landscape history: climate, vegetation and history from two lakes in the Rieti Basin, central Italy **Irene Tunno**	O115 Diversity in Cenomanian forests : an example from the Envigne valley (Vienne, France) **Boura Anaïs**	O119 The early Miocene (Burdigalian) flora of Kimi (Euboea) revisited: biogeography and palaeoecology **Dimitrios Velitzelos**
14:50 - 15:20	Refreshments				

Tuesday 14th August [15:20 - 18:30]

Room	George Moore Auditorium	Intel (Theatre E)	ICON (Theatre D)	ALE (E1.17)	ALE (H1.49)
	Special Session 22 CELEBRATING THE CAREER OF BILL CHALONER - FROM PALAEOPROXIES TO NOMENCLATURAL ISSUES	**Special Session 2** PALAEOZOIC PALYNOLOGY – PRESENT AND FUTURE RESEARCH DIRECTIONS	**Special Session 26** QUATERNARY VEGETATION, CLIMATE, FIRE, AND PLANT RESILIENCE IN EUROPE AND THE NEAR EAST	**Special Session 10A** FOSSIL WOODS - NEW RESULTS AND PERSPECTIVES	**Special Session 21** EARLY EVOLUTION OF SOILS AND THEIR BIOLOGICAL COMPONENTS
15:20 - 15:40	O120 Potential and constraints of tree-ring research in late Paleozoic forest ecosystems **Ludwig Luthardt**	O125 Palynological dating of the Karoo sedimentary rocks of the Moatize - Minjova Basin (N'Condèzi region) in Mozambique **Paulo Fernandes**	O130 *Alnus* population decline and its causes at the end of the first millennium CE in Europe **Heikki Seppä**	O140 Novel Suite of Traits Reflecting Hemiparasitism in the Wood of Xerophytic *Krameria lappacea*: Preliminary Results **Samantha Moody**	O141 Cryptogamic ground covers—models for early soil ecosystems? **Paul Kenrick**
15:40 - 16:00	O121 Paleotraits and paleoproxies – the legacy of Bill Chaloner **Jennifer McElwain**	O126 Early Pennsylvanian-Early Permian (Bashkirian-Asselian) miospore assemblages of the Czech part of the Intra-Sudetic Basin **Jiří Bek**	O131 Socio-economic changes leave their fingerprint on a pollen diagram from Halkidiki (NC Greece) **Sampson Panajiotidis**	O137 Carpological and leaf palaeodiversity from the Pleistocene Porto da Cruz sediments (Madeira Island, Portugal): preliminary results **Carlos A. Góis-Marques**	O142 Soils of the Proterozoic: the influence of early terrestrial microbial ecosystems **Ria Mitchell**
16:00 - 16:20	O122 Stomatal frequency of *Quercus glauca* samples from three sources show the same negative response to pCO_2: a potential proxy for palaeo-CO_2 concentrations **Jin-Jin Hu**	O127 British Zechstein palynomorphs suggests a wetter Late Permian environment **Martha Gibson**	O132 Climatic and land-use changes in the South Carpathians: Late Bronze Age alpine grazing and Subatlantic timberline shift **Enikő Magyari**	O138 New insights into the Ocu fossil forests, Panamá **Oris Rodriguez Reyes**	O143 Characterisation of early soils beneath a Middle Devonian forested ecosystem from New York State. **Jennifer Morris**
16:20 - 16:40	O123 Using plant gas-exchange principles to reconstruct CO_2: exploration of a method and application to the end-Cretaceous and early Paleocene **Dana Royer**	O128 Late Permian palynofloral assemblages from the Daptocephalus and Lystrosaurus Assemblage Zones, Karoo Basin, South Africa: Taphonomic windows into climate oscillation **Robert Gastaldo**	O133 The landscape history of the Imperial harbour of Rome **Alessia Masi**	O139 New results about Cainozoic fossil woods in Greece (Eastern Mediterranean). **Dimitra Mantzouka**	O144 Rooting systems preserved in the Rhynie chert **Alexander Hetherington**
16:40 - 17:00	O124 Vegetation-fire feedbacks and their influence on palaeoatmospheric oxygen **Claire Belcher**		O134 Pollen, seeds and charcoal as evidence of local environment and subsistence at the early medieval stronghold at Pohansko near Břeclav (Czech Republic) **Nela Dolakova**		O145 Diversity and ecology of Mid Devonian forests **Christopher Berry**
17:00 - 17:20			O135 Comparative morphological analysis of *Ceiba* Mill. (Bombacoideae, Malvaceae) pollen through FESEM, CLSM and LM: a sacred plant of Maya (Mesoamerican) civilization **Swati Tripathi**		O146 Fungal diversity in early terrestrial ecosystems **Christine Strullu-Derrien**
17:20 - 17:40					O147 Links between the early evolution of soils, global biogeochemical cycling, and climate **Benjamin Mills**
17:00 - 18:00	Poster Session				
17:30 - 18:30	International Organization of Palaeobotany (IOP) AGM			CIMP Buisness Meeting	Collegium Palynologicum Scandinavicum

Wednesday 15th August [09:00 - 10:40]

Room	George Moore Auditorium	Intel (Theatre E)	ICON (Theatre D)	ALE (E1.17)	ALE (H1.49)
	Special Session 33 PALEOZOIC PALAEOBOTANY	**Special Session 11** A WORLD FULL OF AMBER	**Special Session 24** CAN THE PAST UNLOCK THE FUTURE? USING PALAEOBOTANY & PALAEOECOLOGY TO PREDICT FUTURE ECOLOGICAL TRENDS	**Special Session 14** CENOZOIC PLANT DIVERSITY OF TIBET, HIMALAYAS AND HENGDUAN MOUNTAINS	**Special Session 10B** FOSSIL WOODS - NEW RESULTS AND PERSPECTIVES
09:00 - 09:20	O150 Affinities of nematophytes and their roles in early terrestrial vegetation revisited. **Dianne Edwards**	O155 Mid-Cretaceous Seed Plant Diversity in Burmese Amber. **Shuo Wang**	O160 Short- and long-term changes of plant diversity during the Paleogene greenhouse in Central Europe **Olaf Lenz**	O165 Cenozoic floras of Yunnan, with an emphasis on their elements of the Northern Hemisphere **Zhe-kun Zhou**	O170 Driftwood in fluvial red beds: implications for environment and taphonomic pathways of a Late Carboniferous upland vegetation **Steffen Trümper**
09:20 - 09:40	O151 *Cooksonia barrandei* sp. nov. the oldest polysporangiate land plant **Milan Libertin**	O156 A comparative palaeobotanical study of amber using IR-spectroscopy, with special attention for the Cretaceous of Myanmar **Jippe Kreuning**	O161 Reconstruction of the Paleocene climates of Central Europe using fossil leaves **Laura Tilley**	O166 Cenozoic floras in Tibet: The window into biodiversity and environment in deep time **Tao Su**	O171 Fungal activities in fossil wood **Carla Harper**
09:40 - 10:00	O152 A Lycopsid Forest with New Type Rooting System from the Upper Devonian of South China **Min Qin**	O157 Diversity and analysis of amber from the (Aptian) Crato Formation, north-east Brazil **Emily Roberts**	O162 The trouble with trees: looking at grassland as a conservation priority **Angelica Feurdean**	O167 Southeastern Tibet: surface height, climate and biotic changes at the Eocene-Oligocene transition **Robert Spicer**	O172 Silicified gymnospermous roots from the Changhsingian–Induan (?) in southern Bogda Mountains, northwestern China **Mingli Wan**
10:00 - 10:20	O153 Reconstructing Cathaysian Cordaitales from the Permian of Shanxi (China) by the means of cuticular analysis **Malte Backer**	O158 Plant assemblage and amber from the Coniacian–Santonian of Vernasso, Friuli-Venezia Giulia, northeastern Italy **Bernard Gomez**	O163 Fossil leaves indicate that hot summers follow initial spring warming during climate change **Margret Steinthorsdottir**	O168 Neogene vegetation in Europe: a valuable proxy for the early history of the Himalayan-Yunnan biodiversity hotspot? **Lutz Kunzmann**	O173 Buried alive in situ: Life and Death of the Miocene Petrified Forest on Lesvos, Greece **Carole T. Gee**
10:20 - 10:40	O154 Revealing the intricacies of a Permian high latitude peat swamp forest **Patricia Ryberg**	O159 Amber-bearing deposits of eastern margin of the pre-North Sea epicontinental basin **Barbara Slodkowska**	O164 Palaeoecological insights into ecological consequences of moorland 'improvement' and development of baselines for peatland restoration **Ralph Fyfe**	O169 Oligocene *Limnobiophyllum* (Araceae) from central Tibet and its evolutionary and paleoenvironmental implications **Shook Ling Low**	

Wednesday 15th August [11:10 - 18:00]

Room	George Moore Auditorium	Intel (Theatre E)	ICON (Theatre D)	ALE (E1.17)	ALE (H1.49)
	Special Session 33 PALEOZOIC PALAEOBOTANY	**Special Session 11** A WORLD FULL OF AMBER	**Special Session 24** CAN THE PAST UNLOCK THE FUTURE? USING PALAEOBOTANY & PALAEOECOLOGY TO PREDICT FUTURE ECOLOGICAL TRENDS	**Special Session 14** CENOZOIC PLANT DIVERSITY OF TIBET, HIMALAYAS AND HENGDUAN MOUNTAINS	**Workshop 19** DATABASES, ONLINE SERVICES AND DIGITAL LITERATURE: RESPONSE TO CHALLENGES OF PALAEOBOTANY IN XXI CENTURY
11:10 - 11:30	O175 A coal ball flora from the Hauptflöz Seam (Namurian C, lower Bashkirian, Pennsylvanian) of the Ruhr District, Germany **Hans Kerp**	O179 Reconstructing habitat types and climate of the 'Baltic amber forest': Conifers and other vascular plants **Alexander R. Schmidt**	O183 Bringing fossil wood into policy options: A case study in Indonesia **Listya Mustika Dewi**	O187 Multiple palaeoecological proxies constrain the interplay between Tibetan Plateau growth, the proto-monsoons and floral dispersal during the early India-Asia collision **Natasha Barbolini**	O191 MORPHYLL: a morphometric database for fossil leaves **Anita Roth-Nebelsick**
11:30 - 11:50	O176 Anatomy, affinities, and evolutionary implications of new Early Carboniferous silicified stems of *Sphenophyllum* **Anne-Laure Decombeix**	O180 Reconstructing habitat types and climate of the 'Baltic amber forest': Calicioid fungi and lichens **Jouko Rikkinen**	O184 Using postglacial vegetation history to provide guidance on possible future rates of vegetation change **Thomas Giesecke**	O189 Plant-Insect Interactions during the latest Eocene to earliest Oligocene in southeastern Qinghai-Tibet Plateau **Weiyudong Deng**	O192 Non-pollen palynomorphs database: challenge and implementation **Lyudmila Shumilovskikh**
11:50 - 12:10	O177 Earliest spermatophyte evolution: state of the art and new results. **Cyrille Prestianni**	O181 Palaeogene lichens and their ecological adaptations **Ulla Kaasalainen**	O185 How reliable is the dinocyst genus *Svalbardella* as a temperature proxy: implications for paleoclimatological studies of the late Paleogene **Kasia Sliwinska**		O193 STRADITIZE: An open-source program for digitizing pollen diagrams and other types of stratigraphic data **Philipp S. Sommer**
12:10 - 12:30	O178 Glossopterids last gasp? A reinvestigation of a Late Permian permineralized flora from Antarctica **Patricia Ryberg**	O182 Amber and the araucarian forests of New Zealand **Leyla Seyfullah**	O186 Consistency in the relationship between field-measured stomatal conductance and theoretical maximum stomatal conductance across four biomes provides a new reference for palaeoproxies **Michelle Murray**		
12:30 - 13:30	Lunch				
13:30 - 18:00	Mid-Conference Excursion: Botanic Gardens / Dublin / Wicklow				

Thursday 16th August [9:00 - 11:10]

Room	George Moore Auditorium	Intel (Theatre E)	ICON (Theatre D)	ALE (E1.17)	ALE (H1.49)
	Special Session 8 TRANSFORMATIVE PALEOBOTANY: COMMEMORATING THE LIFE AND LEGACY OF THOMAS N. TAYLOR	**Special Session 18** PLANT EVOLUTION; FLORAL DIVERSITY AND THE RESPONSE OF PLANTS TO ENVIRONMENTAL STRESS FROM DEEP TIME	**Special Session 5** HIGH TEMPORAL RESOLUTION PALYNOLOGY AND PALAEOECOLOGY – FROM CENTENNIAL TO DECADAL VEGETATION CHANGE, TO YEARLY FLOWERING CYCLES AND SEASONAL INSIGHTS FROM STRATIFIED QUATERNARY DEPOSITS	**Special Session 3** ASPECTS OF UPPER PALAEOZOIC TO MESOZOIC PALAEOBOTANICAL BIOSTRATIGRAPHY	**Special Session 25** CENOZOIC PLANT DIVERSITY GRADIENTS IN TIME AND SPACE AND THEIR IMPACT ON EARLY HUMANS (ROCEEH/NECLIME)
09:00 - 09:20	O195 The life and legacy of Thomas N. Taylor **Gar W. Rothwell**	O200 The dynamics of an Emerald Planet – large-scale patterns in vegetation change through geological time **Borja Cascales-Miñana**	O205 Responses of vegetation and plant diversity to the Younger Dryas climate oscillation in the Hengduan Mountains, Southwestern China **Yi-Feng Yao**	O210 Major problems in Late Palaeozoic and Mesozoic palynology **Ellen Stolle**	O215 Plant food resources and implications on the diet of *Homo erectus* in the Caucasus **Angela Bruch**
09:20 - 09:40	O196 New approaches in elucidating the anatomy of early land pla**nts** **Jennifer Morris**	O201 Intra- and interspecific variation in leaf anatomy across climate gradients of extant Cupressaceae and implications for past environmental niches of extinct taxa **Molly Ng**	O206 Stará Jímka a Late Pleistocene glacial lake (Czech Hercynicum, Central Europe). Climatic and vegetation changes based on pollen, paleozoology, and abiotic proxies. **Helena Svitavská Svobodová**	O211 Carboniferous macrofloral biostratigraphy - a new tool for studying floristics and biodiversity **Christopher J. Cleal**	O216 Vegetation change in Primory'e (Far East of Russia) during the Paleogene - a study based on diversity of plant functional types **Olesya Bondarenko**
09:40 - 10:00	O197 Rest well within a microbial mat: Exceptional preservation of microorganisms in the Lower Devonian Rhynie and Windyfield cherts, Scotland **Carla Harper**	O202 Using dispersed cuticles to evaluate canopy density variation in deep time: The loss of plant cover at the Cretaceous–Paleogene boundary (North Dakota, USA) **Antoine Bercovici**	O207 Lateglacial-Holocene abrupt vegetation changes at Lago Trifoglietti in Calabria, Southern Italy: The setting of ecosystems in a refugial zone **Sebastien Joannin**	O212 Early Permian (Asselian) palaeofloral transition from the equatorial Palaeotethys (Indonesia, Sumatra) **Isabel Van Waveren**	O217 Palaeoclimate analysis of the flora of the latest Eocene Insect Limestone of the Isle of Wight, southern England **Peta Angela Hayes**
10:00 - 10:20	O198 How much carbon was stored in the early forests of the Middle Devonian? **Brigitte Meyer-Berthaud**	O203 A High-Resolution Record of Leaf Mass per Area across the Cretaceous-Paleogene Boundary from the Denver Basin, Colorado **Matthew Butrim**	O208 A high-resolution pollen profile and pollen analytical investigation of surface samples from the Aran Islands, western Ireland provide new insights into the interpretation of pollen data **Michael O'Connell**	O213 A new radio-isotopically constrained palynozonation for the Permian Karoo Basin of South Africa **Natasha Barbolini**	O218 Oligocene vegetation of Europe and western Asia - diversity change and continental patterns reflected by Plant Functional Types **Torsten Utescher**
10:20 - 10:40	O199 Woody plants from the Early Devonian of Canada **Patricia Gensel**	O204 On the biological significance of pollen and spore tetrads **Wolfram Michael Kuerschner**	O209 Sub-decadal resolution palynology of a disease mediated elm decline **Fraser Mitchell**	O214 A review of the Gondwana Triassic megasporophyll *Umkomasia* **Heidi Anderson-Holmes**	O219 Vegetation and Climate Signal of the Middle Miocene Plant Record in Europe assessed by the IPR Vegetation Analysis **Johanna Kovar-Eder**
10:40 - 11:10	Refreshments				

Thursday 16th August [11:10 - 13:30]

Room	George Moore Auditorium	Intel (Theatre E)	ICON (Theatre D)	ALE (E1.17)	ALE (H1.49)
	Special Session 8 TRANSFORMATIVE PALEOBOTANY: COMMEMORATING THE LIFE AND LEGACY OF THOMAS N. TAYLOR	**Special Session 18** PLANT EVOLUTION; FLORAL DIVERSITY AND THE RESPONSE OF PLANTS TO ENVIRONMENTAL STRESS FROM DEEP TIME	**Special Session 5** HIGH TEMPORAL RESOLUTION PALYNOLOGY AND PALAEOECOLOGY – FROM CENTENNIAL TO DECADAL VEGETATION CHANGE, TO YEARLY FLOWERING CYCLES AND SEASONAL INSIGHTS FROM STRATIFIED QUATERNARY DEPOSITS	**Special Session 3** ASPECTS OF UPPER PALAEOZOIC TO MESOZOIC PALAEOBOTANICAL BIOSTRATIGRAPHY	**Special Session 25** CENOZOIC PLANT DIVERSITY GRADIENTS IN TIME AND SPACE AND THEIR IMPACT ON EARLY HUMANS (ROCEEH/NECLIME)
11:10 - 11:30	O220 Anatomically preserved glossopterid seeds prior to the end-Permian extinction from northeastern Australia **Stephen McLoughlin**	O224 Extinction, evolution and recovery of the Gondwanan flora through the Permian–Triassic biotic crisis in southern high palaeolatitudes, Australia **Chris Mays**	O228 Secondary temperate forest successions revealed by high-resolution palynological analyses for the Neolithic period in the Lake Mondsee region, Austria **Benjamin Dietre**	O232 Triassic palynostratigraphy of Tulong, southern Xizang (Tibet), China **Jungang Peng**	O236 Are the climatic ranges of plant species impacted by atmospheric CO_2? An attempt of quantification with a dynamic vegetation model **Louis François**
11:30 - 11:50	O222 Extinct diversity near the base of the angiosperm tree: Evidence from Cretaceous mesofossils **Else Marie Friis**	O225 Permo-Carboniferous biodiversity and phytogeographic distribution of Sphenophytes in India **Anju Saxena**	O229 Providing the palaeoenvironmental context to Bronze Age societal collapse in the eastern Mediterranean. **Calian Hazell**	O233 Palynology and palynofacies associations of Late Triassic assemblages from the Mungaroo Formation in the Greater Gorgon Area, Northern Carnarvon Basin, Western Australia **Joseph Scibiorski**	O237 Exploring the neotropical diversity of Miocene Panama: morphology and X-ray computed tomography of extinct and extant *Heliconia* (Heliconiaceae, Zingiberales) seeds **Ashley Hamersma**
11:50 - 12:10	O221 A new species of the freshwater fern *Azolla* from the Upper Cretaceous of Patagonia, Argentina. **M. Alejandra Gandolfo**	O226 Diverse functional appendages in the early Permian Wuda Tuff Flora **Weiming Zhou**	O230 Holocene forest-grassland dynamics and the expansion of the *Araucaria* forest in southern Brazil **Daniela Piraquive Bermudez**	O234 Meaning and validity of the Thüringian concept in palynostratigraphy in the Iberian Peninsula and Balearic Islands **Manuel Juncal**	O238 Worldwide temperate forests of the Neogene: never more diverse? **Edoardo Martinetto**
12:10 - 12:30	O223 Fossils and seed cone morphology in the resolution of phylogenetic relationships among basal Cupressaceae s.l. **Kelly C. Pfeiler**	O227 A mixed hygromorphic-to-xeromorphic flora from one of the most botanically rich localities in western equatorial Pangea, the Early Permian of Texas, USA **Rebecca Koll**		O235 Synthesis of the palynological content of the Lower Cretaceous continental deposits in France: stratigraphic implications **France Polette**	O239 Simulating past and present distributions of *Podocarpus* species in mountain areas of Africa and South America with the CARAIB dynamic vegetation model. **Alexandra-Jane Henrot**
12:30 - 13:30	Lunch				

Thursday 16th August [13:30 - 15:20]					
Room	**George Moore Auditorium**	**Intel (Theatre E)**	**ICON (Theatre D)**	**ALE (E1.17)**	**ALE (H1.49)**
	Special Session 8 TRANSFORMATIVE PALEOBOTANY: COMMEMORATING THE LIFE AND LEGACY OF THOMAS N. TAYLOR	**Special Session 18** PLANT EVOLUTION; FLORAL DIVERSITY AND THE RESPONSE OF PLANTS TO ENVIRONMENTAL STRESS FROM DEEP TIME	**Special Session 5** HIGH TEMPORAL RESOLUTION PALYNOLOGY AND PALAEOECOLOGY – FROM CENTENNIAL TO DECADAL VEGETATION CHANGE, TO YEARLY FLOWERING CYCLES AND SEASONAL INSIGHTS FROM STRATIFIED QUATERNARY DEPOSITS	**Special Session 3** ASPECTS OF UPPER PALAEOZOIC TO MESOZOIC PALAEOBOTANICAL BIOSTRATIGRAPHY	**Special Session 25** CENOZOIC PLANT DIVERSITY GRADIENTS IN TIME AND SPACE AND THEIR IMPACT ON EARLY HUMANS (ROCEEH/NECLIME)
13:30 - 13:50	O240 The evolutionary origin of the plant spore in relation to the antithetic origin of the plant sporophyte **Paul Strother**	O244 Teratology of spores and pollen across the Triassic–Jurassic boundary: implications for the end-Triassic mass extinction **Sofie Lindström**	O248 Medieval Climate Anomaly and Little Ice Age as revealed from a new high-resolution pollen record from the Gulf of Gaeta (central Mediterranean) **Federico Di Rita**	O252 Palaeobotany, palynology and isotopic age evaluation of the “Couche de Muse”, Autun basin (France) **Isabel Van Waveren**	
13:50 - 14:10	O241 Carboniferous wildfire revisited. **Andrew C. Scott**	O245 Detailed Insights into the end-Triassic biotic Crisis with Respect to its Impact on palynofloral Assemblages **Julia Gravendyck**	O249 Ecological impacts of the Industrial Revolution in a lowland raised peatbog near Manchester, NW England. **Sandra Garcés-Pastor**	O253 Ginkgophyte seeds and ovulate structures from the Middle Oxfordian stage of Kutch, India **Subir Bera**	O257 Interrelationships between fossil leaf anatomy, leaf carbon economy and leaf temperature: Potential for palaeo-climate and palaeo-ecology analysis **Wilfried Konrad**
14:10 - 14:30	O242 Conservation Paleobotany: putting our dead to work for the living **Melanie DeVore**	O246 Palynofloral and ecosystem variations across the Triassic-Jurassic transition in the Sichuan Basin, China **Liqin Li**	O250 Using annual resolution pollen analysis to synchronize varve and tree ring records **Martin Theuerkauf**	O254 Palynological data on the Jurassic-Cretaceous transition of the western sector of the Cameros Basin (Terrazas section, N Iberian Peninsula) **Iván Rodríguez-Barreiro**	O258 Early Pleistocene climate and regional environments in Baza Basin, Southern Spain **Yul Altolaguirre**
14:30 - 14:50	O243 Transformative Paleobotany: Papers to Commemorate the Life and Legacy of Thomas N. Taylor – Book presentation **Michael Krings**	O247 Palynological evidence of the Carnian Pluvial Episode (CPE) in the western Tethys from marine successions in the Transdanubian Range (TR), western Hungary **Viktória Baranyi**	O251 All you need is pollen – Insights on cryopalynology **Daniela Festi**	O255 Ecosystem changes during the Early Jurassic Toarcian global warming episode **Sam Slater**	O259 Simulating last glacial and postglacial distributions of African tropical trees with a dynamic vegetation model **Marie Dury**
14:50 - 15:20	Refreshments				

Thursday 16th August [15:20 - 18:00]

Room	George Moore Auditorium	Intel (Theatre E)	ICON (Theatre D)	ALE (E1.17)	ALE (H1.49)
	Special Session 15 THE TIMING AND PHYLOGENY OF FUNCTIONAL TRAITS IN WOOD	**Special Session 18** PLANT EVOLUTION; FLORAL DIVERSITY AND THE RESPONSE OF PLANTS TO ENVIRONMENTAL STRESS FROM DEEP TIME	**Special Session 6A** QUANTITATIVE POLLEN-BASED RECONSTRUCTIONS OF PLANT COVER FOR ENVIRONMENTAL AND ARCHAEOLOGICAL RESEARCH	**Special Session 9A** EXPERIMENTAL PALEOBOTANY: ILLUMINATING THE PAST USING EXPERIMENTS AND MODELLING	**Special Session 16A** ORIGINATIONS, EXTINCTIONS AND SPECIES TURNOVER IN PLANT HISTORY
15:20 - 15:40	O260 Angiosperm wood evolution revisited. Changes in functional traits through time. **Elisabeth Wheeler**	O266 The extinct seed fern *Lepidopteris ottonis* as a proxy for palaeo-pCO_2: progress and new insights **Miriam Andrea Slodownik**	O272 Relative pollen productivity estimates and quantitative pollen-based reconstruction of plant cover in temperate China **Furong Li**	O278 The Fossil Atmospheres Experiment: Improving estimates of deep-time atmospheric CO_2 concentrations from *Ginkgo* leaves **Richard Barclay**	O290 A new clue for the origin of conifers from the Beeman Formation (Kasimovian, New Mexico) **Cindy Looy**
15:40 - 16:00	O261 How many times did wood splinter? Closing in on the origins of secondary growth in euphyllophytes **Kelly C. Pfeiler**	O267 Vegetation dynamics in the Eemian lakeland in the Garwolin Plain (Central Poland): a habitat approach **Irena Pidek**	O273 Quantifying past arboreal cover based on modern and fossil pollen data: A statistical approach **Nils Broothaerts**	O279 Assessing *Ginkgo* leaf traits as a climate proxy for the fossil record **Karen Bacon**	O291 A whole plant species *Paratingia* sp. nov. and its implication on the systematics of Noeggerathiales **Jun Wang**
16:00 - 16:20	O262 Cretaceous angiosperm trees are common in mid-low latitudes of North America **Garland Upchurch**	O268 Patterns of modern pollen and plant diversity across northern Europe **Triin Reitalu**	O274 Pollen-based reconstruction of landscape openness in mountain regions: evaluation of the Landscape Reconstruction Algorithm at the Vicdessos valley, French Pyrénées **Laurent Marquer**	O280 Revisiting Early Permian CO_2 via Improved Input Parameters and Models. **Jon Richey**	O292 New insights into a peculiar mixed flora from the Upper Permian of Jordan **Patrick Blomenkemper**
16:20 - 16:40	O263 Deconstructing secondary growth as developmental potential: a perspective on the evo-devo of wood **Alexandru M.F. Tomescu**	O269 Identifying plant diversity from the pollen record; limitations and considerations **Heather Pardoe**	O275 Pollen-based reconstruction of plant cover in Europe for studies of land-use change as an anthropogenic climate forcing in the past: LandClim II **Esther Githumbi**	O281 Single species or plant assemblage approach? A comparison of plant-based paleoatmospheric CO_2 proxies **Amanda Porter**	O293 The diversity of land plants across the Permian–Triassic boundary: comparing macro- and microfossil records **Hendrik Nowak**
16:40 - 17:00	O264 Secondary xylem character suites in Cretaceous woods **Lisa Boucher**	O270 DEEP TIME, a visual, musical, artistic and scientific experience of life thirty million years ago. **AK Milroy**	O276 Pollen productivity estimates for the reconstruction of land-cover changes in the forest-steppe zone from SE Romania (SE Europe) **Angelica Feurdean**	O282 Leaf Evapotranspiration and Paleophysiology of early Eocene Neotropical Rainforests **Monica Carvalho**	O294 The Permian Triassic Boundary from Kap Stosch, East Greenland **Elke Schneebeli**
5:00 - 5:20			O277 Elemental and Palynological analysis of honey from Azad Jammu and Kashmir Pakistan **Mehwish Jamil**	O283 Improving the use of molecular fossils to identify floristic components in paleoenvironments **David Taylor**	O295 Palynology of the Permian–Triassic boundary in the Norwegian Arctic: palaeoclimatic and palaeoecological implications **Niall William Paterson**
5:00 - 6:00	Poster Session				
7:00 - Late	Gala Dinner				

Friday 17th August [9:00 - 11:10]

Room	George Moore Auditorium	Intel (Theatre E)	ICON (Theatre D)	ALE (E1.17)	ALE (H1.49)	H1.51
	Special Session 31 PLANT EVOLUTION IN THE CRETACEOUS	**Special Session 28** FILLING THE GAPS ABOUT NON-POLLEN PALYNOMORPH ECOLOGICAL SIGNIFICANCE	**Special Session 6B** QUANTITATIVE POLLEN-BASED RECONSTRUCTIONS OF PLANT COVER FOR ENVIRONMENTAL AND ARCHAEOLOGICAL RESEARCH	**Special Session 9B** EXPERIMENTAL PALEOBOTANY: ILLUMINATING THE PAST USING EXPERIMENTS AND MODELLING	**Special Session 4** CRETACEOUS AND CAINOZOIC PALAEOPALYNOLOGY SEEN THROUGH THE ELECTRON MICROSCOPY	**Special Session 16B** ORIGINATIONS, EXTINCTIONS AND SPECIES TURNOVER IN PLANT HISTORY
09:00 - 09:20	O296 Leaves and inflorescences of Araceae and other monocots in the latest Albian (mid-Cretaceous) of Spain: implications for early monocot evolution **James A. Doyle**				O342 SEM investigation of mid-Eocene pollen from Hainan (S China) and a few palaeogeographic implications. **Christa-Ch. Hofmann**	
09:20 - 09:40	O297 Mesozoic fern ontogeny in action: leaf growth pattern of *Weichselia reticulata* **Candela Blanco-Moreno**	O301 Challenging the conventional indicators: anthropogenic activities inferred from algae rather than pollen and coprophilous fungi **Benjamin Dietre**		O312 Benefits of applying X-ray micro-computed tomography to paleobotanical studies **Selena Smith**	O343 SEM investigation of the late Oligocene Chilga palynoflora, Ethiopia, East Africa **Reinhard Zetter**	O322 The Carnian humid episode - a moment of major origination for plants **Evelyn Kustatscher**
09:40 - 10:00	O298 Early Cretaceous anatomically-preserved Marsileaceae from California (USA) and the evolution of sporocarp morphology **Shayda J. Abidi**	O302 Combining presence with the past – an attempt of using modern non-pollen palynomorph surface samples in the palaeorecords - an example from Polish raised bogs **Monika Karpińska-Kołaczek**	O307 How do patterns of subsistence, non-subsistence production and palaeodemographic change relate to regional vegetation cover in Britain and Ireland? **Ralph Fyfe**	O313 The earliest wood documented by synchrotron analyses **Christine Strullu-Derrien**	O344 PalDat – a useful tool for identifying recent and fossil pollen **Martina Weber**	O323 Two in one! Reconstrucing the seed-fern Lepidopteris and restoring Prof. Britta Lundblad´s legacy - a holistic approach from museum archives **Vivi Vajda**
10:00 - 10:20	O299 New findings of the middle Albian angiosperms in Primorye, Russia **Lina Golovneva**	O303 Fungi fragments in deep sea quaternary sediment on the Amazon Fan River, Amazon Basin, Brazil **Nelsa Cardoso**	O309 Mediterranean Vegetation change, Landscape dynamics and Human Population trends through the Holocene **Ralph Fyfe**	O314 Hydraulic conductivity and constraints among Paleozoic plants **Jonathan Wilson**	O319 A SEM and TEM study of two fossil Malvaceae from northern South America provides new insights into past forest composition **Carina Hoorn**	O324 Plant relictualism in the Polar Regions of the Mesozoic–Paleogene greenhouse world **Benjamin Bomfleur**
10:20 - 10:40	O300 Palaeovegetation and palaeoenvironment of the Late Cretaceous of Central Europe **Jiri Kvacek**	O304 Insights into prehistoric human impact around Lake Attersee, Austria, by means of non-pollen palynomorphs **Marie-Claire Ries**	O310 Utilization of mountainous areas in the Iron Age – the potential of land-cover reconstructions **Kari Loe Hjelle**	O315 Refining phytolith analysis in deep-time paleoecology through modern analogue studies **Camilla Crifò**	O320 LM vs. SEM based analyses of the early Miocene Saldanha Bay palynoflora, Western Cape, South Africa **Friðgeir Grímsson**	O349 Much more than “living fossils”: a new phylogenetic hypothesis of the Cycadales. **Mario Coiro**
10:40 - 11:10	Refreshments					

Friday 17th August [11:10 - 14:00]

Room	George Moore Auditorium	Intel (Theatre E)	ICON (Theatre D)	ALE (E1.17)	ALE (H1.49)	H1.51
	Special Session 31 PLANT EVOLUTION IN THE CRETACEOUS	**Special Session 28** FILLING THE GAPS ABOUT NON-POLLEN PALYNOMORPH ECOLOGICAL SIGNIFICANCE	**Special Session 6B** QUANTITATIVE POLLEN-BASED RECONSTRUCTIONS OF PLANT COVER FOR ENVIRONMENTAL AND ARCHAEOLOGICAL RESEARCH	**Special Session 9B** EXPERIMENTAL PALEOBOTANY: ILLUMINATING THE PAST USING EXPERIMENTS AND MODELLING		**Special Session 16B** ORIGINATIONS, EXTINCTIONS AND SPECIES TURNOVER IN PLANT HISTORY
11:10 - 11:30	O326 New species of Cenomanian Anemia (Czechia) **Jiřina Dašková**	O330 New information on phytodebris in palynological and palynofacies samples from the Triassic to Early Cretaceous of the North Sea, including evidence of abundant bryophytes **David Bailey**	O334 The role of climate, forest fires and human population size in Holocene vegetation dynamics in Fennoscandia **Niina Kuosmanen**	O338 UV-B-induced conifer sterility: Implications of ozone shield failure during the end-Permian crisis **Cindy Looy**		O346 The late Campanian Jose Creek flora from New Mexico, a unique window into the ecology of Cretaceous forests during the rise of angiosperms **Dori Contreras**
11:30 - 11:50	O327 Suturovagina intermedia (Cheirolepidiaceae) from the upper Lower Cretaceous Dalazi Formation of Wangqing, Northeast China: cuticle ultrastructure and palaeoenvironmental insights **Xiao-Ju Yang**	O331 Cigars, vases, and dead centipedes: non-pollen palynomorphs from the Middle to Late Miocene Brassington Formation, UK **Jen O'Keefe**	O335 ROPES - Reconstructing past plant abundances without pollen productivity estimates **Martin Theuerkauf**	O339 To what extent did plant evolutionary innovations in plant traits between the Permian and Jurassic influence the nature and behaviour of ancient fires **Sarah Baker**		O347 Trends and regional diversification of Late Cretaceous vegetation as evidenced by Central European megafloras **Adam T. Halamski**
11:50 - 12:10	O328 Diversification of crown group Araucaria: A seed cone from the mid-Cretaceous (Campanian) of Vancouver Island, British Columbia, Canada **Ruth Stockey**	O332 Using Non Pollen Palynomorphs to explore fire and vegetation dynamics and the impact of Mesolithic tribes in The Peak District, U.K. **Karen Halsall**	O336 Herbaceous plants and their pollen signal; which rare pollen types can we interpret and over what source areas? **Helen Shaw**	O340 Testing the applicability of leaf physiognomic proxies for climate on equatorial African floras **Aly Baumgartner**		O348 Origination of Nuphar and Nymphaeaceae clade based on leaf architectural characters of a middle Eocene water lily from Messel near Frankfurt, Germany **Carole T. Gee**
12:10 - 12:30	O329 X-ray tomography using Synchrotron radiation reveals the morphology of a Cheirolepidiaceae cone from the Late Cretaceous of New Zealand. **David Cantrill**	O333 NPP and pollen identification as part of a study on the relationships between land use and climate changes during the Bronze- and Iron Age at Spooners and Great Buscombe, Exmoor, UK **Havananda Ombashi**		O341 Proximal ejecta blankets of small impact craters as time capsules preserving a timelapse of paleoenvironment **Anna Losiak**		
12:30 - 13:00	Closing Remarks and Prizes					
13:00 - 14:00	Lunch and Posters					

Saturday 18th August - Monday 20th August

Post Conference Field Trips

10TH EUROPEAN PALAEOBOTANY & PALYNOLOGY CONFERENCE

ABSTRACTS

EPPC2018
University College Dublin, Ireland
12-17 August 2018

Plen01

THE TERTIARY AND QUATERNARY VEGETATION HISTORY OF IRELAND

Pete Coxon

Department of Geography, Trinity College Dublin, Dublin, Ireland

Ireland's diverse and rugged scenery is the product of both long-term landscape evolution and repeated and very extensive glaciation during the last 2.6Myr (Quaternary). Despite complete and highly erosive ice cover (e.g. during the LGM) biogenic deposits have survived (Coxon and McCarron 2009). This talk will outline the biostratigraphic evidence that allows us to gain an insight into both Neogene and Pleistocene landscape evolution and into Ireland's vegetation history.

The search for Ireland's Palaeogene and Neogene (e.g. Mitchell 1980) has led to the discovery of a number of remarkable sites many of which are located on Carboniferous limestone. Some of these deposits provide irrefutable evidence of Tertiary surfaces, e.g. the gorge and cave infills at Pollnahallia in County Galway and the associated (immediately) subsurface Pliocene lignites whilst others, especially landforms and cave sediments, remain enigmatic. Furthermore the identification of a Neogene surface overlying weathered granite in Connemara (Coxon 2001; Coxon and McCarron 2009) opened up the possibility of finding further datable palaeosurfaces on rocks other than limestone in Ireland.

The majority of Irish Pleistocene temperate stage deposits are believed to be related to one stratotype sequence (the Gortian). The latter are characterised by a Holsteinian (MIS 11) style vegetation succession but attempts at dating suggest the deposits may be younger and may indicate the repetition of Holsteinian style vegetation succession in more than one interglacial.

This talk will examine the nature of Irish Pleistocene biogenic deposits, their gemorphological setting and accommodation space and their floristic assemblages. A possible complete sequence of last interglacial (MIS 5e) age at Knocknacran will also be presented along with organic sediments believed to date to MIS 5 that lie on a raised rock platform around Ireland's coast.

Coxon, P. 2001. Understanding Irish landscape evolution: Pollen assemblages from Neogene and Pleistocene palaeosurfaces in western Ireland. *Proceedings of the Royal Irish Academy,* **101B (1–2),** 85–97

Coxon, P. and McCarron, S.G. 2009. *Cenozoic: Tertiary and Quaternary (until 11,700 years before 2000)* in, editor(s) Charles H. Holland & Ian S. Sanders, *The Geology of Ireland (2nd Edition),* Edinburgh, Dunedin Academic Press, 2009, pp355 – 396.

Coxon, P., McCarron,S. and Mitchell, F. (eds) 2017. Advances in Irish Quaternary Studies. Atlantis Press. Paris. 316pp. DOI 10.2991/978-94-6239-219-9

Mitchell, G.F. 1980. The search for Tertiary Ireland. *Journal of Earth Sciences Royal Dublin Society,* **3**, 13–33.

Plen02

PALYNOLOGY FROM THE PERSPECTIVE OF A POLLINATION BIOLOGIST

Jane Stout

Trinity College Dublin, Dublin, Ireland

Pollination is the process of release, transfer and deposition of the male microgametophyte, the pollen, from anther to stigma in seed plants. This process has influenced the evolution of pollen grains - their structure, chemical composition, how they are stored and released, temporal and spatial patterns of dispersal, and longevity. The study of pollen contributes to several scientific disciplines including biostratigraphy, taxonomy, melissopalynology, archaeological palynology and even forensics, linking the accused to a victim and a place, and methods can be shared across disciplines. For pollination biologists, the study of pollen can help us to understand plant evolution, breeding systems and gene flow, as well as pollinator behaviour, foraging, diet and response to landscape. The quantity and quality of pollen production can influence both the reproductive success of plants, and, as the primary source of protein for many pollinating insects, the fitness of these animals. In this talk, I will use examples from my own work on bee health, invasive plants, and crop pollination, to illustrate how palynology contributes to contemporary pollination biology.

Plen03

THE EVOLUTION OF GRASSES AND GRASSLANDS

Caroline Stromberg

University of Washington, Seattle, USA

Poaceae (grasses) is arguably among the most important plant families on Earth today, dominating vegetation in several ecosystems together estimated to cover nearly half of the terrestrial surface. These ecosystem, which include savannas, woodlands, and grasslands are of immense importance both ecologically and economically; they influence global climate and biogeochemical cycles, and provide habitat and food for billions of animals, including humans. Yet, grasses are thought to have evolved only in the Late Cretaceous, and to have remained relatively rare until the mid-late Cenozoic. Investigation into the evolutionary history of grasses and grass-dominated habitats was long inhibited by the scarce and often ambiguous fossil record of grass macrofossils and pollen, forcing paleontologists to rely on indirect evidence, in particular the occurrence of fossil mammals reminiscent of modern grassland dwellers. In recent years, plant silica (phytoliths) has emerged as an alternative means of tracking grass-and grassland evolution. Unlike pollen and most macrofossils, grass phytoliths are diagnostic of ecologically distinct grass subclades; in addition, phytoliths occur in facies that do not typically preserve plant fossils, such as those reflecting well-oxidized floodplain environments.Combined with other paleontological and geochemical evidence, phytolith data collected on several continents (e.g., North and South America, Asia, Africa) have started to uncover the Cretaceous taxonomic radiation and early ecology of the grass clade, and the complex assembly of the grassland biome during the Cenozoic. Existing data indicate that crown-group grasses had undergone diversification by the end of the Cretaceous and were present on several Gondwanan continents; in addition, they may have formed a substantial part of some plant communities in India. Open-habitat grasses started diversifying at least by the late Eocene, long before their rise to dominance in the Oligocene or Miocene, with the exact timing varying among continents and regions. Similarly, C_4 grasses diversified well before their late Miocene-Pliocene ecological expansion at low-mid latitudes. The decoupling between taxonomic radiation and increase in abundance points to different causal factors for these events. Comparison between faunal and plant silica-based floral data also shows that presumed grazers did not evolve in tight coevolution with grasslands. Thus, in North America and Eurasia, grass-dominated vegetation preceded grazer types by several million years; in South America grazer-like morphology originated independently of grasslands, in non-analog palm shrublands. These results suggest that region-by-region studies integrating multiple lines of evidence are required to test what factors contributed to the unrivaled success of the grass clade.

Key01

A WORLD FULL OF AMBER

Leyla Seyfullah

University of Göttingen, Göttingen, Germany

Amber is a remarkable substance. It is fossilised plant resin, where the originally liquid resin solidifies and then, whilst buried, matures to become amber. This means that both biological and geological processes are involved in the formation of amber. Apart from a few famous deposits, amber was thought of as generally rare in the fossil record, only known from some locations and time points. It is most famous for the fossil organisms that it contains, some of which are exceptionally well preserved. This has meant that interest in amber research has continued, recently resulting in an explosion of new amber deposits being found and described from many new locations with different ages. This gives us a wealth of new information not just on the entrapped organisms, but also clues into past climates and environments preserved in amber. We now recognise that there are major times in earth history where an abundance of amber is found, across the world.

Key02

EXPEDITIONS TO THE ANTARCTIC

Benjamin Bomfleur

Institute of Geology and Palaeontology – Palaeobotany University of Münster, Münster, Germany

Antarctica today is the coldest, driest, most remote, and most inhospitable continent on our planet, and about 99 percent of the Antarctic landmass is currently buried under an ice sheet up to four kilometres thick. However, sedimentary rocks exposed along the coastlines and in isolated mountain ranges host a rich fossil record from former, warmer times in Earth History that already attracted the attention of early Antarctic explorers. Exceptional plant-fossil deposits from the Permian to Jurassic of the Transantarctic Mountains allow us to reconstruct the lush vegetation of Antarctica's past in great detail. After a brief introduction about the history of Antarctic research from the earliest days of exploration to the present, this presentation gives an overview about the most exciting Antarctic plant-fossil deposits, and takes the audience on a short stroll through the peculiar Triassic Polar Forests of Gondwana.

Key03

MAINTAINING THE AIR THAT WE BREATHE: WHY WE NEED TO UNDERSTAND LONG-TERM FIRE-FEEDBACKS TO THE EARTH SYSTEM IN ORDER TO MANAGE OUR FUTURE

Claire M. Belcher

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Fire is a natural process that is integral to the functioning of our planet. It has both destructive and regenerative effects on ecosystems and is an essential tool for man, yet is a foe that society must manage and face. Earth's ecosystems provide a source of fuel that lead to fires that consume huge quantities of biomass across all biomes from tundra to savanna and from boreal to tropical forests. The first evidence of ancient fire predates even the appearance of the dinosaurs, and fires are believed to have occurred on Earth for the last 410 million years of Earth's history. Throughout this huge tract of time the unique products that fires generate have interacted with the carbon and nutrient balance of the planet both immediately after the fire through to much longer timescales operating over millions of years. Fire is therefore an important Earth System process. The concept of the Earth System considers the relationship between individual processes with one another in order to understand how they interact to ensure a stable environment that allows all life to thrive. In this talk I will outline the significant role that fire plays in regulating the amount of oxygen in the atmosphere; maintaining the air that we breathe. My aim being to highlight that it is necessary to include consideration of the long-term role that fire plays in sustaining the habitability of the planet.

O001

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 subsurface stratigraphy, to meet the demands of hydrocarbon exploration in the Kingdom. Pioneering work of Saudi Aramco palynologists since the '60s demonstrated the presence of exceptionally abundant and well-preserved palynomorph assemblages and their huge potential for establishing reliable operational biozonations. A major impetus for further development and refinement of palynological biozonations followed the important hydrocarbon discoveries from Saudi Arabian Paleozoic successions during the '80s and '90s, with an increased need for an improved understanding of the Paleozoic sediments. The establishment of a successful, long-term collaboration between Saudi Aramco and the CIMP (Commission Internationale de Microflore du Paléozoïque) was highly beneficial and resulted not only in the establishment of a robust biostratigraphic zonation of Cambrian to Permian strata, but also in a number of important scientific discoveries. Presently, we face new challenges of discovering unconventional hydrocarbon resources, and smaller conventional fields with subtle trapping mechanisms. The contribution of palynology is therefore even more crucial in all phases of exploration and development.

The Paleozoic Saudi Aramco Operational Zonation comprises 43 palynozones (2 in the Cambrian, 8 in the Ordovician, 8 in the Silurian, 9 in the Devonian, 8 in the Carboniferous, and 8 in the Permian) defined by First Downhole Occurrences (FDOs) of about 200 palynomorph taxa (spores, pollen, acritarchs and chitinozoans) and assemblages characteristics. Within each zone, further stratigraphic subdivision is provided by distinct bioevents (e.g., FDOs and acmes) of regional importance. 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, plants) permit even more accurate correlation with the standard Global Chronostratigraphy. In the lower Silurian, for example, the study of graptolites recovered from extensively cored sections resulted in a robust integrated palynological-graptolite biozonation forming the base of the chronostratigraphic and depositional model for the organic-rich "Hot Shales" of Saudi Arabia. Other applications of the palynological zonation concern the subsurface mapping and understanding of stratigraphic architecture, depositional paleoenvironments and paleoclimatic settings of many important exploration targets such as source rocks and reservoir horizons in the Cambrian-Ordovician Saq and Qasim formations, the Upper Ordovician glaciogenic Sarah Formation, the Devonian Tawil, Jauf and Jubah formations, and the Carboniferous-Permian Unayzah Group and Khuff Formation.

O002

CAMBRIAN AND ORDOVICIAN ACRITARCHS FROM SAUDI ARABIA

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Studies of Cambro-Ordovician acritarchs from Saudi Arabia have focussed on the Middle and Upper Ordovician, whereas Cambrian and Early Ordovician (Tremadocian–Floian) acritarchs are comparatively poorly represented in the published Saudi record, probably because of unsuitable facies. Nonetheless, Cambrian acritarchs are known from the subsurface of eastern Saudi Arabia and from offshore in the Arabian Gulf. Published records from the former comprise a sparse, low diversity assemblage of early to middle Cambrian age, with *Annulum squamaceum* and *Archaeodiscina* spp., from the Burj Formation. A more diverse Cambrian assemblage of Furongian (late Cambrian) age, with typical marker species such as *Ninadiacrodium dumontii* and *Trunculumarium revinium*, has been reported from the Arabian Gulf offshore. A sparse assemblage of Tremadocian (Early Ordovician) aspect is known from the Saq Formation of onshore eastern Saudi Arabia. Higher levels in the Saq Formation (Sajir Member), of presumed Floian–early Darriwilian (Early–Middle Ordovician) age, have yielded low diversity assemblages, dominated by sphaeromorph acritarchs with few acanthomorphs or other morphologically complex forms. Diverse assemblages of acritarchs and associated chlorophycean algae from Saudi Arabia have been reported from the Hanadir Member (Darriwilian) at the base of the Qasim Formation, and include such characteristic forms as *Aureotesta clathrata*, *Barakella* spp., *Stelliferidium* spp., *Frankea breviuscula*, *F. longiuscula*, *Dasydorus cirritus*, *Dicrodiacrodium ancoriforme*, *Orthosphaeridium ternatum*, *Striatotheca* spp. and *Uncinisphaera fusticula*. The Kahfah and Ra'an members of the Qasim Formation generally yielded low diversity assemblages, which nonetheless include some morphologically characteristic forms such as *Monocrodium* spp., *Orthosphaeridium bispinosum* and abundant *Aremoricanium squarrosum*. Diverse assemblages have also been described from the Quwarah Member, the highest of the four members of the Qasim Formation, with forms such as *Cheleutochroa* spp., *Multiplicisphaeridium irregulare*, *Neoveryhachium carminae*, *Orthosphaeridium* spp., *Tunisphaeridium* spp., *Veryhachium oklahomense*, *V. subglobosum* and *Villosacapsula setosapellicula*. Latest Ordovician (Hirnantian) acritarch assemblages have been reported from the glaciogenic deposits of the Sarah Formation; these assemblages are characterized by stratigraphically admixed Ordovician palynofloras, with reworking of Middle and Upper Ordovician forms attributed to processes of glacial erosion and resedimentation. *In-situ* specimens include forms such as *Eupoikilofusa platynetrella*, *E. cucurbita*, large *Baltisphaeridium*, *Veryhachium subglobosum* and *Villosacapsula setosapellicula*. Reworked specimens are most commonly from the Hanadir Member and possibly also from the Kahfah and Quwarah members of the Qasim Formation. Lateral and stratigraphical changes in assemblages reflect environmental control on species distributions, in response to lateral onshore–offshore trends and, stratigraphically, to successive marine flooding events.

O003

ORDOVICIAN CRYPTOSPORES FROM SAUDI ARABIA AS A RECORD OF EARLY EMBRYOPHYTE EVOLUTION

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Unornamented dyads and undescribed tetrads occur in the uppermost Saq Formation of Central Saudi Arabia, so these simple forms comprise the first occurrence of cryptospores in Saudi Arabia. These are followed by a well-characterized assemblage from the Hanadir Member of the Qasim Formation which includes the oldest known examples of tetrahedral spore tetrads in the fossil record. The Hanadir assemblage overall comprises a number of well-characterized cryptospore tetrads and dyads, most of which are also recovered in the uppermost Quwarah Member of the Qasim Formation and in the Sarah Formation. Many of the basic forms that characterize the cryptospore of the Qasim Formation persist well into the Silurian, and, as such, establish for the first time a core set of cryptospore taxa that, ultimately, share an evolutionary relationship with the true land plants, the embryophytes. Although traditionally, paleobotanists have considered tetrahedral tetrads to represent the origin of land plants from their algal ancestors, from the perspective of the evolution of development in land plants, what this really signifies is the canalization of meiotic sporogenesis in the emerging plant life cycle. We have used morphology, topology and sporoderm ultrastructure of cryptospore tetrads and dyads to infer the status of character and character state evolution at a time during which the evolution of the plant sporophyte was not yet complete. Homogeneous sporoderm documented in *Cryptotetras*, and by inference, in *Didymospora*, and *Tetraplanarisporites laevigatus*, likely indicates a tapetal origin, which implies the existence of a unilocular sporangium at this time. This is also the first indication of vegetative (i.e., non-sporogeneous) tissue in the evolving sporophyte, although, admittedly, this is only inferred. There are reports of thin synoecosporal membranes covering some cryptospore tetrads and dyads in the assemblage, but, these have proved difficult to reproduce consistently, leading us to propose that the so-called "sporopollen transfer hypothesis" was complete by this time. The origin of land plants represents an evolutionary transition from simple to complex multicellularity as charophytic algae evolved in response to aeroterrestrial habitats. It did not occur as a singularity in evolutionary time, but required the serial accumulation of novel structures and tissues over an interval of geologic time. Ordovician cryptospores from Saudi Arabia continue to play a significant rôle in documenting the evolution of plant development through the fossil record, which is, after all, the most tangible form of the documentation of the pattern of evolution itself.

O004

CHITINOZOAN BIOSTRATIGRAPHY IN THE SILURIAN OF SAUDI ARABIA

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The Silurian succession in Saudi Arabia is relatively thick, and includes the Qalibah Formation and the lower part of the Tawil Formation. The Qalibah Formation represents a coarsening-upward sequence, which is divided into the Qusaiba and Sharawra members - their distinction is based upon the lithofacies (sandstone-shale ratio) in the succession, resulting in a diachronous boundary controlled by localised depositional environments. The age of this boundary varies from Aeronian, in central Saudi Arabia, to early Homerian in the northern part of the Nafud Basin. As a major phase of global warming developed during the Llandovery, the Arabian Platform was flooded as sea level rose rapidly after the Hirnantian glaciation. Shallow to deeper marine environments were established and thick, organic-rich and fine-grained deposits from the Qusaiba Member accumulated across much of Saudi Arabia. In the late Llandovery-Wenlock, the sandstone-dominated Sharawra Member indicates shallower water depths and higher energy conditions than the underlying shale-dominated Qusaiba Member. After a period of uplift, the Sharawra Member was overlain unconformably by the fluvial to marginal marine sediments of the Tawil Formation, which was deposited throughout the Ludlow and Pridoli.

Although rich palynological assemblages, including chitinozoans, are recovered from both members of the Qalibah Formation, the maximum chitinozoan diversity is recorded in the Qusaiba Member due to its more marine nature. *Spinachitina fragilis*, *Belonechitina postrobusta*, *Ancyrochitina udayanensis*, *Conochitina alargada*, *Sphaerochitina solitudina*, *Angochitina macclurei*, *Plectochitina longicornis*, *Euconochitina silurica*, *Anthochitina jawfensis* and *Salopochitina monterrosae* are examples of chitinozoans having their FDOs in the Qalibah Formation, allowing high-resolution correlation of stratigraphic horizons within this unit. The integration of a recent study of the graptolites from numerous Saudi Aramco wells by Williams et al. (2016), refined the chronostratigraphic control of chitinozoan FDOs through the Qusaiba Member. Although the lower Tawil Formation was deposited in predominantly continental settings, marginal marine assemblages occur in more distal settings in the Nafud Basin and in the Arabian Gulf. In these distal locations, the chitinozoan assemblages are successively characterised by species such as *Fungochitina kosovensis*, *Margachitina elegans* and *Anthochitina superba*.

The current Saudi Aramco operational zonation scheme comprises eight main palynozones in the Silurian. In addition the FDOs of 23 chitinozoan species are routinely used as correlative events on a regional scale.

References:

Williams, M., Zalasiewicz, J., Boukhamsin, H., Cesari, C., 2016. Early Silurian (Llandovery) graptolite assemblages of Saudi Arabia: biozonation, palaeoenvironmental significance and biogeography. Geological Quarterly, 60 (1): 3–25.

O005

AN EXPERIMENTAL EVALUATION OF THE USE OF $\Delta^{13}C$ AS A PROXY FOR PALEOATMOSPHERIC CO_2

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Understanding both the long term carbon cycle and rapid perturbations in atmospheric CO_2 observed through the geological record has become an increasingly important area of scientific enquiry. Recently a new method has been developed based on carbon isotope composition ($\delta^{13}C$) of C_3 plant material and discrimination ($\Delta^{13}C$) with changes in $\Delta^{13}C$ being used as a basis to reconstruct CO_2. From an ecophysiological standpoint changes in $\Delta^{13}C$ are driven by changes in plant water use efficiency (*WUE*) which are ultimately controlled by the opening and closure of stomatal pore complex to regulate gas exchange. For $\Delta^{13}C$ to be used as an accurate and precise method for reconstructed pCO_2 the major requirement is to demonstrate that pCO_2 is the main driver of the opening and closure of the stomata and that this is independent of other environmental conditions that can alter C_i/C_a (ratio of internal CO_2 to external CO_2) which in turn influence *WUE*. Here we look to test one of the most important factors associated with C_i/C_a, namely water availability and how this factor influences the predictive capability of $\Delta^{13}C$ to be used as a proxy to predict pCO_2.

Arabidopsis thaliana was subjected to six separate CO_2 experiments, with CO_2 held at concentrations of 400, 760, 1000, 1500, 2000 and 3000ppm. Nested within each CO_2 treatment, plants were also subjected to one of three watering regimes, (10 ml-1 day-1 7cm pot-1) a medium water treatment (20 ml-1 day-1 7cm pot-1) or high water treatment (consistently saturated compost) resulting in 117 calculations of $\Delta^{13}C$. These data where then used to generate predictions of CO_2 which were then compared to measured values for validation. Our data show large differences between predicted and measured growth CO_2 with this variation increasing as atmospheric CO_2 in the chamber increases. Our results demonstrate that environmental factors that alter stomatal opening can severely impact on the use and reliability of $\Delta^{13}C$ to predict CO_2 and as such, results should be interpreted with caution.

O006

TOWARDS THE DEVELOPMENT OF A HOLOCENE PROXY FOR UV-B RADIATION USING *PINUS* SPP. POLLEN GRAINS

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Incoming ultraviolet radiation (UV-B) has experienced large changes throughout Earth's history with major consequences for biodiversity and ecosystem functioning, but reconstructing past UV-B to investigate impacts on ecosystems on millennial timescales or longer remains a major challenge. It has been suggested that UV-B absorbing compounds found within the sporopollenin of pollen exines (e.g. para-Coumaric acid) are enriched in high UV-B environments, and studies have proposed that variations in the concentrations of these compounds in fossil-pollen could act as a UV-B proxy for reconstructing UV-B over thousands of years. However, whilst more researchers are becoming interested in the potential use of these pollen-chemistry approaches for reconstructing past UV-B irradiance, the opportunities offered by the rigorous procedures in experimental UV-B research on other plant processes have not been taken advantage of by palaeoecologists. Here, we present a new research strategy related to the future the development of this proxy designed for use on *Pinus* spp. pollen, using techniques borrowed from experimental UV-B ecological research. The strategy aims to improve both methodology and fundamental ecological understanding of the mechanisms underlying pollen chemistry techniques by addressing three challenges (i) analytical precision; (ii) uncertainty characterisation, and (iii) understanding the dose-response relationship of between pollen chemistry and UV-B. The goal is to develop a robust proxy methodology grounded in contemporary ecological understanding, so that the method can be used to address a suite of palaeoclimatic and palaeoecological applications.

O007

TOWARDS CHEMICAL IDENTIFICATION OF QUATERNARY POLLEN GRAINS: DRIVERS OF CHEMICAL VARIATION IN FRESH AND DEGRADED *QUERCUS* SPP. AND *EUCALYPTUS* SPP."

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Quaternary palynologists are heavily reliant on the use of morphological analysis of sub-fossilised pollen grains to document compositional assemblage changes through time. However, traditional methods for pollen identification based on morphology are time consuming and limited by taxonomic precision. Fourier transform infrared (FTIR) spectroscopy has been proposed as a promising alternative approach, which uses the information on chemical composition of pollen by characteristic spectral bands and features, using specific signals from lipids, carbohydrates, sporopollenin and other cell wall biopolymers that can be used to fingerprint species. The chemical composition of fresh pollen has also been shown to respond to seasonal variation in temperature and UV-radiation. To apply this approach to pollen grains extracted from sediment cores, it is important to understand the drivers of chemical variation within (i.e. along climatic gradients) and between species. It is also essential to understand how chemical procedures routinely used in pollen analysis can affect the compounds used for species identification. Diagenesis and sample processing (acetolysis) exposes pollen grains to intense degradation, while the grains remain intact to allow for morphological identification, changes in the chemistry are largely unknown.

This study aims to apply FTIR pollen-chemistry methods on *Quercus* and *Eucalyptus* pollen sampled from wild populations in Australia, Portugal and botanical Gardens in Europe as well as *Quercus* pollen from an environmental and climatic gradient in Portugal. Here, we present work which investigates whether: (i) taxonomic signals in chemical spectra of *Quercus* and *Eucalyptus* groups can be identified down to species level, (ii) if chemical variation between *Quercus* species along a climatic gradient can be observed, (iii) how the application of single grain measurements with reproducible spectra to enable classification of single pollen grains using µFTIR-spectroscopy. These results represent an important stepping stone for applying pollen-chemistry techniques to fossil samples. Improved taxonomic resolution would improve our understanding of *Quercus* expansions and contractions in response to climate changes during the Quaternary, as well as fire-vegetation dynamics in *Eucalyptus* dominated systems.

O008

AN 1800-YEAR STABLE CARBON ISOTOPE CHRONOLOGY FROM AUSTRIAN ALPS

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A new multi-century-long stable carbon isotope chronology was built on the basis of sub-fossil tree trunks and contemporary wood of Norway spruce (*Picea abies* (L.) Karst.). This wood was excavated from the bottom of Schwarzensee lake and sampled from the trees growing around this lake. Schwarzensee is a small mountain lake which lies in the region of the Dachstein Mountains in Austrian Alps. The aim of this research was to reconstruct the past climate conditions in the area of Eastern Alps.

The isotopic composition of wood was measured by the application of continuous flow Isotope Ratio Mass Spectrometer IsoPrime EA-CF-IRMS connected to the elemental analyser EuroVector. Prior to isotopic measurements, α-cellulose was extracted from the whole annual growth-rings. For each year of chronology a pooled sample of wood averaged from several trees was prepared.

As a result of the measurements 1800-year long chronology of stable carbon isotopes, covering the period 200 – 2000 AD, was obtained. This chronology was referenced against the meteorological record from the Schwarzensee area. For this purpose monthly averaged data of temperature and sun radiation as well as monthly sum of precipitation were used. The calculations were carried out by the application of the DENDROCLIM 2002 software. Moreover, negative and positive pointer years were determined and compared with the weather instrumental data of the corresponding calendar years.

As a result of the conducted research it was determined that the strongest connections occur between meteorological parameters and $\delta^{13}C$ in the summer months. A positive correlation was observed for sunshine and temperature level during June, July, August and September. In turn, for the monthly sum of precipitation the negative relationship was visible during July and August.

High high-frequency correlations with summer temperature and sunshine level, and a weaker relationship with precipitation indicate that the Schwarzensee chronology has a strong climatic signal and can be used to reconstruct climate conditions. However, the final ratio of stable carbon isotopes is most probably the result of interdependences that exist between several inter-related weather parameters.

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O009

REVIEW OF ANGIOSPERM FLOWERS AND FRUITS FROM THE CLASSIC MOHGAONKALAN CHERT OF CENTRAL INDIA.

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The Deccan Intertrappean beds of upper Cretaceous (Maastrichtian) to Paleocene age are rich in angiosperms comprising both dicotyledons and monocotyledons preserved especially in the form of permineralizations. Silicified within chert, the plants reveal details of morphology and anatomy through examination of fractured surfaces, serial sectioning, and successive acetate peels. In addition to numerous petrified woods, the flora is rich in well preserved silicified flowers and fruits. More than 35 genera of fruits and flowers have been recognized but most of them require intensive comparative work to assess their systematic affinities with confidence. Recovery of new specimens and the application of new methods, including virtual 3-dimensional imaging from successive peels and X-ray CT scan data using Avizo software, and investigation of pollen grains by both transmitted light and scanning electron microscopy, are improving our knowledge of the morphology and anatomy of these reproductive structures. Ongoing investigation of the classic Mohgaonkalan locality (N 22°01'01.6", E 079°10'57.9"), is leading to improved understanding some genera of clear familial affinities, and others with still elusive affinities. Regarding dicot fruits and flowers, some of the confidently identified families and orders include Lythraceae (flowers of *Sahnianthus* and associated fruits of *Enigmocarpon*), Zingiberales (*"Musa" cardiosperma*) and recently recognized seeds of Vitaceae (*Indovitis chitaleyae*). A large number of other taxa present unusual character combinations suggesting that prior taxonomic assignments are in need of reevaluation. Inflorescences, flowers and in situ pollen of the extinct genus *Sahnipushpum* preserve an abundance of distinctive morphological and anatomical characters, showing overlap both with Piperales and Araceae, yet its systematic position does not conform precisely to any modern family. Other taxa under investigation include the monocots *Viracarpon*, *Tricoccites*, *Pantocarpon, Nypa, Palmocarpon, Arecoidocarpon*, *Monocotylostrobus, Hyphaeneocarpon, Graminocarpon* (not really a grass), and a variety of other angiosperms fruits including *Indocarpa, Sahniocarpon, Harrisocarpon, Baccatocarpon, Centrospermocarpon, Chitaleocarpon, Daberocarpon, Deccanocarpon*, *Gyrocarpusocarpon, Triloculocarpon, Lytherocarpon, Oleaceocarpon, Surangea* (capsular fruit--not a fern synangium as originally thought), a triseriate and *Wingospermocarpon* fruits. The flowers include *Chenopodioanthus* (bearing pollen that excludes assignment to Chenopodiaceae), *Raoanthus* (syn. *Sahnianthus*), *Deccananthus, Tetraplasandranthus, Chitaleypushpum* (syn. *Sahnianthus*), and newly found apocarpous polypetalous, tricarpellary, and pentacarpellary syncarpous flowers. Some of these fossils present unusual character combinations that we have not been able to identify with certainty to modem families. In some instances they may represent extinct clades that may have evolved in isolation on the Indian subcontinent.

Keywords: Maastrichtian, Deccan Intertrappean, India, Fruits, flowers.

O010

FRUIT, POLLEN AND WOOD REMAINS OF MALVACEAE FROM THE MAASTRICHTIAN-PALEOCENE DECCAN INTERTRAPPEAN BEDS OF INDIA

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The flora of the Deccan Intetrappean Beds, extending from Maastrichtian to Paleocene, includes a diverse angiosperm flora, with many components of uncertain familial affinity. The Malvaceae are well represented and readily recognizable in these beds based on dispersed pollen, fruits and wood. Pollen attributable to the Malvoideae is known from the classic locality of Mohgaonkalan and other sites. Studied by both light and scanning electron microscopy, these globose grains are characterized 3 poroidate apertures and numerous bulbous-based spinesconsistent with the Abutileae. Two genera of fruits with similarities to Malvoideae have been recognized, both from Mohgaonkalan: *Harrisocarpon sahnii* Chitaley & Nambudiri and *Daberocarpon gerhardii* Chitaley & Sheikh, based on radially symmetrical capsules of five 2-seeded locules and ten single-seed locules, respectively. The holotypes of these species, represented by physically sectioned and peeled specimens providing detailed anatomical information, have been supplemented by new specimens revealing 3-dimensional morphology by nano-CT scanning. Continuing investigation is aimed at reevaluating the affinities of these fruits, which do not seem to correspond precisely to any extant clade within the family. Malvaceous woods include *Grewinium canalisum* (Bande & Srivastava) Srivastava & Guleria from Nawargaon and Mohgaonkalan plus *Sterculinium deccanensis* (Lakhanpal, Prakash, & Bande) Guleria from Mohgaon, Mandla, and *Sterculinium shahpurensis* (Bande & Prakash) Guleria from Ghughua, near Shahpura. These woods, representing Grewioideae and Sterculioideae, do not appear to be directly related to the fruits and pollen described above, but attest to diversity within this family in India when the subcontinent was still isolated from other major land masses and positioned in the equatorial climate belt.

O011

FOSSIL PALM READING: A MORPHOLOGICAL SURVEY OF MODERN AND FOSSIL PALM FRUITS, AND RECOMMENDATIONS FOR RECOGNIZING FOSSILIZED PALM REPRODUCTIVE STRUCTURES

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The fossil record of palms (Arecaceae) is long, rich, and geographically extensive. Although palm fossils are easily recognized owing to their distinctive anatomy and morphology, they can be notoriously difficult to identify below the family level. This is due in part to the large size of vegetative organs, fossils of which can be difficult to recover intact, convergent evolution of many morphological characters within the family, relatively little accessible information on comparative anatomy and morphology at the species and genus level, and the large size of the family (~2400 species in 183 genera), which makes taxonomic comparisons unwieldy. This impedes the utility of the fossil record in understanding the evolutionary history of the family. However, reproductive organs like flowers and fruits have been shown in numerous other groups to possess taxonomically informative characters necessary for placing fossils and elucidating evolutionary relationships. For these reasons, fossilized reproductive structures of palms represent a promising source of information for understanding the evolutionary history of palms in deep time. Here we illustrate the challenges of studying fossil palms and the utility of reproductive structures using examples from our studies of silicified fruits and flowers from the Maastrichtian–Danian Deccan Intertrappean Beds of India. Some of these fossils can be confidently placed within tribes or subtribes of the family, while others remain ambiguous despite exceptional preservation of fruit and seed characters. To help place these fossils in systematic context, we compiled an extensive genus-level dataset of palm fruit morphology using X-ray micro-computed tomography of herbarium and fresh collected specimens, supplemented with descriptions in the literature. Although some clades possess clear and reliable synapomorphies, in many cases palm subfamilies and tribes are characterized by suites of morphological traits for which there are often exceptions. We conclude that reliable taxonomic placement of fossilized palm reproductive organs often requires exceptional preservation of fruit, seed, and sometimes floral characters, and should be aided by phylogenetic analyses. Based on our studies of fossil and extant palms we propose criteria for identifying palm fruit fossils and other reproductive structures, highlight important characters that define palm subgroups, and discuss the diversity in palm fruit morphology, which goes well beyond the archetypal 'single-seeded drupe'.

O013

LATE CRETACEOUS TO PALEOGENE VEGETATION AND TERRESTRIAL CLIMATE CHANGE OF THE AMUNDSEN SEA EMBAYMENT, WEST ANTARCTICA

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The past vegetation and climate of West Antarctica and the evolution of its highly sensitive and dynamic ice sheet are poorly constrained by geological data. The few existing far-field data, and even fewer proximal records, indicate a major ice-sheet build-up in West Antarctica from the Oligocene to the Miocene, with partial or even complete ice-sheet collapses during warm Late Cenozoic intervals with near-modern atmospheric CO_2-concentrations. Here we present first palynological results from the MeBo70 seabed drill cores collected in early 2017 from the Amundsen Sea shelf. The cores contain unconsolidated to highly consolidated sediments of Cretaceous to Holocene age. Preliminary analyses of pollen, spores and dinoflagellate cysts indicate that during the Cretaceous and early Paleogene the Amundsen Sea Embayment was covered by warm-temperate and temperate forests. The paper will focus on Turonian to Santonian (ca. 93-85 Ma) peat layers in the oldest sections of the cores, which contain micro- and macrofossils documenting the evolution of a highly diverse, conifer-rich swamp forest during the Late Cretaceous.

O014

RAPID FLORAL CHANGE IN DIVERSE EARLY PALEOCENE FOSSIL FLORA FROM THE SAN JUAN BASIN, NEW MEXICO, USA

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Early Paleocene floras from western North America are dominated by long lived, cosmopolitan taxa and are typically less diverse than latest Cretaceous floras. Analyses of the floral record suggests low rates of species turnover through most of the Paleocene, and at least for the Northern Great Plains, relatively low rates of origination during the early Paleocene. These low rates of turnover and origination in the Northern Great Plains may be linked to a pattern of decreasing species richness from the early to the middle Paleocene concurrent with a decrease in mean annual temperature. However, due to the lack of research from southern North America, whether this pattern is representative of the Paleocene floral record or if there are regional differences between northern and southern floras is unclear. The San Juan Basin (SJB), located in northwestern New Mexico, preserves a continuous sequence of early Paleocene terrestrial deposits making it an ideal area to study early Paleocene fossil floras from southern North America. Here we present reconstruct floral diversity and paleoclimate during the first 2.0 Myr of the Paleocene in the SJB.

Fossil floras were collected from the early Paleocene Ojo Alamo Sandstone and lower Nacimiento Formation (~66.0 to 64.0 Ma). These floras are equivalent with the Puercan (Pu) 1 through Torrejonian (To) 1 North American Land Mammal ages. The SJB flora was composed primarily of endemic taxa dominated by dicotyledonous angiosperms with monocotyledonous angiosperms, pteridophytes, conifers, and cycads as accessory taxa. A significant facies effect on floral composition and diversity was observed indicating a high degree of lateral heterogeneity in species composition across the basin. Paleoclimate estimates indicate a warm (25.2 to 27.4 °C) and wet (1961 to 2554 mm/yr) climate, corresponding with a modern tropical seasonal forest. Numerous floral turnover events were found with large events at ~65.0 and ~64.5 Ma contemporaneous with the Pu2 – Pu3 and Pu3 – To1 mammal transitions suggesting a regional mechanism. When compared to contemporaneous floras from western North America, the SJB flora was 30-60% more diverse and experienced higher rates of extinction and origination. We hypothesize that the warmer and wetter climate in the SJB allowed for the development of greater floral diversity and that the thermophilic SJB flora was more sensitive to changes in paleoclimate leading to increased floral turnover rates. This suggests a differential latitudinal response and rapid establishment of a north-south diversity gradient following the K-Pg boundary.

O015

THE LATE PALEOCENE AND EARLY EOCENE ARCTIC MEGAFLORA OF ELLESMERE AND AXEL HEIBERG ISLANDS, NUNAVUT, CANADA.

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The Canadian High Arctic during the early Paleogene hosted diverse mesothermal mixed deciduous forests of ferns, conifers (e.g., *Metasequoia* and other Cupressaceae) and broad-leaved trees (e.g., *Aesculus, Alnus*, *Betula, Juglans*, and *Ulmus*), and a unique polar fauna (e.g., tapirs, alligators, and terror birds). These polar forests existed at time when global temperatures were much higher than modern values, punctuated by a series of superimposed short-lived hyperthermal events (e.g., the Paleocene-Eocene Thermal Maximum (PETM) ca. 56 Ma, and the Eocene Thermal Maximum 2 (ETM-2) ca. 53.7 Ma) - intense episodes of global warming that represent the warmest intervals of the Cenozoic. Late Paleocene to early Eocene deposits on Ellesmere and Axel Heiberg islands preserve fossil evidence of these high latitude forests that provides proxy evidence for the warm and wet climates (e.g., MAT ≥ 12 °C and MAP ≥ 150 cm/yr) that characterized the high latitudes at that time. Just as today, the High Arctic experienced extreme photic seasonality, with extended periods of continuous day and night during the respective polar summer and winter, yet with an otherwise equable climate. The fossil megafloras of the Canadian Arctic Archipelago share many taxa across the boreal and polar latitudes of Europe and Asia, as well as coeval floras from mid-latitudes in North America, but also include some endemic elements. New descriptions of these megafloras offer insight into regional phytogeographic history during a climatically dynamic time in Earth's history. The taxonomic composition and architectural character of the leaves in these floras may have been influenced by hyperthermal extremes and may offer insight into how these megafloras responded to Eocene climatic events. The composition of these fossil megaflora collections supports earlier studies based on pollen suggesting that the forests of the Canadian Arctic during the early Eocene were similar in diversity to modern mid-latitude temperate mixed deciduous forests. Furthermore, contemporaneous floras of the northern Great Plains of North America (e.g., Bighorn and Williston basins) are similar in species diversity to these High Arctic floras, which suggests that the modern equatorial-polar diversity gradient was greatly reduced during the early Paleogene. The fossils of Ellesmere and Axel Heiberg islands thereby offer insight into polar vegetation growing beneath the midnight sun during a globally warm period in Earth's history.

O016

A MULTI PROXY ATMOSPHERIC CO_2 RECONSTRUCTION OF THE EARLY PALEOCENE FROM THE SAN JUAN BASIN, NEW MEXICO, USA

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The Cretaceous-Paleogene (K-Pg) boundary marks a critical extinction event in Earth's history that is associated with a major perturbation to the global carbon cycle. We presently lack robust atmospheric CO_2 (pCO_2) estimates directly following the K-Pg boundary that can provide context to the climate and biological response. The few early Paleocene pCO_2 estimates range between 300-600 ppm; however, the age constraints on many of these estimates are relatively poor and have large uncertainties (± 0.5-1 myr). Furthermore, there are few pCO_2 estimates from the first 5 million years of the Paleocene (~66-61 Ma). Thus, both short-term changes and long-term trends in pCO_2 during the Paleocene are essentially unknown.

Here we reconstruct pCO_2 for the early Paleocene (~65.6-62.0 Ma) using fossil leaves collected from the Nacimiento Formation in the San Juan Basin located in northwestern New Mexico, USA. Fossil leaves were collected from localities within a chronostratigraphically well constrained section with age uncertainties for each locality of ± ≤ 0.1 myr. Atmospheric CO_2 was estimated from the species *Platanites raynoldsii* using the traditional stomatal index method and two models based on basic plant gas-exchange. The pCO_2 estimates were then paired with contemporaneous mean annual temperature (MAT) estimates generated by using leaf margin analysis (LMA) and digital leaf physiognomy (DiLP) on fossil leaves to reconstruct regional climate sensitivity. The use of paired pCO_2 and temperature estimates from the same fossil localities ensures synchronous climate sensitivity estimates. Preliminary results indicate that pCO_2 was relatively low through most of this interval (~≤1000 ppm). These pCO_2 estimates coupled with MAT estimates from the same floras suggest a regional climate sensitivity that is similar to, or slightly lower than, modern climate sensitivity. This record is the first to reconstruct pCO_2 during the late Danian (63-62 Ma), an interval that is relatively poorly studied in the terrestrial realm. This type of combined pCO_2 and temperature record is crucial in placing the anthropogenic rise in pCO_2 into geological context, and has the potential to enhance our understanding of climatic response to major perturbations in the carbon cycle.

O017

A MODERN REVISION OF THE UPPER TRIASSIC FLORA FROM THE TATRA MTS, POLAND.

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Described by Maryjan Raciborski in the 1890 floral assemblage from the Upper Triassic sediments of the Tatra Mountains need an up-to-date review. Modern description and illustrations are essential to fully understand this interesting fossil plant assemblage and to introduce it to a broader audience of palaeobotanists. Beautifully situated in the West Tatras, fossil-bearing strata "Tomanova Beds" (*sensu* Raciborski) are part of Tomanova Formation, composed of dark grey mudstones and sandstones. Interpreted as Norian-Rhaetian in age sediments are rich in ichnofossils, including dinosaurs footprints. Plants are preserved as impressions without cuticles suitable for preparation. The most abundant are fragments of stems and leafy twigs, usually accompanied with plant debris. The plant assemblage consists of horsetails, ferns and conifers. Noticeable is domination of sphenophytes remains. Raciborski described *Schizoneura hoerensis* (Hisinger 1840) Schimper 1869, Equisetum an *bunburyanum*?Zigno 1856 and *Equisetum chałubińskii* Raciborski 1890. Ferns are represented by genera *Cladophlebis*, *Clathropteris*, *Coniopteris*, *Dictyophyllum*. Nearly all of the species need to be revised. The least numerous are conifers. Only two species were described *Widdringonites* sp. and *Palissya brauni* Endlicher 1847. Specimens from historical collections housed in the Tatra Museum in Zakopane, Geological Museum of the Institute of Geological Sciences PAS in Kraków, Institute of Botany, Jagiellonian University, Poland, and Natural History Museum in Stockholm, Sweden, were revised. Preliminary observations show that leaves of *Equisetites chałubiński*, an endemic horsetail described by Raciborski, have different morphological features from other *Equisetites* species. Moreover, the details of *Cladophlebis roessertii* forma *parvifolia* pinnules suggest that these specimens should be assigned to *C. roessertii* and *Schizoneura hoerensis* to *Neocalamites lehmannianus* (Goeppert 1846) Weber 1968.

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O018

SUCCESSION IN CYCADOPHYTE-DOMINATED JURASSIC PLANT COMMUNITY AS A CONSEQUENCE OF PALEOENVIRONMENTAL CHANGES IN THE CIANOWICE AREA, SOUTHERN POLAND.

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The profile of continental Jurassic sediments in the Cianowice2 borehole (depth 265.3 – 244.0 m) shows four facies units reflecting environmental changes in this area (flood plain – river channel – lake) and at the top a thick complex of regular cycles (flood plain – channel – flood plain – channel). The last was characterized by meandering and/or anastomosed channels. Each complex contains flora macroremains as well as palynomorphs. Although the diameter of the cores is quite small (10 cm), many small fragments of macroremains are abundant in each sample. They are mainly leaves, but Cycadolepis scales from bennettite strobili are found sporadically. All four are composed mainly of bennettites and cycads representing species of Otozamites, Ptilophyllum, Pterophyllum, Nilssoniopteris, Anomozamites and cycads such as Ctenis and Pseudoctenis. Occasionally the seed ferns Pachypteris and Ctenozamites, ginkgophyte Pseudotorellia, fern Coniopteris and spenophyte Neocalamites occur. The assemblages, although all highly dominated by bennettites, differ in species composition, proportions of genera, and the presence of other taxa. The most diverse is the assemblage representing a river channel.

The composition of the assemblages shows a clear relationship with the type of environment, but at the same time the gross morphology and cuticular structure of the plants show high uniformity: small leaf size and relatively thick cuticles through the whole sequence.

Pollen analysis of the four complexes suggests the presence of some more ferns (*Klukisporites variegatus* Couper, *Marattisporites scabratus* Couper) and the probable occurrence of Caytoniales (*Vitreisporites pallidus* Couper) and Cheirolepidiaceae (some pollen of Classopolis). The preliminary dating of the sequence based on the pollen analysis is Lower to Middle Jurassic (from Pliensbachian to Batonian/Callovian).

O019

NEW DATA ON LOWER JURASSIC PLANTS FROM THE HOLY CROSS MOUNTAINS (CENTRAL POLAND)

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Plant fossils from the Lower Jurassic of the Holy Cross Mountains are known since the late 19th century. Pioneering research by Raciborski (1891, 1892) and Makarewiczówna (1928) provided the first data on the taxonomical composition of the flora, and some new taxa such as the gymnosperm male cone *Ixostrobus* were established. The next new data for this flora were supplied by Reymanówna et al. (1987) and Barbacka et al. (2010, 2014). The following plant groups were recognized: lycopsids, sphenopsids, ferns, seed ferns, cycadaleans, bennettitaleans, gnetaleans, ginkgoaleans and conifers (summarised in Pacyna 2013). Overall, this flora is similar to coeval floras of Sweden, Denmark and Germany but has fewer taxa and is less well preserved. In recent years, numerous new collections of fossils have been gathered from the Lower Hettangian of the Gromadzice outcrop, one of the localities most prolific in fossils in this region. Plants are preserved in crevasse splay deposits and are dominated by leaves of ginkgoalean and czekanowskialean plants probably shed during dry seasons. Other taxa such as sphenopsids (*Neocalamites*), ferns (*Phlebopteris*, *Dictyophyllum*), seed ferns (*Sagenopteris*, *Pachypteris*), bennettialeans (*Otozamites*), cycads (*Nilsonia*) and conifers (*Brachyphyllum*, *Pityophyllum* and *Stachyotaxus*) are rare. Numerous lax female and male cones have been found among mats of *Sphenobaiera*, *Podozamites*, *Desmiophyllum* and *Czekanowskia* leaves. Only some of them could be unequivocally identified as *Leptostrobus*, *Stachyopitys*, *Cycadocarpidium* and *Ixostrobus*. Many resemble female cones of *Stachyotaxus* and male cones of *Ixostrobus* and *Stachyopitys,* but important details differ in some specimens. This assemblage may contain new taxa for the European Lower Jurassic, and it also provides new important data on species poorly known at present.

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O020

RECOGNISING THE RANGE OF MORPHOLOGICAL VARIATION IN MICROSPORES PRODUCED BY A SINGLE FOSSIL PLANT SPECIES IN DISPERSED ASSEMBLAGES; NEW OBSERVATIONS FROM THE SLEIPNER FORMATION (MIDDLE JURASSIC) OF THE NORTH SEA.

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Many palaeobotanical studies of fossil plant remains that include *in situ* reproductive structures have highlighted the wide morphological variation in microspores produced by a single parent species. Much of the variability is thought to reflect different stages of late ontogenetic development prior to dispersal. Understanding the full range of variation is critical in distinguishing between growth-related and species-dependent morphological features in dispersed assemblages. It is generally assumed that most miospores in palynological samples are mature, because there is no advantage in plants releasing non-viable microspores. In certain terrestrial environments however, the microfloras may include significant numbers of immature specimens, which are introduced via normal erosion/weathering processes. These are observed in some units within the Sleipner Formation (Late Bathonian-Mid Callovian) in the North Viking Graben, which was deposited in a lower coastal plain swamp environment. Minimal transport of plant debris is indicated by the abundance of cells and cell structures that remain linked together in life position, including remnant sporangia with attached microspores. The occurrence of variably mature specimens enables a better appreciation of the full range of morphological variation in microspores produced by a single fossil plant species. This is demonstrated here for a few of the more common spore types observed in the Sleipner Formation microfloras. Several specimens of each are illustrated, reflecting different stages of late ontogenetic development, and arranged in order of increasing maturity. Examination of these "growth profiles" has also identified some previously undescribed morphological features related to the development and operation of the germination structure in these forms.

O021

LATE GLACIAL AND HOLOCENE VEGETATION HISTORY OF SOUTH BALKAN: A COMPARISON BETWEEN THE NEW POLLEN ARCHIVES OF LAKES OHRID AND PRESPA

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A high-resolution pollen record from Lake Ohrid (DEEP core) provides new insights into the flora composition and vegetation changes over the last 17000 years. Given the fact that existing Late Glacial and Holocene records from Lake Ohrid suffer from discontinuities in sedimentation, this study presents the first continuous pollen record from Lake Ohrid. Furthermore, the comparison of the new Late Glacial-Holocene record with the pollen archive from the adjacent Lake Prespa, allows for inferring regional vegetational patterns and local features. From 17000 cal BP onwards, the palynological data from both lakes suggest a rather open landscape dominated by steppe elements (mainly Artemisia and Chenopodiaceae) along with grasslands. Pines appear to be the dominant trees in the region during the Late Glacial, while oaks are continuously present in low abundances. During the Bølling/Allerød deciduous oaks dominate arboreal tree percentages at Ohrid, while at Prespa pines remain dominant throughout this period. During the Younger Dryas, the resurgence of steppe features (mainly Artemisia and Chenopodiaceae) accompanied by Betula, Ephedra and Hippophae in both lakes point to cold and arid conditions. The beginning of the Holocene is characterized by the gradual expansion of mixed deciduous woodland dominated by oaks indicating the presence of dense deciduous oak forests in the surroundings of Lakes Ohrid. A markedly short-term shift highlighted by an abrupt rise of Artemisia percentages, corresponding to the 8.2 cooling event is registered in the pollen records of both lakes. During the Middle and Late Holocene, the closed forests diversify and percentages of other deciduous taxa such as Acer, Alnus, Carpinus, Fagus, Ostrya increase in both records, especially at Prespa. Although Lake Ohrid is situated a 150 m lower than Lake Prespa at 693 m asl, the presence of Mediterranean elements such as Pistacia and Phillyrea in Ohrid pollen spectra is rather limited compared to Prespa. Intensifying anthropogenic activities during the last two millennia can be inferred in both records from the decline of tree percentages and the coeval increase in pollen of cultivated plants such as walnuts and cereals.

O022

LONG-TERM DISTURBANCE DYNAMICS OF MOUNTAIN SPRUCE FORESTS INFERRED FROM POLLEN RECORDS

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Disturbances such as fire, grazing, windthrows or pathogens play an important role in long-term ecosystem dynamics. Mountain ecosystems of central Europe, such as spruce-dominant forests, experience a variety of disturbances that are threatening their survival. Therefore, long-term observations of ecosystem disturbance dynamics may provide a better understanding of natural vs. anthropogenic disturbance ecology within spruce forests, which may be crucial for their future conservation.

We developed a new method of quantifying overall disturbance by linking pollen records with plant indicator values for disturbance. Here we use pollen, macrofossil and charcoal records from two sedimentary basins in the Bohemian Forest (Prášilské jezero and Stará jímka), Czech-German borderland, one representing a regional signal and another more local development. Pollen spectra from both well dated pollen records served for calculation of mean disturbance frequency, which was calculated by assigning each pollen to plant taxon with a disturbance index derived for central-European flora. Reconstructed levels of disturbance frequency were then compared to fire activity (frequency) inferred from contiguous macrocharcoal analysis, and then interpreted along with vegetation changes inferred from pollen and macrofossil analysis. Surrounding vegetation was moreover interpreted quantitatively by application of Landscape Reconstruction Algorithm (using both regional and local scales, REVEALS, LOVE).

Our results reflect similar trends in both pollen records showing continuously increasing disturbance frequency over the entire Holocene. Distinct disturbance events in the early Holocene are associated with increased fire frequency. The local vegetation during this time was mostly dominated by pine, but with increasing spruce after 8000 cal. BP. For this period we interpret fire as the main disturbance agent probably fueled by drier and warmer-than-present climate. The period between 6500 and 3500 cal. BP is marked by quite stable disturbance frequency (ca. once in 50 years), with slightly increasing trend at the local site. This period is also marked by the lowest fire frequency. A profound increase in disturbance frequency between 3000 and 2000 cal BP is not accompanied by increased fire suggesting human impact or other disturbance factors playing the crucial role. The last millennium is defined by highest disturbance frequency accompanied by increased fire activity. This regime is most probably triggered by increasing human occupancy in the study area.

Our methods introduces another dimension in disturbance regime reconstructions by quantifying other than fire disturbance. We also suggest that disturbances were inherent part of spruce forests development in the past.

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O023

TOWARDS A MORE DETAILED DISTURBANCE HISTORY IN MONTANE SPRUCE FORESTS: INTEGRATION OF DENDROCHRONOLOGICAL AND PALAEOECOLOGICAL RECORDS

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Future projected climate change will affect the disturbance regime in temperate montane forest ecosystems in central Europe. Understanding the processes that drive the disturbance events and their impacts on these forests can provide important knowledge for maintaining biodiversity and the functionality of these ecosystems. Here we link disturbance signal from decadal dendrochronological records from tree-rings with millennial palaeoecological proxies from lake sediments, both of which provide information of vegetation and disturbance patterns at different spatial and temporal scales. Comparison of data from these two different datasets increases our understanding of the importance of different disturbance agents on the forest dynamics.

Multiproxy data-sets spanning the last 500 years have been extrapolated onto 10-year temporal resolution for a detailed reconstruction of the disturbance history in central European montane spruce forest in Šumava National Park, Czech Republic. The stand-scale disturbance history is reconstructed based on tree-ring records and compared to a high resolution multiproxy lake sediment record from a small glacial lake situated at 1100 m.a.s.l. in the study area. Fossil pollen is used to reconstruct changes in the forests composition and landscape openness, micro- and macroscopic charcoal to reveal the past fire events, fossil bark beetle remains to reconstruct insect outbreaks, and geochemical data to identify the impact of forest disturbance events on the lake catchment.

Tree-ring data demonstrate peak in disturbance signal between years 1780-1820 AD, at the beginning and at the end of 20th century. Results from sedimentary records suggest that fires occurred in the study area at around 1800 AD corresponding with the canopy opening suggested by tree-ring records. Pollen influx values show slight decrease in *Picea* pollen corresponding with the disturbance signal around 1800 AD, but more notable decrease in pollen abundance, and change in forest composition, occur during the disturbance events in the 20th century.

The comparison of disturbance signal from tree-ring and high resolution sedimentary data demonstrate similar patterns between dendrochronological and palaeoecological proxies. Our results suggest that fires have been important part of the disturbance regime in temperate montane spruce forests together with bark beetles and windstorms, which are currently considered as main disturbance agents in the region. Most notable changes in the forest composition in relation to the disturbance events occur during the last 100 year period and it can be speculated that the multiple stressors of intensified human impact and increasing temperatures may decrease the resilience of these forests against disturbances.

O024

TOWARDS AN INTEGRATED UNDERSTANDING OF MONTANE SPRUCE FOREST DISTURBANCE DYNAMICS IN CENTRAL EUROPE

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The montane spruce forest ecosystem located in the Tatra Mountains, central Europe is of high ecological and economic importance yet, the spruce dominated forest is highly susceptible to windstorms, pathogens, and fire disturbance. An unprecedented windstorm in 2004; Bora Alžbeta destroyed an area of 12,000 ha of forest spanning >30 km. Subsequent decades of re-occurring bark beetle outbreaks, wildfires and less severe windstorms has left a highly-disturbed, semi-natural forest ecosystem requiring management interventions including widespread logging.

Palaeoecology can inform forest managers on long-term processes including forest resilience and recovery rates. While dendroecology can offer *in situ*, annual disturbance history for recent centuries, sedimentary palaeoecology and geochemistry can reconstruct millennial regional disturbance dynamics, resilience and recover rates. Here we present forest disturbance dynamics data from both dendroecology (Holeksa et al. 2016; Janda et al. 2017) and new sedimentary palaeoecology records. Dendroecology analysis from over 250 plots were analysed for tree-growth release and tree-recruitment, to reconstruct both regional and localised disturbance history of the high and low Tatra Mountains during the last 200 years. A series of 5 small forest hollows located within the region of the dendroecology plots were independently dated (C-14, Pb-210) and analysed for pollen, charcoal, macrofossils (flora and fauna), and geochemistry.

The sedimentary records range between 1,000 – 3,000 BP. There is clear evidence of anthropogenic cultivation present consistently from approximately 500 BP, indicating a history of human activity within the region. Macroscopic charcoal data suggests that fires have been more frequent than previously suggested. The dominance of spruce varies between 10 > 50% across all sites suggesting shifting vegetation abundance driven by natural and anthropogenic disturbance dynamics. The relative shifts in dominant disturbance regimes, forest resilience and recovery are presented for both dendroecology and sedimentary data.

O025

SILURIAN ACRITARCHS AND PRASINOPHYTE ALGAE FROM THE SUBSURFACE OF SAUDI ARABIA

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Acritarchs and prasinophyte algae are key components of palynofloras in the Silurian Qalibah and Tawil formations of Saudi Arabia. More than 200 species have been identified in 15 Saudi Aramco wells. Restudy of graptolites in the Qusaiba Member (Qalibah Formation; Llandovery-Wenlock), resulted in revision of previous age assignments of the chitinozoan and acritarch zonations in this unit. Additional data come from the younger Sharawra Member (Wenlock), and from the marine marginal facies of the Tawil Formation (Ludlow-Přídolí). Zone 1, early Rhuddanian in age, encompassing the "Hot Shale" interval, is poorly diversified, but occurrence of *Dorsenidium polorum* allows comparison with palynofloras from the Medina Group of Western New-York (USA). Zone 2 (middle Rhuddanian) marks a general increase in acritarch diversity, especially netromorph acritarchs. First Appearance Datums (FAD) of *Eupoikilofusa saetosa*, *Neoveryhachium carminae constricta* and *Sol radians* mark the base of Zone 2, while its top is defined by the FAD of *Disparifusa horrida* and *Multiplicisphaeridium circumscriptum*. These two species characterize Zone 3 of late Rhuddanian to mid-Aeronian age, which is equivalent to the *Angochitina qusaibaensis* Chitinozoan Zone. Malformed (teratological) acritarchs characteristically occur in Zone 3. Acritarch Zone 4 is characterized by the inception of *Dactylofusa* species and of *Crassiangulina variacornuta*. This association, known from many paleo-continents, is very valuable for correlation of upper Aeronian to lower Telychian strata. Additional important species of Zone 4 are *Antruejadina grotesca*, *Cymbosphaeridium armatum*, *Domasia elongata/trispinosa* morphotypes, and *Pteroverricatus zonocylindrus*. Zone 5 is equivalent to the *Angochitina macclurei* Chitinozoan Zone of early Telychian age, and includes *Anomaloplaisium johnsium*, *Baltisphaeridium diabolicum*, *Geron guerillerus*, *Multiplicisphaeridium breviculum*, *Visbysphaera* spp. and *Veryhachium owensii.* In the upper Qusaiba Member, middle-late Telychian in age, a shallowing trend is evidenced by a decrease in acritarch diversity, occurrence of abnormal acritarchs and "opportunistic" elements, and precocious occurrence of *Ovnia desertica*. Zone 6, described from the uppermost Qusaiba or basal Sharawra Member (Sheinwoodian, early Wenlock), is defined by the FAD of *Arkonia nova*, *Buedingiisphaeridium incertum*, *Leprotolypa gordonense*, *Ovnia uahabita*, and *Tyrannus giganteus*. In the uppermost Sharawra member Member and in the Tawil Formation, fresh water influx is supported by the presence of coenobial forms of possible hydrodyctyacean algae, such as *Deflandrastum* spp., *Kahfia arabica* and *Proteolobus cylindrus.* Zone 6 also includes *Perforella perforata, Triangulina alargada, Multiplicisphaerdidum malum and Quadraditum incisum.* Finally, Zone 7, occurring through the Tawil Formation (middle Přídolí), features *Cepillum puercospinoides*, *Hemibaltisphaeridium dedosmuertosi*, *Visbysphaera bonita* and *V. jardinae* as important index species

O026

SILURAIN DISPERSED SPORE ASSEMBLAGES FROM THE ARABIAN PLATE: A SYNTHESIS

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Silurian dispersed spore assemblages from the Arabian Plate have been described from the Qalibah and Tawil formations. The Ordovician-Silurian boundary is difficult to locate due to the complicated stratigraphy (with downcutting, glacial tillite infill etc.) and extensive palynomorph reworking associated with the Hirnantian glaciation. However, rich Llandovery and Wenlock-Ludlow spore assemblages have been described from the marine deposits of the Qalibah Formation including its two members, Qusaiba Member and Sharawra. Spores are currently poorly documented from the overlying continental deposits from the lower part of the Tawil Formation, but sparse assemblages recovered from cuttings samples indicate a Ludlow to Pridoli age. However, exceptionally rich and well preserved mid Pridoli spore assemblages have been described from marginal marine deposits from a marine intercalation higher in the Tawil Formation. Nonetheless, the exact location of the Silurian-Devonian boundary within the Tawil Formation has yet to be precisely pinpointed. The Silurian spore assemblages from the Arabian Plate show significant differences to those from beyond Gondwana highlighting the extent of palaeophytogeographical differentiation and hence problems of intercontinental correlation of Silurian spores. This can be quantitatively demonstrated by statistical analysis of these differences using coefficient of similarity (CS) and Jaccard Index (JI) analyses. Rather surprisingly, despite extensive intercontinental differences in taxon composition, measures of spore disparity are remarkably similar.

O027

DEVONIAN PALYNOLOGY OF SAUDI ARABIA: REVIEW AND SYNTHESIS

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In Saudi Arabia, exposed Devonian rocks are known only from their type sections in the northwest (Nafud Basin) and in the southwest (Wajid outcrop), adjacent to the Precambrian Arabian Shield. Most of the Devonian deposits, which comprises the upper Tawil, Jauf and most of the Jubah formations, occur in subsurface, not only in the northwest but also in eastern Saudi Arabia. Some exploration wells have penetrated up to 2,300 ft of Devonian section throughout eastern Saudi Arabia and more than 5,000 ft in the centre of the Nafud Basin. Although the Devonian is seemingly conformable with the overlying Mississippian section, its upper boundary is often eroded by either the pre-Khuff or pre-Unayzah (Permo-Carboniferous) unconformities in eastern Saudi Arabia, particularly on structural highs. Whereas in the Nafud Basin, it may be truncated by the Early Cretaceous pre-Wasia Unconformity.

The Saudi Arabian Devonian succession was generally deposited in a continental to shallow marine depositional systems in which substantial siliciclastic-dominated deposits accumulated, in essentially broad transgressive-regressive cycles. These are: a retrogradational cycle (fining-upward) encompassing the Early Devonian Tawil and Jauf formations, followed by a progradational cycle (coarsening-upward) through much of the Middle-Late Devonian Jubah Formation. The terrestrially dominated paleoenvironments of the upper Tawil, Jauf and Jubah formations provide a record of the rapid evolution of Devonian land plants in the form of their dispersed miospores. Thus, these palynomorphs are the chief biostratigraphic tool to age date and correlate these deposits. Acritarchs and chitinozoans are often absent or generally less abundant although they do occur in some specific levels.

A dozen manuscripts on Saudi Arabian Devonian palynology have been published since 1967 but from a restricted number of wells. Despite numerous endemic species, the Devonian spore assemblages were often compared to standard Euramerican zonations with little to moderate success. Due to the absence, or scarcity, of several key species, these zonations are not always easily applicable to Saudi biostratigraphy. The progressive homogenization of the vegetation, which took place during the Middle and Late Devonian, make international correlations more reliable for these levels. Thanks to extensive amounts of material and data from Devonian sections, the current operational palynozonation developed by Saudi Aramco palynologists is robust. It consists of nine palynozones combined with numerous palynological events. Although palynomorph distribution and abundance vary both stratigraphically and regionally, it nevertheless has proven to be an invaluable tool in providing stratigraphic control for hydrocarbon exploration and development.

O028

MISSISSIPPIAN PALYNOLOGY OF SAUDI ARABIA: REVIEW AND SYNTHESIS

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The Mississippian (Tournaisian to Serpukhovian) succession is not exposed in Saudi Arabia and therefore our understanding of this succession is entirely dependent on subsurface data. Sediments of this age occur only in the Arabian Gulf and in the Nafud Basin in northern Saudi Arabia. The Mississippian is usually missing due to significant truncation by the Hercynian Unconformity, at the base of the Unayzah Group in central Saudi Arabia or by the Early Cretaceous pre-Wasia Unconformity in the north. This succession comprises the uppermost part of the Jubah Formation and the entire Berwath Formation. The basal part of the Berwath Formation rests more or less conformable on the underlying Jubah Formation in the Arabian Gulf but the two formations are separated by a regional unconformity and seismic reflector in the Nafud Basin that shows angularity adjacent to Hercynian structural highs.

The Mississippian succession was deposited in very shallow marine and marginal marine coastal plain environments. This wide coastal plain was periodically inundated when sea level rose, and the argillaceous dolomitic limestones and dolomites were deposited. It comprises, at the base, a series of early-middle Tournaisian clastic sediments of the uppermost part of the Jubah Formation, followed by late Tournaisian to early Visean dark grey mudstones of the lower Berwath Formation. The upper Berwath Formation (late Visean to Serpukhovian) is consistently more silt- and sand-prone, with dolomitic intercalations but pertaining a shallow marine setting. Palynofloras suggest a warm humid paleoclimate, with persistent marine influence throughout the succession.

Although many wells penetrated this succession and were palynologically studied, Ar'ar-1, ABSF-29, and ST-8 and 667-44 were the only wells from which palynological assemblages were published. The Mississippian assemblages are dominated by miospores. Most of these are diverse and well preserved but correlation with other areas is tenuous. Indeed, previous attempts to date and correlate Saudi Arabian assemblages mainly utilized zonal schemes erected in Australia, Libya, and the Amazonas Basin, northern Brazil, but with unsatisfactory results. This is due to the infrequent occurrence of several of the zonal index species. Therefore, a new zonal scheme has been erected for the Arabian Plate based on core data, in parallel to the five operational palynozones already used in-house by Saudi Aramco palynologists for the Mississippian succession.

O029

PALYNOLOGY OF PENNSYLVANIAN TO PERMIAN SUCCESSIONS IN SAUDI ARABIA (JUWAYL, NUAYYIM AND KHUFF FORMATIONS)

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Palynology has provided important chronostratigraphic, paleoenvironmental and paleoclimatic controls in the development of the current understanding of depositional architecture, sedimentary facies and regional stratigraphic relationships within the highly variable and complex reservoir units of the Pennsylvanian to Permian succession on the Arabian Peninsula.

The Unayzah Group, comprising the Juwayl and Nuayyim formations, ranges in age from Early Pennsylvanian (Bashkirian) to Early Permian (Artinskian/?Kungurian), and is bound by significant tectonically driven surfaces, the Hercynian Unconformity at the base and Pre-Khuff Unconformity at the top. The Juwayl Formation encompasses a range of depositional facies associated with fluvio-glacial and glacio-lacustrine processes, in response to glacial advance and retreat. The Nuayyim Formation also encompasses a range of depositional facies associated with a post-glacial succession.

The Khuff Formation (Middle Permian-Early Triassic) reflects an overall marine transgression, following the initial phase of rifting associated with opening of Neotethys. Basal Khuff Clastics Member comprising coarse clastic fluvial sediments and overbank paleosols, occur from the base of the Middle Permian (Roadian-Wordian) and followed by thin transgressive tidally influenced shallow marine sandstones, shales and limestones. The latter are deposited progressively later (Wordian-Capitanian) from southeast to northwest and signify the diachronous nature of Basal Khuff Clastics and the transition to dominant limestone deposition throughout the remainder of the Khuff Formation.

Late Paleozoic palynostratigraphy of the Arabian Peninsula was developing in Oman from the mid 1980's with several zonations published. Pioneering palynological studies of the succession in Saudi Arabia were from the early 1990's, but no zonation was published. In early 2000's the first correlations between Saudi Arabia and Oman defined a series of semi-regional palynozones and palynosubzones for the late Moscovian-Capitanian. In parallel, and based on subsurface samples from exploration wells, an operational palynozonation was developed specifically for Saudi Arabia comprising seven palynozones and eight palynosubzones, and spanning the Bashkirian to Changhsingian.

These assemblage zones and subzones reflect a complex interplay of paleoclimate and paleogeography, resulting from the impact of both latitudinal and altitudinal controls on megafloral communities. Recognition of occasional chronostratigraphically significant palynomorphs enable broad correlation with global standards, but precise age assignments are still debated, particularly around the Carboniferous-Permian transition. Clear evidence of phytopaleogeographic provincialism adds to the challenge of fully understanding the palynostratigraphy of the Arabian Peninsula. Nevertheless, the palynozonation developed provides a robust stratigraphic framework, and demonstrates apparent diachroneity of transition from glacial to deglacial and deglacial to post-glacial successions.

O030

POLLEN EDNA METABARCODING FROM ICE CORES AS A TOOL FOR RECONSTRUCTING PLANT BIODIVERSITY DYNAMICS. A CASE STUDY FROM THE LARGEST AND DEEPEST SOUTHERN ALPS GLACIER: ADAMELLO, ITALY.

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DNA obtained from environmental samples (eDNA) is an important source of biological information and eDNA metabarcoding is an emerging approach for reconstructing biodiversity changes through space and time. Past eDNA can be retrieved from many different sources such as ice cores, permafrost, terrestrial and lake sediments, caves, speleothems, etc.

To this end, Alpine glaciers can be viewed as precious climate and biological archives, located in the proximity of areas that are facing dramatic land use and climatic changes since the last decades. Due to the good preservation of pollen DNA in the ice and the detailed stratigraphy, they offer a unique opportunity to test the potential of eDNA metabarcoding approach, specifically aimed at investigating plant biodiversity dynamics in adjacent and surrounding areas.

Despite the obvious power of this emerging molecular approach, several caveats associated with the eDNA metabarcoding workflow need to be considered: false positives due to contaminations, false negatives resulting from primer biases, errors due to cross-contamination and chimaera sequences. Moreover primer choice, that affects taxonomic coverage and resolution, the need of complete reference databases, as well as difficult interpretation of results relative to the nature and spatial scale of eDNA represent other critical issues.

We first present and discuss different eDNA metabarcoding approaches (e.g. PCR-based sequencing vs PCR-free sequence-capture enrichment), together with their main advantages, limitations and challenges.

Second, we show the preliminary results from CALICE (CALibrating Biodiversity from Glacier ICE), a three-years research project aimed at estimating plant biodiversity changes through the last decades in the Adamello glacier catchment area. Adamello is the largest, 16.4 km^2, and deepest, 270 m, Italian glacier whose catchment area, mainly lying in the Po valley in Northern Italy, is characterized by strong anthropogenic pressure.

Our results, referring to a 10 m section extracted from the glacier at a depth of 45-35 m, demonstrate that ice cores provide a valuable source of pollen eDNA, allowing taxonomic identification at the species level. We couple eDNA data with classical high resolution morphology-based palynological analyses to provide complementary taxonomical information on the original vegetation as well an annual/seasonal timescale for the core. Our contribution will highlight the potential of integrating a molecular and morphology-based approach to encourage further studies.

O031

USING STABLE ISOTOPE ECOLOGY OF HISTORICAL *THUJA* (CUPRESSACEAE) SPECIMENS AS A TOOL TO IDENTIFY CARBON SOURCES IN DEEP TIME

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The isotopic composition of atmospheric carbon dioxide ($\delta^{13}C_{atm}$) has not been constant over geologic time due to changes in atmospheric CO_2 sources, but past fluctuations are poorly constrained. $\delta^{13}C_{atm}$ has changed rapidly since the start of the Industrial Revolution as a result of fossil fuel combustion, providing a natural experiment to test potential proxies for $\delta^{13}C_{atm}$. Here we use stable isotope biogeochemistry to track this change with herbarium and modern leaf specimens (1806 – present) of two evergreen gymnosperms in family Cupressaceae, Northern white cedar (*Thuja occidentalis*) and Pacific red cedar (*Thuja plicata*). *Thuja* has little intraspecific isotopic variation, spans a range of precipitation and temperature conditions in North America, and has a fossil record dating back into the Late Cretaceous. Thus, the results from historical herbarium samples of *Thuja* can be applied to *Thuja* fossils up to ~71 million years old to reconstruct $\delta^{13}C_{atm}$ at the time. Stable carbon isotope ($\delta^{13}C_{leaf}$) compositions were measured for historical leaf samples of North American *Thuja* (n=137) using a Picarro Cavity Ring-Down Spectroscope at the University of Michigan. A second parameter (Δ_{leaf}) was calculated by the subtracting $\delta^{13}C_{leaf}$ from $\delta^{13}C_{atm}$ values at the time the plant was growing that were derived from direct and interpolated measurements. Δ_{leaf} reflects the deviation of a tree's ^{13}C fractionation from the moving (as a result of the burning of fossil fuels, i.e. the Suess Effect) atmospheric baseline. $\delta^{13}C_{leaf}$ values ranged from -21.9 to -28.8‰ and were more negative with decreased $\delta^{13}C_{atm}$, demonstrating that *Thuja* is a potentially useful recorder of the paleo-atmosphere composition on both historic and potentially longer time scales. Δ_{leaf} values were nearly constant (mean: 18.11‰ ± 1.14‰) indicating that carbon isotope fractionation of these evergreen gymnosperms has not been affected by climate variables over the period of Industrialization. The consistency within this genus supports its potential use as a paleoclimate indicator across a broad range of (paleo-)environments. The linear relationship between *Thuja* $\delta^{13}C_{leaf}$ and $\delta^{13}C_{atm}$ was applied to compressed leaf fossils from the Cretaceous, Eocene, and Oligocene to estimate $\delta^{13}C_{atm}$; results showed the same relative differences from each other as values found by Tipple et al. (2010) using foraminifera. Thus, *Thuja* $\delta^{13}C_{leaf}$ values provide a reasonable additional proxy for paleo-$\delta^{13}C_{atm}$ and can help us to consider potential geologic sources of pCO_2.

Tipple, B. J., et al. (2010). *Paleoceanography*, *25*(3): PA3202.

O032

CHEMICAL CLASSIFICATION OF GRASS POLLEN: A NEW TOOL FOR PALYNOLOGISTS AND ARCHAEOLOGISTS TO STUDY CROP DOMESTICATION

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The grass family (Poaceae) is one of the most economically important plant groups in the world today. In particular many major food crops, including rice, wheat, maize, rye, barley, oats and millet, are grasses that were domesticated from wild progenitors over the course of the Holocene. Archaeological evidence has provided key information on domestication pathways of different grass lineages through time and space. However the most abundant empirical archive of floral change – the pollen record – has so far been underused for reconstructing grass domestication patterns, because of the challenges of classifying grass pollen grains based on their morphology alone. Here we test the potential of a novel approach for pollen classification based on the chemical signature of the pollen grains, measured using Fourier Transform infrared (FTIR) microspectroscopy. Using a dataset of eight domesticated and wild grass species, we demonstrate a 95% classification success rate on training data, and an 80% classification success rate on validation data. This result shows that FTIR spectroscopy can provide enhanced taxonomic resolution for palynological studies, and further information on the spread of crop domestication and agriculture over the last 10000 years.

O034

PALAEOECOLOGICAL RECONSTRUCTION OF HIGH-MOUNTAIN PEAT BOG COMMUNITIES BASED ON CLASSICAL AND MOLECULAR METHODS: A COMPARATIVE SYNTHESIS.

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Peat bogs located in high mountains are suitable systems to study environmental responses to climate variability. With the aim of investigating environmental changes in high mountain ecosystems during the Holocene in relation to climate forcings, we performed a multi-proxy palaeoecological reconstruction based on two sediment cores from Bassa Nera, a lentic system located close to the montane–subalpine ecotone in the Central Pyrenees. Using non-molecular analyses of pollen, plant macroremains, charcoal, chemical elements and loss-on-ignition at centennial to decadal resolution, we reconstructed the vegetation and lacustrine dynamics during the last 10,000 years. A montane pollen ratio was also used as a palaeoecological indicator of altitudinal shifts in high mountain vegetation. In order to compare the information from classical palaeoecological methods to the one that can be retrieved from molecular methods based on DNA sequencing, we also performed a metabarcoding study using universal 18S and COI markers to assess the molecular eukaryotic biodiversity at five sedimentary depths and reconstruct the palaeoecological communities recovered from ancient sedimentary DNA. Pollen results showed upward shifts of deciduous forest and its presence in Bassa Nera from the onset of the Holocene until 4200 cal yr BP, when it was replaced by coniferous taxa. The montane ratio showed a link between vegetation and North Atlantic influence, while changes in *Sphagnum* macroremains and aquatic taxa allowed description of local ontogenic changes from the initial pond to the present peatland. We successfully amplified ancient DNA with both universal markers from the five sedimentary samples (from 140 to 10200 cal yr BP). Even though 18S could amplify a broader group of organisms, the taxonomic resolution was lower than that obtained from COI, and typically reached the family or genus levels. Results from ancient sedimentary DNA do not entirely overlap with the reconstruction based on pollen and macroremains, and the combination of both reconstructions reveals more detailed information. This first molecular approach has allowed to prove that the diversity of past eukaryotic peat bog communities can be assessed using universal metabarcoding markers and opens the way for more detailed reconstructions.

O035

USING THREE-DIMENSIONAL SHAPE ANALYSIS OF PHYTOLITHS TO TEST THE TAXONOMIC AFFINITIES OF GRASS FOSSILS FROM THE LATE CRETACEOUS LAMETA FORMATION, CENTRAL INDIA

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The origin and early diversification of grasses (Poaceae) have remained largely unknown, in large part because of the poor fossil record of the clade. Sparse fossilized grass pollen has suggested that grasses had evolved by the Paleocene, if not the Late Cretaceous. However, because of the relatively uniform morphology of pollen within the grasses, the taxonomic affinities of these fossils have not been further resolved. Cuticle and attached grass phytoliths extracted from dinosaur coprolites and paleosols from the Maastrichtian Lameta Formation in Central India described in the last 15 years have allowed more detailed assessments of the timing of grass evolution and added to our understanding of paleoenvironments during the early stages of Deccan volcanism. Based on the mapping of qualitative anatomical traits across the Poaceae, phytolith morphotypes from this assemblage were assigned tentatively to the Bambusoideae, Oyzoideae, Puelioideae, Pooideae and PACMAD lineages. Subsequent phylogenetic analysis placed two of these morphotypes in the Oryzeae tribe. The diversity of phytolith forms and the classification of some to the tribal level suggested that major diversification of the family had already occurred by the end of the Cretaceous and that the family was substantially older than previously estimated. The phylogenetic placement of these Maastrichtian phytolith morphotypes—and the consequences for the timing of grass evolution—have been met with scepticism among grass systematists, primarily because a family-wide and statistically-robust analysis of three-dimensional (3D) phytolith shapes has not yet been completed. To address these concerns, we developed new methods to image and quantify the complete 3D surface of isolated phytoliths, resulting in a digital reference collection of 3D phytoliths spanning the Poaceae. The 3D surface representations provide a high degree of shape detail and are suitable for geometric morphometrics, virtual animations and 3D printing. This reference collection enables us to classify fossil phytoliths into clades with a greater degree of precision and using multiple quantitative methods, including 3D morphometric and machine learning computer vision algorithms. We will report on a new quantitative analysis of the phytolith morphotypes described from the Lameta Formation based on their 3D shape. We use the results to refine our taxonomic and ecological understanding of the grasses that existed in India at the end of the Cretaceous, and of the timing of the early evolution of grasses as a whole.

O036

RE-INVESTIGATION OF CONIFER OVULATE CONES FROM THE MAASTRICHTIAN-DANIAN DECCAN INTERTRAPPEAN BEDS OF INDIA

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The Deccan Intertrappean Beds of India preserve a terrestrial flora with 3D anatomy, spanning both a globally significant event – the Cretaceous-Paleogene Boundary – and a time when India was geographically isolated. As such the flora has much potential to expand our understanding of phylogenetic and biogeographic relationships among plants. While much attention has been paid to the angiosperms, which comprise the majority of species diversity preserved here, other major plant groups are also represented and need to be considered for a holistic reconstruction of the assemblage. Conifers in the Deccan Intertrappean Beds are represented by wood, ovules, ovulate cones, and pollen cones primarily assigned to Araucariaceae or Podocarpaceae but also some to Taxaceae or incertae sedis. Wood is the most widely distributed, being found at six localities, in contrast to cones, which have only been recovered from two localities. Here, we re-evaluate the fossil conifer ovulate cones that have been described in order to assess their morphology and structure. Five taxa have been recognized to date: *Mohgaostrobus, Harrisostrobus, Takliostrobus, Pityostrobus*, and *Indostrobus*. The first two come from the Mohgaonkalan locality, and the other three from the Takli locality. Some are known only from a single specimen (e.g., *Harrisostrobus, Indostrobus*) while others are represented by multiple specimens (e.g., *Takliostrobus*). Proposed affinities are with Araucariaceae or Pinaceae. We used X-ray micro-computed tomography to non-destructively visualize the three-dimensional structure of these specimens, supplemented by investigation of available peels and slides. One specimen of *Takliostrobus* was found to represent an infructescence of the monocot *Viracarpon*. *Takliostrobus* and *Indostrobus* cones have two seeds per cone-scale complex and other features suggesting affinities to Pinaceae, and we interpret them as likely being congeneric. They do show some differences, such as seed shape. In contrast, "*Pityostrobus*" *crassitesta*, *Mohgaostrobus*, and *Harrisostrobus* all have >5 seeds per cone-scale complex. These seeds are tightly clustered together and appear to have relatively thick sclerotic seed coats, two chambers, and are surrounded by a parenchymatous tissue, possibly a wing. Seeds are much more elongate than wide. These seeds are unlike any other gymnosperm seeds we have been able to find to date, and thus these conifers may represent an extinct, possibly endemic, lineage, and further work is underway to determine their affinities. These investigations suggest the taxonomy of the cones needs to revised and affinities re-considered, and demonstrate there was some small diversity of conifers in India at the Cretaceous-Paleogene boundary.

O037

PALYNOFLORA ACROSS LATE CRETACEOUS-EARLY PALEOGENE IN DECCAN VOLCANIC ASSOCIATED SEDIMENTS OF INDIA

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Deccan volcanic eruptions are considered as one of the causes for mass extinction at the Cretaceous-Paleogene (K-Pg) boundary. The age and duration of the Deccan basalt eruptions are a matter of debate however, based on radiometric dating this volcanism is considered to have spanned 68-62 Ma. To understand the impact of volcanism on flora, palynological study of the Deccan volcanic associated infratrappean (Lameta Formation) and successive intertrappean beds was carried out. Palynological study of fluvio-lacustrine Lameta sediments show presence of palynomorphs of gymnosperms -*Araucariacites*, *Classopollis*, *Cycadopites* and *Podocarpidites* angiosperms- *Cretacaeiporites*, *Compositoipollenites* and *Graminidites*. However onset of volcanism changed the floral assemblage and in the intertrappean lake/pond new palynoassemblage characterized by presence of dominantly pteridophytes - *Azolla*, *Crybelosporites, Gabonisporis* and *Triporoletes*, angiosperms- *Aquilapollenites*, *Tricolpites*, *Triporopollenites*, *Farabeipollis* and *Normapolles* group pollen appeared. At higher stratigraphic level close to the K-Pg boundary and in early Danian palynomorph recovery is poor which could be due to increased volcanic activity. Later on, during waning phase of volcanic activity good palynofloral assemblage is recorded from the intertrappean beds.

The recovered palynotaxa from Late Cretaceous–Early Paleocene Deccan volcanic associated sediments are grouped into five major groups 1) Palynotaxa characteristic of Late Cretaceous (Maastrichtian) and could not cross the K-Pg boundary- *Azolla cretacea* (Salviniaceae), *Crybelosporites* (*Regnellidium*), *Triporoletes reticulatus, Farabeipollis* spp., *Scollardia conferta*, 2) Taxa remained unaffected during Cretaceous-Paleogene transition and continued in Paleocene sediments- *Spinizonocolpites echinatus* (*Nypa*, Arecaceae), *Proxapertites* spp. *Aquilapollenites bengalensis, Gabonisporis vigourouxii* and Normapolles Group pollen 3) Taxa which appeared in Danian and continues in Paleogene- *Neocouperipollis* (Arecaceae), *Haloragacidites* (Haloragaceae), *Intrareticulites brevis* (?Gunneraceae), *Palmaepollenites eocenicus, Longapertites vaneendenburgii* (Arecaceae), *Striatricolporites striatus* 4) Taxa exclusively confined to Paleocene (Danian)- *Gabonisporis intertrappean*, *Mulleripollis bolpurensis, Rhombipollis sp.* 5) Taxa which became extinct after Danian- *Gabonisporis vigourouxii* (?Marseliaceae), *Aquilapollenites* spp., and Normapolles Group pollen. Overall palynological data from Deccan volcanic associated sediments shows that the palynofloral changes across Cretaceous- Paleogene were gradual and commensurate with onset of Deccan volcanism.

The present study also recorded pollen grains of family Malvaceae from the Late Cretaceous (Maastrichtian) intertrappean sediments of central India. This is the oldest record of palynomorphs associated with this family and suggests its 'out of India' migration. Deccan volcanism induced climatic and environmental changes in Late Cretaceous-Early Paleocene as well as latitudinal position of Indian subcontinent were probably responsible for the evolution and extinction of many angiosperm families on this subcontinent.

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O039

FINE-TUNING THE POSITION OF PALEOBOTANICAL LOCALITIES WITHIN THE DECCAN BASALT STRATIGRAPHY OF INDIA RELATIVE TO THE K-PG BOUNDARY

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A series of paleobotanically productive cherts has been known for many years along the eastern part of the main Deccan basalt province and farther east into the Mandla basalt province. While generally recognized as Maastrichtian to Paleocene in age, it has been a challenge to correlate the cherts of intertrappean beds with the better exposed and more thoroughly investigated basalt sequence of the Western Ghats. We now place these fossil localities more precisely with respect to the K-T boundary using contextual information derived from mapping together with chemostratigraphic and paleomagnetic analysis of locally bounding over-and underlying flows. The following sites on the eastern main plateau are placed within Chron 29r: Takli and Mahurzari near Nagpur; Nawargaon, Shibla, and Murai Patan. Chron 29r spans from the Maastrichtian to Paleocene and includes the K-Pg boundary, currently placed at 66.0 MA. In the Mandla province, the classic Mohgaonkalan chert also appears to fall in Chron 29r, while petrified wood sites more to the east such as Ghughua and Parapani are apparently higher in the succession, Chron 29n or younger, and likely Paleocene. Without more precise radiometric dates, we currently rely on the palynological correlations to derive relative timings to one another and to the K-Pg boundary. Palynologically, the Mahurzari and Murai Patan localities appear to be Maastrichtian, and the floristic similarity among megafossils suggests that the Shibla, Takli, and Ambabogholi sites may be nearly contemporaneous and also late Maastrichtian.

O040

GLOBAL VEGETATION AND TERRESTRIAL CLIMATE OF THE SUPER-WARM EARLY EOCENE

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The early Eocene (56 – 47.8 Ma) contains the warmest climate in the Cenozoic era characterised by high atmospheric pCO_2 concentrations with the peak of warmth recognised as the early Eocene climatic optimum (EECO; ca. 53 – 50 Ma). The EECO is an ideal geological time period for assessing the ability of state-of-the-art climate model projections to capture warmth in polar regions where known geological evidence (e.g. trees in the Arctic) supports warming. However, the lack of comprehensive quantitative geological data in periods of super warmth for data-model comparisons are limited. Here we present a new global synthesis of vegetation and terrestrial climate reconstruction covering the EECO and an extended dataset spanning the early Eocene (360 localities). Quantitative climate estimates are derived from palaeobotanical records using various techniques including the Coexistence Approach (CA) and Bioclimatic analysis for palynological data and Climate-Leaf Analysis Multivariate Program (CLAMP) and Leaf Margin Analysis (LMA) for the fossil leaf record. Using a multi-proxy approach and various methodologies will allow for an extensive assessment of uncertainties surrounding our climate reconstructions. This dataset will aid in the evaluation of the baseline climate models from the Super-Warm Early Eocene Temperatures (SWEET) project.

O041

OLIGOCENE CLIMATE SIGNALS AND FORCINGS IN EURASIA REVEALED BY PLANT MACROFOSSIL AND MODELLING RESULTS

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The Oligocene represents a transitional time period from a warm climate to a cooler climate that is more representative of the modern climate; yet, a general view of the continental climate pattern and forcings are still lacking. Different proxies and models show striking disparities, especially in the mid-high latitudes, requiring validation of Oligocene climate reconstruction in order to understand the large-scale processes that drive the observed climate changes. Here, we compiled 149 macrofossil floras in the mid-high latitudes of Eurasia, then quantitatively reconstructed the Oligocene climate using Coexistence Approach (CA) and combined previous published paleoclimate data across the continent. The climate of the Oligocene in Eurasia mid-high latitudes was mainly dominated by a humid subtropical climate (warm and humid summer, and relatively mild or cool winters). Mean annual temperature (MAT) ranged between 5.4 °C and 25.5 °C with mean annual precipitation (MAP) ranging from 338 to 2453 mm. No significant climate changes were observed between the Early and the Late Oligocene, however, three regions (Europe, central Eurasia and eastern Asia) indicate different climatic regimes, with a generally warmer and wetter climate in Europe and a colder and drier climate in central Eurasia. The climate anomalies between the Oligocene and present indicate that geographic changes (e.g. retreat of the Paratethys Sea) played an important role in shaping the climate pattern of Eurasia. By comparing the fossil data to a range of different HadCM3L model simulations of the Oligocene with differing boundary conditions (e.g. CO_2, topography), we demonstrate similar large-scale climate spatial patterns between models and fossil data, however, models generated much higher simulated temperature seasonality (lower simulated winter temperatures, but higher simulated summer temperatures) in Eurasia. When focusing on the mean annual temperature, analysis shows that simulations with 560 and 1120 ppmv CO_2, and Robertsons paleogeographic data matched better with fossil data. These results provide some constraints that should be considered for future paleoclimate modeling.

O042

THE ROLE OF GRASSES IN THE EAST AFRICAN VEGETATION ACROSS THE OLIGOCENE-MIOCENE BOUNDARY: NEW RESULTS AND PERSPECTIVES FROM PLANT SILICA (PHYTOLITH) ANALYSES AT CHILGA AND MUSH VALLEY (ETHIOPIA).

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The savanna biome today occupies about ~50% of the African land surface. Savannas are characterized by a continuous grass substratum, which feeds zebras, rhinos, and a variety of bovids, all known for possessing tooth morphologies adapted to withstanding abrasive grasses and soil particles ingested with them. We seek to document the history of savannas (i.e., the ecological dominance of grasses, in the family Poaceae) in the geologic past of Africa, in order to elucidate factors that may have triggered their expansion in this part of the world. On other continents, pollen and grass silica remains (phytoliths) indicate that the first grass-dominated habitats appeared asynchronously during the Oligocene to Pliocene epochs. In East Africa, paleobotanical data (macrofossils, palynofloras), functional morphology of fossil faunas, and carbon isotope ratios suggest that grass-dominated vegetation started expanding at the expense of forests during the early/mid-Miocene, but likely not until 21 Ma. To test this hypothesis, we have conducted phytolith analyses in several deposits dated from before grass-dominated vegetation is thought to have spread in East Africa. Specifically, we present results from study of phytolith assemblages from terrestrial paleosols and sediments of the Chilga (ca 28-27 Ma) and Mush Valley (ca 22 Ma) localities on the Ethiopian Plateau.

Our new phytolith data support the existence of forested environments at these two localities, regardless of their different taxonomic composition. Diagnostic grass silica bodies make up <25% of the total sum of diagnostic phytoliths, indicating that grasses were present, but not abundant in vegetation overall. Among these grasses, C_3 taxa related to forest-dwelling early diverging lineages and/or the Bambusoideae subfamily were present in grass communities at Chilga, whereas these same lineages seemed to have co-existed with representatives of the largely open-habitat Pooideae subfamily at Mush. Furthermore, high percentages of non-diagnostic grass phytoliths (silicified bulliform cells, trichomes) in a few samples from both localities suggest variations in evapotranspiration or water supply either caused by seasonal climate and/or by repeated or persistent underwater conditions. Our results add to the previous interpretation of Chilga and Mush as forests by showing that grasses existed in the understory or in forest openings. More broadly, our results are consistent with the hypothesis that significant grass expansion in East African environments did not take place until after 21.73 Ma.

O043

ASSESSING PLIOCENE PALAEOCLIMATE VARIABILITY WITH HIGH-RESOLUTION POLLEN RECORDS FROM THE ASIAN INTERIOR (KUNLUN PASS AND QAIDAM BASIN)

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The climate of East Asia is mainly controlled by the East Asian Monsoon providing warm and wet air in summer, and cold and dry air in winter. Westerly winds transport comparatively small amounts of precipitation from the Atlantic Ocean and Mediterranean Sea into the Asian interior. 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. Here we present new palaeoreconstructions of Pliocene vegetation from two sites located at the northwestern limit of the EASM (Kunlun Pass and Qaidam Basin) to further understand climate changes in a warmer world with elevated atmospheric pCO_2.

Preliminary palynological results from the Kunlun Pass Basin (4.3 – 1.4 Ma) show that the vegetation was characterised by semi-desert shrubs, especially Chenopodiaceae and *Artemisia* spp., *whereas* grasses (Poaceae, Cyperaceae) occurred in minor amounts. Long-term climate cooling during the Pliocene and Pleistocene is characterised by a decline in coniferous and broadleaved trees and a strong increase in Cyperaceae at the Pliocene/Pleistocene transition. Although the timing of Kunlun Pass uplift is still being debated, our data suggests that modern altitudinal differences between the Kunlun Pass Basin and Qaidam Basin (~ 2000m) have already been established during the Pliocene which is consistent with oxygen isotope data from the same record.

The high-resolution pollen record from the western Qaidam Basin (SG-1b drilling site) shows that between 3.495 – 3.011 Ma the vegetation was dominated by xerophytic shrubland with Chenopodiaceae and *Artemisia* spp. Spectral analysis on *Artemisia*/Chenopodiaceae ratios suggests that palaeoprecipitation in the Qaidam Basin are controlled by 41ka and possibly 100ka orbital cycles.

At the top and bottom of the record, Poaceae and Cyperaceae amounts are consistently higher which might indicate palaeo lake level changes. Higher amounts of grasses reflect an increased input from locally growing plants surrounding the lake, and can therefore be attributed to intervals of smaller lake size. Our palynological interpretation will be complemented with data from XRF core scanning and C/N element analysis, that will provide independent information about the evolution of the lake system. First result of XRF core scanning reveal that sedimentation alternates between intervals of predominantly terrigeneous input and phases of high authigenic carbonate formation most likely caused by lake level fluctuations.

O044

QUANTITATIVE RECONSTRUCTIONS OF PALAEOCLIMATE IN ALTAI-SAYAN MOUNTAIN AREA (SOUTH SIBERIA, RUSSIA) IN LATE GLACIAL AND HOLOCENE TIME BASED ON POLLEN DATA FROM FIVE SECTIONS OF PEAT AND LAKE SEDIMENTS.

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Quantitative palaeoclimatic reconstructions with help of transfer functions based on a series of author's modern spore-pollen spectra (120 samples) and corresponding climatic parameters compiled by the method of multivariate statistical analysis are performed. The quantitative palaeoreconstructions of the annual amount of precipitation, temperature of January, and temperature of July were reconstructed by calibrating of palaeopolanological data on the optimums of the transfer functions. In general, three global models of the post-glacial climate were clearly manifested in the Altai-Sayan region: the climate of the Late Glacial age, the Middle Holocene and the late Holocene climates. In the Late Glacial period in the Altai and in the Western Sayans mountains, the climate as a whole was dry and more continental than the modern one. The January temperatures were lower than today's, and the July temperatures were higher than today's. At the same time, in the western regions the climate, in comparison with the modern, was much more continental than in the eastern regions. The climate of the early and middle Holocene has been reconstructed significantly wetter than the late glacial and more humid than the modern one. Changes in the temperature regime resulted in a significant decrease in the continentality of the climate due to an increase in winter temperatures and a certain decrease in summer temperatures in the western and southern regions of the Altai. But, in the eastern regions, the reconstruction showed an increase in both winter and summer temperatures. In the late Holocene after 6000 cal. years ago, another global climate change occurred, which, however, affected only the southern and eastern regions of the Altai-Sayan mountainous region. Thus, the quantitative paleoclimatic reconstructions of Late Glacial and Holocene based on the palynological data of the Altai-Sayan mountain area revealed the heterogeneity of climatic changes in different regions of the area, manifested in a change in the abundance of precipitation, the January and July temperature characteristics, and the seasonal contrast of the climate, especially in the western regions. The research was supported by Russian Foundation for Basic Researches No. 17-55-5202MHT_a. and Budget Research Theme of IMCES SB RAS.

O045

DISPERSED GYMNOSPERM CUTICLES FROM THE MUKHEIRIS FORMATION OF JORDAN – A GLIMPSE INTO ANISIAN (MIDDLE TRIASSIC) PHYTODIVERSITY AT THE NORTHERN MARGIN OF GONDWANA

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During recent field work in the Triassic of Jordan a new fossil meso-flora consisting of dispersed cuticles has been discovered from the Upper Member of the Middle Triassic (late Anisian) Mukheiris Formation at the eastern rim of the Dead Sea. The assemblage consists of a number of different types of cuticles which can all be attributed to gymnosperms, mostly without a more specific taxonomic assignment. Very few of these cuticles can be assigned to conifers (of assumed Voltziaceaen affinity) whereas cuticles (tentatively) assigned to the corystospermalean taxon *Dicroidium* are fairly abundant. Our data suggest that during the late Anisian, like in other regions worldwide, the gymnosperm component of the land vegetation in the Near-East region was rather diverse. Compared to the palynoflora, which yielded various types of conifer pollen, and pollen of other gymnosperm groups, as well as spores of ferns and lycophytes, the meso-flora is obviously lacking a number of plant groups present in the source vegetation. It is likely that the differences can be explained by taphonomic biases. The data from cuticles and palynology together prove, that either regional terrestrial ecosystems had already recovered, at least to some extent, from the devastating effects of the end-Permian ecological crisis or that these effects were less devastating at least in this region as assumed by previous studies.

O046

A NEW RECORD OF BENNETTITALEAN FLOWER *(WILLIAMSONIA)* FROM THE LOWER JURASSIC IN SOUTHERN CHINA

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The Order Bennettitales (Cycadopsida) represents a highly interesting group of extinct gymnosperms with a widespread distribution and a high diversity during the Mesozoic interval all around the world. The bennettitaleans have a high evolutionary significance due to their peculiar reproductive structures and vegetative organs, due to their diversity as well as due to their palaeoecology and palaeogeographic distribution. Their systematic position is still disputed, with suggested affinities with the Gnetales or considered as an independent clade. Peculiar reproductive structures with radial symetry, such as *Williamsonia*, *Wielandiella* and *Williamsoniella* et al., hint them as possible ancestors for a part of the angiosperm polyphyletic group. Diverse foliage records belonging to Bennettitales are widely documented in China. However, the bennettitalean reproductive structures have been very rarely reported. Here we report a new species of *Williamsonia* Carruthers 1870, *W. shenzheniana* sp. nov. from the Lower Jurassic terrestrial Jinji Formation in Shuitousha, Guangdong Province, China. The new species is represented by an ellipsoidal ovuliferous cone surrounded by two whorls of smooth and elliptical-elongated bracts. *Williamsonia shenzheniana* sp. nov. has systematic affinities with *W. gigas* Carruthers 1870, *W. banatica* (Krasser) Popa 2014, *W. latecostata* (Krasser) Popa 2014, among other *Williamsonia* species, and it is associated with *Otozamites hsiangchiensis* Sze 1949 foliage and branches, hinting to belonging to the same whole plant. *Williamsonia shenzheniana* is the first species belonging to genus *Williamsonia* reported from China.

O047

LATE TRIASSIC FLORAL DIVERSITY OF THE CENTRAL TRANSANTARCTIC MOUNTAINS: RE-INVESTIGATING THE FOSSIL FLORA OF "ALFIE'S ELBOW".

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Due to Antarctica's paleogeographic location at the center of Gondwana, fossil deposits from this continent are an essential data source for understanding the paleobiogeographic history and diversification of Mesozoic southern floras. Moreover, the Transantarctic Mountains contain some of the most extensive and continuous terrestrial Triassic sequences in the Southern Hemisphere. This provides an excellent opportunity to examine Gondwanan plant diversity, especially at high/polar latitudes during the early Mesozoic. The 2017-2018 University of Kansas field expedition to the Shackleton Glacier area resulted in the recovery of abundant Late Triassic plants from the "Alfie's Elbow" locality (upper Fremouw to lower Falla formations). Exposures of this locality consists of a near 42 m thick sequence of floodplain and fluvial channel deposits. Furthermore, this site has been recognized as one of the most diverse Triassic compression assemblages known in the Transantarctic Mountains and has been reported to consist of *Neocalamites*, *Umkomasia uniramia*, *Pteruchus*, several types of *Dicroidium*, *Telemachus*, *Heidiphyllum*, *Taeniopteris*, and other taxa. In this reinvestigation of the "Alfie's Elbow" flora, we reexamined previously collected material and provide a preliminary report on the fossils recovered from the 2017-2018 field season. Thus far, an additional diversity of ferns and seed plants that has not been previously recognized at this locality or in some cases, Antarctica have been identified. Newly recognized ferns are represented by leaves of *Clathopteris* and *Cladophlebis*. The expanded gymnosperm assemblage includes a conifer leafy stem consisting of helically arranged needle-shaped leaves with decurrent leaf bases, ginkgophyte leaves of *Baiera* and ?*Ginkgophyllum* as well as potentially *Hamshawvia* ovulate structures. Furthermore, a gigantopterid-like seed-bearing leaf, a cycadophyte ovulate cone, peltasperm ovulate organs and leaves of *Matatiella* and *Dejerseya* have been identified. In addition, silicified peat with charcoalified material was also recovered from the locality. Overall, the newly recognized taxa at this site furthers our understanding of the floras that existed at high polar latitudes just before the end of the Triassic.

O048

CUTICULAR ANALYSIS OF MUMMIFIED PLANT REMAINS FROM THE TRIASSIC LEIGH CREEK COAL MEASURES OF SOUTH AUSTRALIA

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We present the first results of an ongoing study of well-preserved plant remains from the Triassic Leigh Creek Coal Measures (Carnian–Norian) of the Telford Basin (South Australia). Occurrences of plant fossils in the area have been known for more than a century. Recently ceased open-pit mining operations have created extensive exposures of plant-bearing deposits, which enabled documentation and collection of exceptionally well preserved plant-fossil assemblages from 14 stratigraphic levels. Most remarkable are intercalations of paper shales that are composed of mass accumulations of mummified plant remains. Since the host deposits are unconsolidated to weakly lithified mudrocks, we are testing novel methods of palaeobotanical bulk maceration for retrieval of large volumes of macro- and mesofossils via various treatments using, e.g., a combination of heated hexametaphosphate solution and Schulze's reagent. The vast majority of plant fossils recovered so far belong to the iconic Triassic seed-fern frond *Dicroidium* (Corystospermales/Umkomasiales); additional taxa include net-veined leaf fragments of *Rochipteris* (Petriellales) and as yet unidentified pteridosperm frond fragments. Various additional plant parts are also represented with unusual cellular preservation, including possible fragments of stem cortices. Also remarkable is that the *Dicroidium* cuticles host diverse evidence for plant-insect interactions, including various types of external feeding damage, leaf mining and possible galling. We are confident that on-going large-scale maceration and preparation of these highly promising host deposits may eventually yield reproductive organs that might offer insights into the reproductive biology of Umkomasiales and Petriellales. Future studies of this exceptional material will: (1) enable precise taxonomic assessment of the systematic composition of the various plant assemblages; (2) allow detailed interpretation of the biology and autecology of the constituting plant taxa; and (3) facilitate analysis of the abundance and diversity of plant-insect interactions in Late Triassic Gondwanan coal-forest ecosystems.

O049

THE PALAEOECOLOGICAL IMPLICATIONS OF MEGAHERBIVORE COPROLITES FROM THE UPPER TRIASSIC OF POLAND.

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Rich assemblages of plant-bearing coprolites from the Upper Triassic of Poland provide surprising perspectives on the feeding behaviour of their producer, large megaherbivore. Their content, size and shape linked them with the elephant-sized, toothless and plant-eating dicynodonts (Therapsida), which bones are abundant in the same strata where coprolites were collected. The study of coprolites content revealed the presence of numerous plant remains, which are preserved in the carbon-rich and pyrite-mineralised coprolite matrix. Tree coprolite specimens were investigated in details. Each coprolite contained wood fragments, higher plant cuticles, disaggregated higher plant tracheids and black amorphous organic particles. Plant cuticles are the most numerous component of the coprolites. Cuticles, even that fragmentary, are well preserved, lacking a distinctive trace of degradation that could be associated with digestive processes. Unfortunately, most of the cuticles are incomplete and many of the important features are lost. Nevertheless, cuticle specimens were divided into morphotypes on the basis of combination of cuticle characters that are consider to be of taxonomical importance among gymnosperms: the differentiation of adaxial and abaxial leaf side, the presence of stomata, the orientation, arrangement and density of stomata, the shape and structure of stomata complex, the shape and arrangement of other epidermal cells, the ornamentation of epidermal cells and the presence of trichomes. Cuticles of leaves are the most represented. The clearly dominating group are conifers, including the most abundant *Brachyphyllum* and *Pagiophyllum*-type of foliage. But whether plants from which they originate where a dietetic choice of dicynodont remains uncertain. The most important cuticles, from the nutritious point of view or favoured by the animal could get dissolved in the gastrointestinal system, and only the most resistant cuticles remained. Still, the plant content of the coprolites can provide valuable information about the local vegetation and can be a supplementary data to the high-resolution reconstruction of the ancient plant assemblages.

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O050

PERSISTENCE OF TEMPERATE TREES DURING THE LATE GLACIAL PERIOD IN THE CENTRAL-EASTERN EUROPE (CZECHIA AND SLOVAKIA).

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Presence of temperate tree pollen during the late Glacial in the profiles from the northern part of the Pannonian Basin and Western Carpathians has been traditionally interpreted as long-distance pollen dispersal from the southern regions. During the last decade, new palaeoecological data from Pannonian/Western Carpathian border indicated, that temperate trees (*Corylus, Ulmus, Quercus, Fraxinus*) occurred mostly in wet, base-rich hilly regions and their foothills during the late Glacial and early Holocene. New pollen records also confirmed an exceptionally early Holocene expansion of temperate trees into this region, which was supported by finds of macro-remains of oak. However, the direct proof (macro-remains, wood, charcoals) of the presence of temperate trees during the late Glacial period was still missing.

In 2012, an organic sediment was recovered near Lanžhot located in the northern part of the Pannonian Basin (S Czechia). Radiocarbon dating of basal layers (14670 cal. BP) confirmed Allerød age (GI 1) of the peat accumulation. Continual higher abundances of temperate tree pollen in the lower layers suggest, that glacial forest steppe contained patches of temperate trees. Surprisingly, in the layer dated to Allerød period, the piece of *Quercus* wood radiocarbon dated to 14.533 cal BP was found.

We conclude that the increase of temperature and precipitation recorded at around 14700 cal. BP (Pleniglacial/late Glacial transition) triggered a spread of temperate forest species. Such an early occurrence of temperate trees implies either their early late-glacial immigration to this region from their glacial refugia situated elsewhere in the Pannonian Basin, where their survival was recorded during the Last Glacial Maximum. Or another explanation is an existence of their close cryptic glacial refugia in the study region, where temperate trees may have persisted in the micro-climatically favorable places with higher humidity (e.g. along rivers and streams).

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O051

NEOLITHIC LANDSCAPE AND PEOPLE IN CENTRAL EUROPE, UNIQUE PERSPECTIVE FROM PALEOBOTANICAL EVIDENCE OF TWO WOODEN WELL IN CZECH REPUBLIC

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Spreading of first farmers after 7500 BP in central Europe is most important change of then society, so called Neolithic revolution or transition. This is a last period of relatively small human impact on nature and it cold be considered like beginning of culture landscape.

Sources of present day knowledge are mainly natural paleobotanical profiles out side of human settlement and archeobotanical evidence of Neolithic objects. This dry evidence is scare and poor for archeobotanical evidence. We are analyzing of Uničov well (central Moravia) and Velim well (central Bohemia) excavated 2 years ago. Both objects are dendrochronological dated to time span 5278 to 5104 BC.

Wet infill of Neolithic wells has advantage of rich and good preserve and quantity of plant remains like natural sites, but it has detail record of terrestrial species and cultivated plants. Human subsistence wasn't based only on crop plantation, but picking of broad spectra of wild plants. Abandoned well was used for flax processing for textile production. It gives small percentage of cereal pollen in well record under 5 % directly in Neolithic village. Together with other proxies like beetle remains, or mollusk it can allow reconstruct surrounding landscape and their ecology. Existing evidence confirm surviving of species of open habitats, including steppe elements from Early Holocene, or to even Late Glacial. It was probably supported endured relatively dry continental climate. It allows continues existing of open habitats species through Middle Holocene, co called Holocene forest optimum and formation of synantropic plant communities and open habitats communities, which existence is condition of human activity. Dry grassland represents present day refugia of Early Holocene species.

The research is supported by Czech grant agency project number GA17-11711S.

O052

LOOKING AT THE BYZANTINE RESILIENCE USING PALAEOCLIMATE PROXIES: POLLEN, GEOCHEMISTRY AND BIOMARKERS ANALYSES FROM LAKE DOJRAN (GREECE, F.Y.R. OF MACEDONIA)

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Existing evidence suggests that the Byzantine society, with all its complexity, successfully adapted to a variety of environmental conditions. The ways in which societal and environmental processes influenced each other remained surprisingly varied. In order to gain a better understanding of how these processes interacted, we compare palaeoenvironmental archive with historical data within the framework of an independent research group recently created at the Max Planck Institute for the Science of Human History in Jena.

Lake Dojran (Greece and FYROM) (1), within the historical region of Macedonia, provided a valuable record of Holocene environmental change, including several proxies, such as pollen, NPPs, geochemistry and biomarkers data. In this paper, we focus on the last 2000 years of palaeoenvironmental data supported by a robust age-depth model to present a case study that offers an insight into our approach.

A reduction in arboreal vegetation occurred since the first century BC (ca. 2000 yr BP), when the new Roman province of Macedonia was integrated into the Roman market economy. Among trees, *Pinus* is the most affected taxon probably due to a selection in timber cutting by Romans. For almost 600 years the environment, that was already undergoing a transition to drier conditions, was clearly impacted as attested by the presence of cultivated and synanthorpic taxa. Then, at the end of the Roman period, arboreal vegetation expanded again. Between 600 and 850 AD (ca. 1400-1250 yr BP), the Plague of Justinian, the collapse of the Roman order in the Balkans and the coming of the Slavs (2) seem not impacting on pollen data but could be related to some changes in biomarkers. After a hiatus in cereal cultivation, probably related to the Black Death, cereal pollen achieves its highest values in the 16th and 17th c. (ca. 500-250 yr BP), which is clearly related to the role that Ottoman Macedonia played for the provision of the Ottoman armies and the city of Constantinople, as well as in the international grain trade in the Mediterranean.

(1) Masi, A., Francke, A., Pepe, C., Thienemann, M., Wagner, B., Sadori, L., 2017. Vegetation history and palaeoclimate at Lake Dojran (FYROM/Greece) during the Late Glacial and Holocene, Climate of the Past Discussion, https://doi.org/10.5194/cp-2017-114.

(2) Izdebski A, Koloch G, Słoczyński T., 2015. Exploring Byzantine and Ottoman economic history with the use of palynological data: a quantitative approach. Jahrbuch der österreichischen Byzantinistik, 65, 67–110.

O053

AGROPASTORAL ACTIVITIES IN LAKE MAHARLOU BASIN (SW IRAN), DURING THE ACHAEMENID PERSIAN EMPIRE, WITH INTRODUCTION OF NEW ARBORICULTURAL ELEMENTS

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This study presents the results of a high-resolution palynological investigation on a 355 cm core from the seasonal saline Lake Maharlou in Zagros Mountains, SW Iran. The studied section of the core (185 – 230 cm: 1700-2800 cal BP) spans the period before, during and after the development and flowering of the Achaemenid Empire, the largest imperial state in the Antiquity. Consequently, we place emphasis on the role of man in modifying the natural vegetation and landscapes of the area. The new pollen record reveals a novel arboricultural element i.e. *Punica granatum* (Pomegranate) to the formerly evidenced cultivated trees (*Olea, Juglans, Platanus, Vitis*). The very under-represented pollen representation of pomegranate implies the existence of extensive cultivation of the tree in the study area and may show compatibility with historical documents about the value of pomegranate twigs in Zoroastrian rituals and ceremonies. Furthermore, the pollen record depicts a significant increase in agriculture, arboriculture and urbanization in this period. Besides, the hypothesis of massive cypress tree cultivation in 'Persian gardens' and urban areas, is supported by the continuous curve of Cupressaceae which co-varies with other cultivated trees i.e *Platanus*. Therefore, this suggest the importance of cypress tree in Ancient Iran. Furthermore, general increase in cultivated and native trees such as *Fraxinus*, *Ulmus*, *Pinus* and *Salix* also suggests that these trees were also cultivated in Ancient Persia. The considerable presence of agriculture-related pollen types such as *Rumex*, *Plantago lanceolata*-type beside Cerealia-*type* and dung-related fungi, as pastoral indicators and obvious changes in drought and disturbance indicators such as *Euphorbia* and *Prosopis farcta*-type pollen can be interpreted as continuous extensive human activities in the area. Evidence of aridity and decrease in extent of water-logged area around the Lake is revealed by slight increase of desert shrubs such as *Zygophyllum*, *Ephedra* and *Tamarix* along with decrease in *Riella* spores and natural vegetation species such as *Pistacia* and *Amygdalus*.

O054

CARPOLOGICAL ANALYSIS OF THE SANTI QUATTRO CORONATI PIT (ROME, ITALY)

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Results of archaeobotanical analyses carried out in a Renaissance pit situated in the Santi Quattro Coronati complex in Rome are presented. The study focuses on carpological remains, preserved through mummification by desiccation. The complex, first attested in 499 AD, underwent a long series of transformations and additions over the course of the centuries. In the 13th century it was divided between a monastery filiated with the Umbrian Abbey of Sassovivo and a vast palace, meant to host the cardinals. Starting from 1564 the complex hosted the Conservatory of the Orphan Girls, run by Augustinian Nuns, who still guard the complex.

The area under analysis derives from the partial closure of the staircase of a Carolingian tower set in the eastern side of the complex. This was used as a disposal pit during the 16th and 17th centuries, in correspondence of the occupation by the court of the cardinals and perhaps the Orphan Girls. The tower was emptied during excavations carried out in 1996, leading to the identification of five stratigraphic units. After a rough selection of the remains, the rest of the sediment was deposited in sealed buckets and stored in the context of retrieval.

Part of the material belonging to stratigraphic units 3 and 4 was selected for analysis. The material was first sieved and later handpicked. Approximately 6,000 well-preserved fragments of seeds and fruits, belonging to 35 taxa, mostly identified at species level and attributed to 18 different plant families were identified. The main findings are represented by *Pastinaca sativa* (parsnip), *Juglans regia* (walnut) and *Vitis vinifera* (grape). Except for a few wild species, the plant assemblage is rich in diet remains. These include cereals, such as oat (*Avena fatua/sterilis*), legumes, with a prevalence of faba beans (*Vicia faba* – var. *major*), fruits, including peaches (*Prunus persica*), walnuts (*Juglans regia*), pomegranates (*Punica granatum*), as well as spices, including fennel (*Foeniculum vulgare*). A peculiar finding is constituted by New World species.

The good state of conservation of the botanical remains in the Santi Quattro Coronati pit, as well as their abundance, are correlated to the favourable thermo-hygrometric conditions found in the tower. The botanical assemblage confirms the high social status of the inhabitants of the complex at the time of usage of the pit.

The presence of New World species identifies the complex as one of the first landmarks where goods were brought to from the newly discovered continent.

O055

SNAPSHOTS FROM THE LIFE AND TIMES OF WILLIAM G. CHALONER FRS – PIONEERING PALAEOBOTANIST AND PALYNOLOGIST.

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Bill Chaloner was one of the world's leading authorities on the study of plant fossils. His work was wide-ranging and he developed new approaches in his research, including integrating data from plant macrofossils with those from fossil pollen and spores and helping to develop the field of palaeopalynology. He studied Paleozoic lycopsids, especially their *in situ* spores, and the ecology of ancient plants using both macrofossils and palynology. In studies on fossil plants and the palaeoatmosphere he used charcoal as an indicator of ancient oxygen levels and stomatal density/index as a measure of ancient CO_2 levels. He used growth rings in fossil wood as a paleoclimate indicator and also studied the chemistry of fossil plants. Bill was Secretary of IOP until 1977 and President from 1981-1987 and he served for many years on various committees dealing with nomenclature of plant fossils including on the editorial committee for the Sydney, Berlin and Tokyo codes. Bill possessed a polymath-like grasp of diverse subject matter, and with a clear and critical mind he was especially adept at distilling disparate information into a coherent and understandable whole. As an engaging, accomplished and enthusiastic teacher and mentor he inspired countless young scientists, including through five decades of service to several colleges of the University of London. In this poster we present images from Bill's life and career as part of the symposium "Celebrating the career of Bill Chaloner: from palaeoproxies to nomenclatural issues".

O056

THE FAMILY CHALONERIACEAE 35 YEARS ON, AND ITS INFLUENCE ON ISOETALEAN LYCOPSID PHYLOGENY.

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Pigg and Rothwell published a paper in 1979 on a lycopsid plant base from the Late Pennsylvanian coal-ball flora near Steubenville, Ohio, USA that showed anatomical structures comparable to those of modern Isoetes. Features of this "woody lycopsid" included secondary cortical tissues and bilateral symmetry of the plant base. Pigg and Rothwell completed the study of this coal-ball plant in 1983 and named it *Chaloneria cormosa*, in honor of Bill Chaloner for his contributions to the understanding of lycopsid cones with in situ spores. The whole-plant reconstruction of *Chaloneria* provided the basis for the family Chaloneriaceae. Diagnostic features include sparsely-branched to unbranched stems, a cormose plant base, typical Paleozoic lycopsid vegetative anatomy and bisporangiate fertile zones. In situ spores were the auriculate *Valvi(si) sporites auritus* megaspores with megagametophytes and pseudosaccate *Endosporites globosa* microspores, often found still in their tetrads. In 1985, the authors expanded their study of *Chaloneria* to detail primary and secondary cortical tissues that formed the anatomical basis for certain decortication patterns such as *Asolanus* and *Knorria*. Gensel and Pigg (2010) used this model, plus those presented by Chaloner and collaborators, to understand the cortical tissues and stem surface patterns of the Mississippian lycopsid from the Price Formation of Virginia, USA, previously assigned to *Lepidodendropsis*. This plant is thought to have produced *Protostigmaria*-like plant bases with multiple lobes that appear to develop in a manner similar to the plant bases of modern *Isoetes*.

This presentation will detail with the significance of *Chaloneria cormosa* to our current understanding of taxa assigned to the isoetealean clade, especially noting the importance of understanding cortical features in multiple preservation modes for delimiting leaf base/cushion features, traditionally an important taxonomic character. We are currently investigating additional taxonomic features of reproductive structures and spore types of the Mississippian Price Formation plant. Considering Devonian-Carboniferous tree lycopsids, various combinations of vegetative and/or reproductive features occur. Given that, how important is strobilus type and spore morphology in delimiting lycopsids? In particular, are spore types diagnostic of lineages? If so, how do they correlate with the other characters and ecology- again "channeling Bill Chaloner".

O057

THREE ASPECTS OF THE CHALONERESQUE APPROACH.

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"Chaloneresque" was a term coined by Al Traverse in 1993, around the time when Bill Chaloner retired as Head of School of Life Sciences, RHUL, Egham, England.Traverse described Bill as "a man for all subjects"; like a latter day Alexander von Humboldt.Below are three aspects of Bill's work and ideas that, to me, illustrate his polymathic approach to fossil botany.

1) At the University of Reading, Bill submitted a rather short thesis for his Ph.D. in botany in 1953;he illustrated it with camera lucida drawings and photographs of Carboniferous lycopsid cones and their spores.That thesis was typical of how Bill went on to combine evidence from more than one source and to present it in diverse pictorial forms. His bar charts showed not only the numbers of spores of varying diameter from certain cones, but Bill used them also to demonstrate the advent of heterospory in the Devonian. Bill used cellulose ethanoate peels in projector slide mounts to teach students palaeobotanical techniques and to illustrate the anatomy of plants permineralized in coal balls.In retirement, he developed his skills as an artist in water colours.

2) In his *magnum opus,* (Lycophyte part of *Traite de paleobotanique*, 1967) Bill skillfully surveyed hundreds of lycopsid taxa that had been named since 1820.His critical approach drew together evidence from adpressions, casts, molds, permineralizations and *sporae dispersae* with respect to international nomenclatural conventions and established taxonomic groupings. Bill's treatments of the Carboniferous lycopsids *Lepidocarpon, Sigillariostrobus* and *Mazocarpon* are typical of how he combined palaeobotanical and palynological lines of evidence to produce a coherent systematic framework.

3)Bill was a master of communication with students, with fellow palaeobotanists and in the political realm too. He encountered monarchs and ministers of state, demonstrating the value of biological collections and importance of scientific research. He served as a trustee at the Royal Botanic Gardens, Kew, England, there drawing the plant kingdom to the attention of senior managers of the British Broadcasting Corporation. Bill was concerned that changes in information technology should preserve and convey information on fossil plants to future generations as effectively as have printed words and pictures over the past centuries.

O058

STUDIES OF FOSSIL AND MODERN SPORE WALL SPOROPOLLENINS USING FTIR.

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The pollen and spore (sporomorphs) fossil record is one of the most complete archives available to palaeobiologists in terms of temporal and spatial range. This record is a function of both their production and their preservation potential. This enhanced preservation is due to the exine of both spores and pollen being composed of the biomacromolecule sporopollenin, which is regarded as one of the most resilient naturally occurring compounds. Twenty six year ago Professor Chaloner and colleagues published a paper (Hemsley AR et al 1992 *Annals of Botany* **69** 545–549) that used ^{13}C solid state NMR to probe the composition of sporopollenin. In this publication they state:

"The capacity of NMR to demonstrate variation in structure, in what is clearly a heterogeneous class of organic macromolecules, suggests the possibility that this procedure could be of use in characterizing the sporopollenin of different plant groups. The fact that such material retains its structural integrity in the fossil state further opens up the possibility of our following evolutionary changes through time of this inert biomacromolecules."

This presentation will discuss how our understanding of sporopollenin has developed since the publication of this study. We will focus on two distinct areas of enquiry. Firstly how sporopollenin chemistry can be used as a tools to elucidate taxonomic affiliation of isolated sporomorphs potentially allowing us to address evolutionary questions. Then we will discuss how specific components of sporopollenin are regulated by the environment and how these chemical changes can be used to inform on past climate change. The presentation will conclude with a discussion on how new instrumentation/ technology has the capacity to drive the field forward.

O059

EXPERIMENTALLY GENERATED CHARCOALS: IMPLICATIONS FOR RECOGNITION AND INTERPRETATION OF FOSSIL AND MODERN WILDFIRE CHARCOAL

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Margaret's research career began as RA to Bill Chaloner and Bill was PhD supervisor to both Margaret and Andrew. During our time with Bill we both greatly benefited from experiencing his diverse research approaches. For example, as a RA Margaret worked with Bill studying latex replicas of plant fossils and as a PhD student Andrew worked with Bill feeding spores to locusts. It is with this variety of experimental approaches in mind that we will present here some new results on laboratory experimental heating (charcoal production) of plant material. The new data from study of the experimentally generated charcoals have implications for (i) recognition and identification of charcoal produced during ancient and modern wildfires and (ii) the interpretation of macerals in lignites and coals.

O060

ACRITAX: A NEW ONLINE TAXONOMIC DATABASE OF ACRITARCHS

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Digital technology has not only revolutionised the way we access, store and manipulate data, but also our expectations with regard to undertaking these activities. Anyone can now search for, and hopefully find, information on virtually anything. Students, non-specialist researchers, even expert taxonomists increasingly expect to find answers via the web rather than from traditional monographs. Consequently, there is an increasing need to deliver reliable taxonomic data through the WWW. This absolutely applies to acritarch taxonomy, which, despite having many users in academia and industry, has a notably limited digital footprint.

Acritax is a soon-to-be delivered open access online database of acritarch taxonomy and images, which we have been developing since 2016 using the *mikrotax* taxonomy content management system, developed for the nannotax and pforams@mikrotax websites. It has two components: *Acritax*-JWIP and *Acritax*-main.

Acritax-JWIP comprises a scanned version of the entire acritarch catalogue from the *John Williams Index of Palaeopalynology* (JWIP), housed in the Natural History Museum, London. There are currently 1,392 acritarch genera and 11,435 acritarch species recorded in *Acritax*-JWIP, where each genus and species has one or more cards, each individually scanned. Information found on the cards includes generic diagnoses, emendations, all recorded occurrences of species, their ages, locations and abbreviated references. It is intended that species diagnoses and emendations will also be added. This system, therefore, enables you to check the description, occurrence, synonymy, age range and biogeographical distribution of any acritarch.

Acritax-main is the second component of *Acritax* and is intended as a documentation of working taxonomy. It fulfills the following functions:

1. Provides an up-to-date alphabetical listing of species we regard as useful, their current and alternative combinations, and links to the JWIP entries for those taxa.

2. Provides for each accepted taxon images, notes on morphology, taxonomic concepts, temporal/biogeographical distributions, and bibliographic references.

3. Provides search tools to find records on taxa using name, synonym(s), authorship, age, location, geology, Downie Classification and/or morphological characters.

The mikrotax system provides the framework for this work, including tools for handling large image collections with metadata, and plotting range charts and even evolutionary trees. Populating *Acritax* is at an early stage but we plan to have a useful level of coverage for Cambrian acritarchs by the time of the meeting. This talk is intended to introduce *Acritax*, outline our progress and plans and, especially, to stimulate suggestions and feedback from potential users.

O061

REVISION OF THE CAMBRIAN–ORDOVICIAN ACRITARCH GENUS *VULCANISPHAERA* DEUNFF, 1961 - ECOPHENOTYPISM IN EARLY PALAEOZOIC ACRITARCHS?

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While their biological affinities remain enigmatic (by definition), many Palaeozoic acritarchs are considered to represent cysts of organic-walled microphytoplankton. Due to the often purely descriptive approach of many earlier studies, neglecting the palaeoecological context, it can be argued that a large part of the described acritarch taxa are not real biological entities but rather represent different (eco-) phenotypes. In order to better understand their biology and ecology, comparison with various modern groups of phytoplankton can be an appropriate approach. Dinoflagellate cyst morphology is known to vary in response to environmental changes, such as salinity and temperature (e.g. Kokinos & Anderson 1995; Ellegaard 2000). While the effects of changing environmental conditions on Palaeozoic acritarchs have not been systematically documented, assumptions as to a possible relationship between the morphological variability and palaeoecology are obvious in certain cases, such as the Cambro-Ordovician galeate acritarch plexus (Servais et al. 2004). Critical taxonomic revisions taking into account palaeobiological and palaeoecological factors are needed to identify morphological trends in certain acritarchs in response to those factors.

In this new study the Cambrian–Ordovician genus *Vulcanisphaera* Deunff, 1961 is revised and the possible influence of ecological conditions on the morphology is being discussed. In total 32 species had been attributed to the genus. The new study includes an extensive review of the literature and statistical analyses based on morphometric investigation of large populations of *Vulcanisphaera* in material from Algeria and England. It shows clearly that only three species, *V. africana*, *V. capillata*, and *V. simplex*, can be maintained within the genus. We assume that the observed large intraspecific variability might reflect palaeoecological changes, and therefore is pointing towards ecophenotypism.

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O062

PERI-GONDWANAN ORDOVICIAN ACRITARCHS FROM THE LLANOS ORIENTALES BASIN (COLOMBIA, NW SOUTH AMERICA)

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Palaeozoic beds from Colombia have been mainly recorded in outcrops from the Magdalena Valley, the Central Cordillera, the Eastern Cordillera and the Amazonian area. However, the Colombian Llanos Orientales Basin also displays an extensive Palaeozoic sedimentary sequence in its subsurface, especially of Ordovician, Devonian and Carboniferous age (e.g. Dueñas 2001). This sequence has been restudied in recent years from several oil exploration wells. It is overlain by a Cretaceous-Cenozoic siliciclastic sequence, from which an intense hydrocarbon exploration and production activity has been developed.

There are few publications on the precise age and palaeogeography of these Palaeozoic rocks. In the present study the Pluspetrol Paisa-1 well, located in the central part of the basin, is investigated palynologically, in order to determine the age, the palaeoenvironment and the palaeogeography of the sedimentary basin. The lowermost stratigraphic interval of the well (4939-5040'; ~1505-1536 m) is composed of alternating sandstone and black shale beds, from which a well-preserved assemblage of Ordovician acritarchs has been recovered.

The acritarch assemblage contains some diagnostic taxa, including, among others, the genera *Arbusculidium*, *Barakella*, *Coryphidium*, *Dactylofusa, Striatotheca*, and *Veryhachium*, indicating an Early Ordovician age. The presence of a few biostratigraphical index species, such as *Dactyolofusa velifera* or *Coryphidium bohemicum,* points to a (early to middle) Floian (Early Ordovician) age, following the biostratigraphical scheme of Servais et al. (2018).

As the three diagnostic genera (*Arbusculidium*, *Coryphidium*, *Striatotheca*) are present, the assemblage clearly belongs, in terms of palaeobiogeography, to the peri-Gondwanan acritarch province. Our study thus extends the geographical distribution of this province to the north-western part of South America, completing the palaeobiogeographical distribution map of Early-Middle Ordovician acritarchs by Molyneux et al. (2013).

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O063

NEW DATA ON UPPER ORDOVICIAN ACRITARCH ASSEMBLAGES FROM THE KALPIN AREA, NORTHWEST TARIM BASIN, CHINA

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Ordovician outcrops are well exposed in the Kalpin area, northwest Tarim Basin, China, with carbonates, shales, and carbonaceous shales. The Dawangou section, located in Kalpin county, was accepted as the auxiliary section for the Global Boundary Stratotype Section and Point (GSSP) of the base of the Upper Ordovician in the Sargan Formation. Acritarchs of the Dawangou area have been studied in the context of a palynological investigation carried out from some additional sections, aiming for a better understanding of the biostratigraphical significance of acritarchs from this area. Our sections, the West Dawangou, Sishichang and Tierekeawati sections, are nearby the Dawangou section in the Kalpin area. The typical Ordovician sequence in this area in ascending order is composed by the Dawangou, Sargan, Kanling, Qilang, Yingan, and Tierekeawati formations. Our new material comes from the Sargan, Kanling, and Qilang formations. The Sargan Formation represents strata of the uppermost Darriwilian to lowermost Sandbian, the Kanling Formation strata of the lower to middle Sandbian, and the Qilang Formation strata of the upper Sandbian to lower Katian.

The acritarch assemblage from the Sargan Formation is dominated by *Leiosphaeridia* with 16 species assigned to 10 genera, the Kanling Formation is dominated by *Leiosphaeridia*, *Navifusa*, and acanthomorphic forms with 10 genera and 15 species, and the Qilang Formation is dominated by acanthomorphic forms with 28 species attributed to 15 genera.

The acritarch assemblages from the West Dawangou, Sishichang and Tierekeawati sections show a slightly different composition, maybe coming from slightly different facies.

The diversity and compositional changes of the acritarch assemblages, combined with the sedimentological evidence, suggests a transgressive sequence from the Sargan Formation to the Qilang Formation.

O064

ULTRASTRUCTURAL STUDY CONFIRMS THAT, YES, *MOYERIA* IS A EUGLENOID.

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The fossil excavates are currently limited to one problematic lower Paleozoic acritarch genus, *Moyeria* Thusu 1973. In the 1980s, this organic-walled microfossil was hypothesized to be a euglenoid, based primarily on its unique wall morphology, which is characterized by helically-arranged parallel surficial ridges. Using transmission electron microscopy (TEM), we have now characterized the wall ultrastructure of *Moyeria* based on a specimen extracted from the Silurian of Scotland. Originally considered as surface ornament, the helical ridges are now seen to be a series of flattened, interlocking, S-shaped strips, corresponding to well-characterized ultrastructure of some extant euglenid pellicles. Intriguingly, the pellicle strips in *Moyeria* also show a poleward reduction in number, which is characteristic of photosynthetic euglenids today. The unresolved root of the eukaryotic tree based on molecular phylogeny is now thought to lie somewhere between the Opisthokonta and Excavata super-group branches. A paleontological perspective on the excavate lineage now takes on a more significant role, and we are exploring the fossil record of *Moyeria* and other, possibly related palynomorphs, in an effort to recover a Neoproterozoic to Recent record of the Excavata super-group.

O065

THE POWER OF MELISSOPALYNOLOGY: REVIEW AND NEW CHALLENGES

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Melissopalynology has a long history and has become a focus of modern-day palynological research for various important reasons. The initial interest of honey producers in the source and transport of pollen by bees has now expanded considerably, due to growing concerns about the consequences of global warming, about the impacts of pesticides on bee health and their function, about the role of environmental changes and, additionally, about the growth in interest in beekeeping in urban areas.

A careful review of the literature allows us to identify the most drivers of modern melissopalynological studies, which provide a clear understanding of the scope of the field and its main goal. The applications of the method includes, but is not limited to: 1. Geographical and botanical origins of honey, based on pollen analyses; 2. Methods of pollen tracking in the study of honey, including isotopes and amino acid methods; 3. Reconstruction of the evolution/degradation of plant communities, based on the study of pollen from honey; 4. Climatic effects on pollen productivity and its relationship to honey quality; 5. Specification of bee-pollinated plants for specific geographical regions (including urban areas); 6. Developing advanced methods for the identification of pollen in honey. 7. Documentation of agricultural land use changes based on pollen composition of honey.

The most valuable parameter for linking source vegetation with the pollen content of bee honey is the "honey pollen coefficient (HPC)" (Bryant, V. M. and Jones, G. D. 2001). New research shows a strong response of pollination and bee populations to climate change, weather, and environmental pollution, so obviously, the HPC as a universal palynological criterion has to be developed and unified into a larger picture. A new and promising branch of modern melissopalynology is the study of pollen DNA and pollen isotopic signals from honey for bee pollination, with subsequent application to the interpretation of fossil pollen record.

Ultimately, the study of pollen in modern honey provides us a key to understanding the role of pollination by bees in the past and an opportunity to predict future consequences of climate change.

Bryant, V. M. and G. D. Jones (2001). "The r-values of honey: Pollen coefficients." Palynology 25(1): 11-28.

O066

THE ONLINE POLLEN CATALOGUE NETWORK (RCPOL): SUBSIDES TO MELISSOPALYNOLOGY STUDIES

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Conceived in 2009 and created in 2013 RCPol's main objective is to promote interaction among researchers and the integration of data from their pollen collections, herbaria and bee collections. In order to structure RCPol work, researchers and collaborators have organized information on Palynology and trophic interactions between bees and plants, which would be included in the information system. During project development, different computing tools were developed and provided on RCPol website (www.rcpol.org.br), comprising interactive keys with multiple inputs for species identification. Those tools were developed in partnership with researchers and collaborators from Escola Politécnica (USP) and other Brazilian and foreign institutions that act on Palynology, floral biology, pollination, plant taxonomy, ecology, and trophic interactions. The interactive keys with multiple inputs for species identification may help plant taxonomists, which use floral morphology as one aspect of species identification. Similarly, morphological description of pollen grains may enable plant species identification, since pollen has been used as a natural marker for species grouping in different studies. The RCPol have been important to studies about melissopalynology, which consists in the identification of pollen on bee products allowing its floral and geographical description, with application on quality control of bee products (honey, for instance), identification of plants visited by bees, and studies of trophic ecology of bees. Currently there are four interactive keys for species identification available at the RCPol website: Palynoecology, Palynotaxonomy, Paleopalynology and Spores. Considering the first three interactive keys there are 1,751 specimens included at RCPol. The plant species cover all Brazilian regions and also other countries, including crop species and species used in landscaping. The diets of 22 species of bees were already studied and the interactions established with the plant species were identified through information available in RCPol. We already have the interaction networks between bees and plants available in RCPol and have been used to identify the food sources used by honey bees, stingless bees and solitary bees.The next interactive key is relative to melissopalynology and will be presents information about honey and pollen nutritional value, among other aspects. During the project's first three years 106 partners, among researchers and collaborators from 28 institutions from Brazil and abroad actively participated on the projects structure.

O067

POLLEN DEVELOPMENT ACROSS THE POLLEN LIFECYCLE IN *RUPPIA MARITIMA* (ALISMATIDAE): INSIGHT INTO THE CONSEQUENCES OF THE ECOLOGICAL TRANSITION TO HYDROPHILY.

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Transitions to water-pollination (hydrophily) have been repeatedly accompanied by modifications in pollen development. However, comprehensive investigations of pollen development in hydrophilous plants, particularly that which occurs after pollination, are limited. Investigating the consequences of the transition to hydrophily for the pattern of pollen development in a comparative context will yield information about the lability of the pollen developmental pathway, as well as the functional pollen traits required for successful water-pollination. The objective of this study was to characterize pollen structure and development across the entire pollen lifecycle, from microsporogenesis to fertilization, in the hydrophilous angiosperm *Ruppia maritima*. Field collections and experimental pollinations were conducted, followed by analysis with combined light, scanning electron, and transmission electron microscopy. Anthers and developing pollen grains at the sporogenous, microspore mother cell, tetrad, 'free' microspore, and mature grain stage were documented, as well as all stages of pollen germination and pollen tube development in the carpel.

Divergence in exine development between the proximal and distal walls occurs during the free-microspore stage, resulting in heteropolar pollen grains with a reduced exine on much of the distal surface. There are no major ultrastructure differences in the endexine or intine between the proximal and distal surfaces. On the proximal surface, muri that comprise the reticulum consist of a solid band of sporopollenin, with no infratectal columellae. We show, unequivocally, that a distinct foot layer surrounds the entire microspore. Tapetal cells invade the anther locule before meiosis and this timing supports the close relationship of Ruppiaceae and Cymodoceaea. On stigmas, pollen germination first occurred within 5 minutes after pollination and the majority of pollen grains germinated within 15 minutes. Pollen tubes first entered the ovule 45 minutes after pollination and by 60 minutes after pollination most ovules had been entered.

Modifications to the pollen developmental program in *Ruppia* give rise to traits that are hypothesized to be adaptive for water pollination. Pollen development in *Ruppia* will be compared to what is known from other hydrophilous species, as well as closely-related wind and animal-pollinated species and the role of pollen ontogeny in ecological transitions will be discussed.

O068

LOSS AND RE-GAIN OF POLLEN APERTURES: STEPS TOWARDS OMNIAPERTUATE CONDITION IN AQUATIC BASAL MONOCOTS (ALISMATALES)

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Transition from monosulcate to tricolpate condition was the most important and enigmatic event of evolution of angiosperm pollen in Lower Cretaceous. One possible scenario for this transition is a loss of sulcus followed by gain of colpi, i.e., through the inaperturate condition. Thus it is of great importance to assess the degree of reversibility of the transition to the inaperturate condition in angiosperms using younger evolutionary radiations and to infer possible factors driving de novo origins of the apertures. We use the basal monocot of the order Alismatales as a model to investigate these questions. Tepaloid core Alismatales form a well-supported clade. It holds Aponogetonaceae, Scheuchzeriaceae, Juncaginaceae and Maundiaceae forming four successive members of the grade leading to a monophyletic group that includes Potamogetonaceae and other more specialized aquatics. Pollen is monosulcate in Aponogetonaceae, but inaperturate in Scheuchzeriaceae, Juncaginaceae and Maundiaceae, suggesting a loss of the aperturate condition in the lineage sister to Aponogetonaceae. Potamogetonaceae includes 6 genera, of which 5 have inaperturate pollen. The sixth genus, Althenia s.l., includes two species with omniaperturate and several species with diaperturate pollen. Phylogenetic position of Althenia strongly suggests de novo origin of the aperturate condition. The number and structure of apertures in Althenia differ from those in Aponogeton further supporting this conclusion. Species of Althenia with diaperturate pollen fall in two groups based on structure of sporoderm revealed by scanning and transmission electron microscopy. The first group comprises at least five species, the second group includes A. patentifolia. Fine structure of sporoderm in the apertural region in the first group is similar to the sporoderm along the entire surface of pollen grain in the omniaperturate species A. australis, while the apertural region of A. patentifolia fits the entire sporoderm of the omniaperturate species A. bilocularis. These data suggest that the omniaperturate condition appeared twice in course of evolution of Althenia, each time by expansion of the apertural area onto entire surface of the pollen grain. We speculate that the transition from inaperturate to diaperturate pollen in Potamogetonaceae should be viewed as an evolutionary step towards a complete loss of interapertural type of sporoderm. We use molecular phylogenetic data for testing these hypotheses. The work is supported by Russian Science Foundation (14-14-00250, pollen morphology in 6 species) and RFBR (18-04-00797, evolution).

O069

THE IMPORTANCE OF TREE POLLEN IN SUPPORTING CROP POLLINATORS: POLLEN PREFERENCES AMONG THE BEE SPECIES VISITING APPLE (*MALUS PUMILA*) IN NEW YORK

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Maintaining a diverse and abundant wild bee community is essential for sustainable agricultural pollination, especially in crops in which wild bees are effective pollinators. Many land managers have an economic interest in encouraging healthy wild bee populations, and often to achieve this will plant supplemental floral resources in wildflower strips. In New York apple orchards, wild bees of the mining bee family (Andrenidae) play a critical role as pollinators, but are active early in the spring before most forbs begin to flower. Thus, to better understand which flowering plant species might serve as alternative pollen hosts for the most abundant and effective wild bee species in New York apple orchards, we analyzed the pollen loads carried by 15 wild bee species and one managed bee species (*Apis mellifera*) collected during apple bloom. We identified the pollen grains carried by these bees and found that the majority of alternative pollen hosts for apple visitors are early blooming tree species, including six other tree genera. This may partly explain why the presence of forest fragments is an important predictor of bee abundance and species richness in New York apple orchards.

O070

EOEMBRYOPHYTIC EVOLUTION OF PLANT LIFE: NEW MEGAFOSSIL DATA AND PERSPECTIVES

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The fossil record indicates that vascular plant diversity followed five different but complementary dynamics through the Phanerozoic Eon, the so-called Evolutionary Floras. Those floras reflect major transitions of plant evolution, from the earliest undoubted occurrences of vascular plants in the macrofossil record (tracheophytes; mid-Silurian times, ~430 Ma) through to the current dominance of angiosperms. However, the early establishment of land plants (embryophytes), probably the most critical Earth geobiosphere transition because it triggered the foundations of the current land ecosystems, is much older (mid-Ordovician, ~470 Ma, or earlier). Many questions remain about the initial steps of the greening of the Earth's surface, especially because evidence of these pre-vascular plants is mostly restricted to spores, with very little information on their parent plants. Current spore data suggest that the earliest land plants were small non-vascular bryophyte-like organisms. Spore evidence also suggests that the first radiation of tracheophytes probably occurred during Katian times (mid-Late Ordovician, ~450 Ma). In this communication, we discuss embryophyte macrofossil evidence recently discovered from the Hirnantian Stage (uppermost Ordovician, ~445 Ma) of Poland and its implications. The assemblage includes plant remains consisting of dichotomously branched slender stems with terminal sporangia. Morphologically, the plants are closely comparable to the younger plant macrofossils, including *Cooksonia*-type specimens. This suggests a very low evolutionary rate for basal land plants and a faster dispersal of the earliest Gondwanan floras than expected. Moreover, we found a putative stoma similar to that of *Akdalophyton caradocki*, a Sandbian (early Late Ordovician, ~455 Ma) possible early bryophyte from Kazakhstan. Most importantly, the observed diversity of the reproductive structures found at the Polish locality parallels that seen in the microfossil record, which further supports that existence of diverse Late Ordovician floras. It also suggests that these early floras might have played a major role as a climate driver of the incipient terrestrial biotas. These early, pre-vascular plant floras have previously been referred to as the Eoembryophytic phase of plant evolution and should perhaps be regarded as a sixth Evolutionary Flora.

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O071

ASSESSING THE ROLE OF [O_2] AND [CO_2] IN DRIVING PHYSIOLOGICAL CONVERGENCE/DIVERGENCE AMONG HIGHER PLANTS: IMPLICATIONS FOR PALAEOPHYSIOLOGY AND MACROEVOLUTIONARY PATTERNS.

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The photosynthetic rate (P_n), water use efficiency (WUE) and photosynthetic nitrogen use efficiency (PNUE) are crucial factors in the ecological success of plants and are largely governed by the relative abundances of [O_2] and [CO_2]. Interestingly, a synthetic consideration of the fossil record and models of [O_2] and [CO_2] over the last 500 million years suggests that the timing of major evolutionary 'tipping points' (i.e. when former dominant plant groups are ecologically replaced by others that have newly evolved) between the 3 major reproductive grades of higher plants (i.e. monilophytes, gymnosperms and angiosperms) coincided with significant changes in Earth's atmospheric composition. To assess the impact of atmospheric composition on the photosynthetic physiology of the 3 major groups of higher plants, we carried out 5 highly novel 'miniworld' experiments. Early diverging angiosperm, gymnosperm and monilophyte species were grown under different O_2 and CO_2 concentrations and their responses were assessed using physiological and anatomical methods. Our results showed that the magnitude and, in some cases, the trend of the observed physiological responses differed between the 3 plant groups. Empirical relationships describing the response of all major photosynthetic parameters to changing atmospheric composition were constructed for each group and their Pn, WUE and PNUE were modelled throughout the Phanerozoic. Deep time modelling of palaeo-physiology demonstrates that past changes in the O_2:CO_2 ratio resulted in shifts in the relative competitiveness of angiosperms, gymnosperms and ferns providing insights into the role of atmospheric change in shaping macroevolutionary patterns.

O072

TESTING THE IMPACT OF CHANGING ATMOSPHERIC COMPOSITION ON VASCULAR PLANT REPRODUCTION

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Atmospheric oxygen (O_2) and carbon dioxide (CO_2) concentrations, and O_2:CO_2 ratio, have varied widely throughout Earth history. Both atmospheric O_2 concentration and O_2:CO_2 ratio increased beyond critical threshold levels in the Late Devonian, thus allowing the evolution of seeds, and again in the mid-Cretaceous, allowing the evolution of flowers, resulting in ecological turnover in world vegetation from spore-bearing pteridophytes to seed-bearing gymnosperms and to flower-producing angiosperms. Atmospheric oxygen is essential for aerobic respiration, which fuels reproduction in plants. The purpose of this study was to investigate the role of atmospheric change as a driver of evolutionary and ecological change over the past several million years, specifically by assessing the impact of varying O_2:CO_2 ratios on plant reproductive output. Representatives from two plant groups: pteridophyte (fern) and angiosperm (flower and seed-bearing plants) were grown for six months in Conviron BDW40 plant growth chambers at UCD Programme for Experimental Atmospheres and Climate (PÉAC) facility under a range of O_2:CO_2 treatments: 525:1 Ambient control (20.9% O_2, 380ppm CO_2); 400:1 Low O_2 (16% O_2, 380ppm CO_2); 110:1 High CO_2 (20.9% O_2, 1900ppm CO_2) and 84:1 Low O_2/High CO_2 (16% O_2, 1900ppm CO_2). Gymnosperms were excluded due to the time required to reach sexual maturity. Reproductive output was measured weekly in *Cheilanthes lanosa* (fern), *Saruma henryi* (dicot with early angiosperm lineage), *Brachypodium distachyon* (graminaceous monocot) and *Triticum aestivum* 'Sparrow' (monocot cultivar). Results for all four species confirm that reproduction was higher in the elevated CO_2 treatment than in the ambient control, was highest in the low O_2 treatment (greatest reproductive output), and was lower than ambient control in the low O_2/high CO_2 treatment, regardless of plant phylogeny. Past studies have observed an inverse relationship between O_2:CO_2 ratio and pteridophyte, gymnosperm and angiosperm speciation rate. In contrast, our results show a positive relationship between O_2:CO_2 ratio and reproductive output. The implications of these results in terms of plant evolution and ecological turnover will be discussed.

O073

BRIDGING THE GAP BETWEEN FOSSIL EVIDENCE AND THEORIES IN ANGIOSPERM SYSTEMATICS

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Angiosperms are the most important plant group for the human beings, but little is known about the origin of angiosperms. This situation makes the evolution and systematics of angiosperms tentative. To expel the mystery over the origin of angiosperms, Fu et al. (2018) report a new angiosperm from the Early Jurassic of eastern China, *Nanjinganthus*, based on the information of 284 specimens. *Nanjinganthus* has 4-5 sepals and 4-5 petals arranged along the rim of the cup-formed receptacle. The gynoecium includes a unilocular ovary with an ovarian roof completely enclosing the ovules from the above. The style located on the center of the ovarian roof in *Nanjinganthus* is unique and characterized by its dendroid form. Enclosed ovules/seeds and actinomorphic morphology as well as non-comparability to any known gymnosperms suggest that *Nanjinganthus* is currently the earliest flowers related to angiosperms. The occurrence of inferior ovary with epigynous perianth in *Nanjinganthus* is seen in neither *Magnolia* nor *Amborella*, and thus unexpected by any known theories of angiosperm evolution, suggesting that there is a huge gap between these theories and actual history of angiosperms. Such a discrepancy between fossil evidence and theories requires us to re-think and double check what is wrong, either the fossils are faked or misinterpreted, and thus needing further work, or the theories and their approving are problematic, demanding further modifications. To reach this goal is not an easy task, requiring meticulous examining all evidence from various fields of botany, including but not restricted to palaeobotany, anatomy, morphology, development, and genetics. I share some published data with you and hope you can find your own answer and solution.

O074

PALEOCLIMATE VARIATIONS AND PALAE-CO2 CHANGE DURING THE TOARCIAN (EARLY JURASSIC) BASED ON SOUTH CHINA FLORAS

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The inverse relationship between pCO_2 and the stomatal index of vascular plant have been used widely to estimate ancient levels of CO_2. However, some paleo-CO_2 data show little congruence because they are estimated by different correlative methods, or different fossil plant species and stomatal criteria. Here we first apply three methods (two empirical proxy methods and one a mechanistic method) for single fossil *Ginkgo* species to track and improve the accuracy of pCO_2 during Early Jurassic. Based on this, we also acquired the first curve for paleo-CO_2 concentration change during the early Jurassic from South China. By using an inter-comparison of three methods, a high degree of consistency in pCO_2 estimates trend has been observed in two empirical proxy methods; whereas, the mechanistic method shows inconsistence with other two methods and yields a higher pCO_2 value. To test the accuracy of pCO_2 estimates, we also run all three methods by two Ginkgoalean fossil species. All three methods show species-dependent uncertainty in pCO_2 estimates when applied to different Ginkgalean fossil species in same bed. The genome size of fossil and living *Ginkgo* taxa was analysed based on the significant positive relationship between genome size and guard cell size. The result shows that polyploidy of *Sphenobaiera huangii* may result in overestimated pCO_2 in the two empirical method and the muti-regression method.

O075

HISTORICAL BIOGEOGRAPHY OF THE ICACINACEAE MIERS DURING THE PETM

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The Icacinaceae Miers are a basal lamiid family of trees, shrubs, and lianas with a pantropical distribution. The group has been the subject of intensive phylogenetic studies over the past 20 years, leading to a highly reduced circumscription of the family including around 23 genera and 160 species. This family is well known in the Paleocene and Eocene fossil record, particularly from the Northern Hemisphere, although fossil evidence from the Southern Hemisphere has recently been increasing. In the Paris Basin, Icacinaceae are represented by numerous fossil endocarps from five main localities. Among these, Rivecourt (Thanetian) and Le Quesnoy (Ypresian) are geographically and temporally very close. The Paleocene-Eocene thermal maximum (PETM) event occurs (temporally) between these two fossil outcrops. Thus, the study of the Icacinaceae fossil in those localities provides a good opportunity to elucidate the impact of the PETM on this family in the Paris Basin. Furthermore, available data from recent molecular phylogenetic studies allows us to reconstruct a dated, global biogeographic history for the Icacinaceae family, which may compliment the information given by fossils.

Based on 266 fossil specimens attributed to Icacinaceae, from the five Paris Basin localities, we conducted detailed anatomical (using SEM) and morphological studies. In addition, using the same process, we analyzed fruits representing as 64 ingroup species and 6 outgroup species. Next, we conducted phylogenetic analyses (molecular and combined molecular-morphological) to reconstruct phylogenetic relationships among extant and extinct species of Icacinaceae. Finally, we used this combined phylogeny as the basis for divergence dating and biogeographic analyses.

The study of fossils from the Paris Basin led to the recognition of nine new species from two extant genera. No clear extinction is shown through the PETM, but a floral change across the PETM is demonstrated, possibly due to immigration of new plant taxa (in concert with faunal immigrants). The phylogenic framework allows us to date major diversification events for Icacinaceae and to reconstruct biogeographic processes during the Paleocene-Eocene transition. We discuss the implication of global patterns for understanding the changes occurring in the Paris Basin during the PETM and most generally for the Northern Hemisphere during the Cenozoic.

O076

FOSSIL FRUIT (*LAGOKAOPOS*) FROM TIBET REVEALS THE FLORISTIC LINKAGE OF THE NORTHERN HEMISPHERE DURING PALEOGENE

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In the Northern Hemisphere, many related taxa are today disjunctly distributed in eastern Asia, Europe, and North America. The fossil record can be used to explain these discontinuities. Usually, the Northern Hemisphere early Paleogene has been divided into two biogeographic regions based on pollen records, of which one is western North America plus most of Asia, and the other eastern North America plus Europe. Here we report fossil fruits of Lagokarpos from the Niubao Formation, Bangoin County in north Tibet and show that the fossil distribution of Lagokarpos does not conform to the above mentioned general biogeographic pattern.

Lagokarpos, an extinct fossil-genus based on fruits without a family affiliation, consists of an elliptical fruit body with two elongated entire-margined and V shaped, apical wings. The pinnate venation pattern of the wings includes a strong midvein with numerous lateral secondary veins and tertiary veins. Previously, it was only known from western North America and the Messel Pit in Germany (latest Paleocene to early middle Eocene). The genus has never been observed from other well-collected fossil sites in eastern North America, South America, or Asia before.

The age of the Niubao Formation has been controversial, ranging from late Cretaceous to Oligocene. The presence of Lagokarpos may suggest that the age of the Niubao Formation is closer to latest Paleocene to early middle Eocene.

More importantly, the occurrence of Lagokarpos in north Tibet reveals the floristic connection between QTP, western North America and Europe during the latest Paleocene to early middle Eocene. Based on the fossil evidence currently available Lagokarpos may have dispersed across Beringia, the North Atlantic or island chains in the Tethys. This hypothesis is also in agreement with the finding of fossil Ailanthus (Simaroubaceae), Koelreuteria (Sapindaceae), the extinct genus Cedrelospermum (Ulmaceae) and Limnbiophyllum (Araceae) from Paleogene strata in north Tibet nearby our fossil locality.

O077

BIOGEOGRAPHIC PATTERNS IN THE HISTORY OF TROCHODENDRACEAE

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The Trochodendraceae, which are today confined to the two monotypic east Asian genera, *Trochodendron* and *Tetracentron*, were more widespread geographically in the fossil record, with occurrences in western North America in the late Cretaceous to Neogene of the Northern Hemisphere. New data from micro-CT scanning of infructescences along with high resolution light and SEM investigations of pollen and leaf cuticles have lead to improved understanding of the morphology and systematic affinities of fossil representatives. The extinct genus *Nordenskioeldia*, based on fruits, and associated foliage (*Zizyphoides*), is known from the Santonian of Far East Russia and the Campanian of western Canada and was widespread in the Paleogene with records in Greenland, Spitsbergen as well as North America and eastern Asia. A refugial population of *Nordenskioeldia* survived in the middle Miocene of western North America (Idaho, Washington, British Columbia). Another extinct genus, *Concavistylon*, is known from infructescences and leaves (in one instance attached on the same twig, proving their identity as part of the same plant), was common in the early Middle Eocene of western North America and survived to the middle Miocene in Oregon. Widely dispersed fossil records of the two modern genera indicate that their modern distribution is only refugial. Trochodendron is confirmed by infructescences from the Eocene of Oregon to British Columbia, as well as from the Miocene of Kamchatka and Japan. *Tetracentron* is known by infructescences and foliage from the Eocene to Miocene of western North America, and by fruits and pollen from the Miocene of Iceland and leaves from the Miocene Japan. Leaf remains suggest that both the evergreen habit (*Trochodendron*, *Concavistylon*) and deciduous habit (*Tetracentron*, *Zizyphoides*) have long records in the history of this family.

O078

BIOGEOGRAPHIC HISTORY OF FAGACEAE (OAK FAMILY)

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The Fagaceae are the most diverse and economically important family of woody angiosperms in the Northern Hemisphere. They have an excellent fossil record and this record has been used in several time-calibrated molecular phylogenetic studies ("dating studies"). Here I use the revised, rich fossil record of Fagaceae (>> 150 records) and a phylogenetic framework for Fagaceae based on recently published phylogenies of the family, particular genera, and infrageneric groups. I map stem group and crown group fossils on the phylogenetic tree in order to investigate the temporal and spatial evolution of 18 extant lineages in the Fagaceae (*Fagus* subgenera *Fagus* and *Engleriana*, *Colombobalanus*, *Trigonobalanus*, *Formanodendron*, *Castanea*, *Castanopsis*, *Chrysolepis*, *Lithocarpus*, *Notholithocarpus*, *Quercus* sections *Cyclobalanopsis*, *Ilex*, *Cerris*, *Lobatae*, *Protobalanus*, *Ponticae*,*Virentes*, and *Quercus*). In addition a number of extinct lineages are traced. I show that several extinct lineages extend back to the Cretaceous and some extinct lineages persist until the Miocene. Most extant lineages originate in the Paleogene and achieve intercontinental disjunctions early in their fossil history. I discuss cases in which divergence times seen in the fossil record are in harmony with dates inferred from molecular studies and cases where the inferred dates are in strong disagreement. One explanation for discrepancies between dates from traditional molecular dating studies and the fossil record might be that several dating studies have not used fossils to calibrate internal nodes of genera leading to far too young crown ages of extant genera. Additionally, molecular dating studies still struggle with strongly different rates of molecular evolution in related groups. Finally, I will express my hope that neobotanists and palaeobotanists will cooperate more closely in the future to avoid unnecessary shortcomings in dating studies and to gain deeper insights into the mode and speed of molecular evolution in plants.

O079

ANALYSES OF THE GLOBAL MACROFOSSIL RECORD OF PALMS: ENVIRONMENTAL AND PALEOCLIMATIC INSIGHTS

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Palms (Arecaceae/Palmae) are an important component of many modern and ancient forested terrestrial ecosystems. While they are dominantly equatorial in biogeographical distribution today, their macrofossil record extends back to Cretaceous time and, during some periods of Earth's climatic history, into polar paleolatitudes. Much recent work on the evolution, systematics, historical ecology, and biogeography of modern palms has shed light on the group's evolutionary origins, ecological interactions, and environmental history. What deserves more study, however, is the global fossil record of this group in space and time and how that record relates to paleoclimate data.

More than 300 palm macrofossil (leaf, fruit, axis, inflorescence taxa) occurrences from over 220 localities reported in the published literature were collected in a database. The reported genus, species, and/or form taxon occurrences tallied from the literature comprise 67 organ genera overall and no attempt has yet been made to update the taxonomic assignments of the floral elements. Locality information for each occurrence includes the stratigraphic formation, age reported in the literature, age constraint, lithology of fossil preservation, the locality's modern geographic coordinates, and its rotated paleogeographic coordinates to the reported literature age.

Analyses of the data show the greatest paleolatitudinal extent of the palm macrofossil record to be during Early Paleogene time, with occurrences spanning more than 100 latitudinal degrees. The paleolatitudinal span of the record then constricts toward more temperate and subtropical distribution through Late Paleogene and Neogene time. The data also show a bimodal paleolatitudinal distribution in northern subtropical-temperate and southern subtropical bands when totaled across Cretaceous to Pleistocene occurrences. This occurrence pattern contrasts with the concentrated distribution of modern palm diversity centered near the equator. Analysis of co-occurring fossil plant groups and sedimentological indicators of environments of deposition can assist us in understanding environmental tolerances and preferences of ancient palms as well.

Understanding the paleobiogeographical record of these iconically tropical plants (in the modern world) can help elucidate Earth's paleoclimate, paleoecological, and paleoenvironmental history and provide context for modern and future global change.

O080

CYMASTROBUS, A NEW PALEOZOIC LYCOPSID FROM AUSTRALIA INVESTIGATED THROUGH A COMBINATION OF OLD (THIN-SECTIONS), LESS OLD (SEM), AND NEW APPROACHES (X-RAY SYNCHROTRON MICROTOMOGRAPHY)

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This paper addresses one of Bill Chaloner's earliest center of interest, the reproductive structures of the Paleozoic lycopsids and their in-situ spores, through the analysis of a new cone genus, *Cymastrobus*. *Cymastrobus* is represented by a single anatomically preserved specimen collected from a marine deposit of Famennian age in northern New South Wales. The cone was closely associated with a small lycopsid stem comparable in dimensions to its central axis. To preserve its entirety, we choose to investigate the cone structure by means of propagation phase-contrast X-ray synchrotron microtomography at ESRF, Grenoble. Spores extracted from the sporangia were observed in SEM at the University of Montpellier. A thin section of the cone axis was made for comparison with a transverse section of the small stem in order to test their conspecificity.

Cymastrobus is a large bisporangiate cone consisting of tightly packed sporophyll-sporangium units helically arranged around a narrow axis. This axis is characterized by the wavy outline of its primary xylem and an invaginate pattern of trace emission. The cone is megasporangiate in its proximal third. The sporophylls are comprised of a long narrow pedicel widening distally and of a delicate distal lamina. Pedicels show an abaxial keel, and a distal heel forming an hexagonal shield protecting the sporangium. Megaspores and microspores are represented by the casts of their central bodies. Megaspore casts show several rows of circular pores around the trilete mark. Microspore casts show one small pore between the rays of the trilete mark and are assignable to the genus of sporae dispersae *Endosporites*. Pores like those of the mega- and microspore casts are known to correspond to papillae or laminated zones of the exospore in extant spores (Grauvogel-Stamm & Lugardon, 2004).

The vascular system of the cone axis differs from that of the associated stem which belongs to a different lycopsid. The structure of *Cymastrobus* is similar to that of the Carboniferous *Flemingites* cones (Brack-Hanes & Thomas, 1983) but its spores are different. It is also close to that of two Famennian genera of uncertain affinities, *Clevelandodendron* (Chitaley & Pigg, 1996) and *Bisporangiostrobus* (Chitaley & McGregor, 1988), the latter sharing a similar type of spores but differing by its size and shape. The possession of spores with pores/papillae/laminated zones appears to be plesiomorphic and unhelpful to precise the systematic position of *Cymastrobus* within the basal members of the rhizomorphic lycopsids.

O081

PALAEOZOIC HORSETAILS – HOW DO WE ASSESS THEIR TAXONOMIC DIVERSITY?

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Horsetails (Sphenophyta) are today widely regarded as a pest, but they are in fact one of the most successful groups of plants, with an evolutionary history spanning over 350 Ma and today having an almost global distribution. However, they also today have a remarkably low species diversity, with probably less than 20 species recognised world-wide. But determining species diversity from the palaeobotanical record is difficult as the fossils have relatively few taxonomically useful characters. This issue is being addressed through a study on Pennsylvanian (late Carboniferous) age sphenophyte foliage and cones found as adpressions in palaeotropical Euramerica. As a case study, results of work on a group of Pennsylvanian sphenophytes with large leaf-whorls traditionally named *Annularia stellata* and cones named *Calamostachys tuberculata* will be discussed. This suggests that a true understanding of species diversity in these fossil plants is best revealed by looking at the two parts of the plant in parallel. This does not mean that the fossil-taxonomy of these plant parts should be merged – they are still best kept separate – but it does present us with questions as to how the taxonomic diversity is best recorded.

O082

A REMARKABLE MASS-ASSEMBLAGE OF THE LYCOPSID *BRASILODENDRON PEDROANUM* CHALONER ET AL. 1979 FROM THE RIO BONITO FORMATION, LOWER PERMIAN OF THE PARANÁ BASIN, RIO GRANDE DO SUL, BRAZIL

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In Brazil, arborescent and sub-arborescent lycopsids are considered as important floristic components of the early Permian peat-forming vegetation of the Paraná Basin and have generally been assigned to *Brasilodendron pedroanum* Chaloner et al. 1979. However, fossil genera such as *Lycopodiophloios* and *Cyclodendron* have also been described from the lower Permian deposits of the Paraná Basin. These plants are mostly preserved as impressions and compressions, which are very fragmented, incompletely preserved and lack reproductive structure. Consequently, the taxonomy and systematic position as well as the biology and ecology of the early Permian arborescent and sub-arborescent lycopsids from Brazil are still poorly understood.

During recent fieldwork a remarkable mass assemblage of *Brasilodendron pedroanum* axes has been discovered. These axes are preserved in the plant bearing sub-level N8b of the Morro do Papaléo outcrop, Rio Bonito Formation, early Permian of the Paraná Basin, Rio Grande do Sul state, Brazil. They are massively concentrated, without any preferential depositional orientation, forming a monotypical assemblage. They are unbranched and preserved as impressions. Three morphological patterns, occurring on distinct axes, were described for leaf cushions. This mass-assemblage is probably a result of allochthonous deposition and hydraulic size-sorting. The massive concentration of *Brasilodendron pedroanum* suggests that this fossil taxon was an important floristic element somewhere in the upstream area of the braided river system preserved in the Morro do Papaléo outcrop.

O083

NEW INSIGHTS INTO THE LATE MISSISSIPPIAN FLORA FROM KINGSWOOD FIFE, SCOTLAND.

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The fossil plants from the Late Mississippian (late Visean) of Kingswood, Fife Scotland are preserved in limestones associated with volcanic ashes. These ashes are thought to have been erupted by a basaltic phreatic eruption and the plants grew on the inner flanks of the post-eruption crater. The plants living near the crater-lake were preserved as calcareous permineralizations and included gymnosperms and the herbaceous lycopsid *Oxroadia*. Some *Setispora* megaspores were also found as well as a number of unassigned megaspore species. In addition, the vegetation higher on the crater flank was subjected to frequent wildfires and the resultant charcoalified plants washed down into the lake. The plants thus preserved include a wide variety of gymnosperms including several pteridosperms that are represented by a wide range of leaves, pollen organs, ovules and stems as well as rare sphenopsids. The palynoflora suggests a NM zone age (Asbian) and indicates the flora is of a similar age to the nearby Pettycur flora. However, there are no elements in common and it is believed that this later flora was associated with either lowland peat-forming environments (flora dominated by lycopsids and pteridosperms) or disturbed volcanic environments (flora dominated by ferns) and the sediments containing the plants were ripped up and incorporated into baslaltic lava flows. We shall present new data on the Kingswood flora based on both scanning electron microscopy (sem) and Synchrotron radiation x ray tomographic microscopy (SRXTM).

O084

THE EARLY DEVONIAN ALLUVIAL/MARGINAL MARINE PALYNOFACIES FROM THE BUKOWA GÓRA QUARRY (HOLY CROSS MOUNTAINS, POLAND)

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The palynological investigation was carried out on Early Devonian clastic sediments from the Bukowa Góra Quarry (Holy Cross Mountains). All analysed samples contained the high abundance of plants remains (miospores, phytoclasts, fungi and algae as well). Animal remains and Nematophytes were also present but in limited number.

Based on rich and well-preserved miospore assemblages, the age of analysed deposits was established as the *douglastownense-eurypterota* Miospore Zone (Emsian). Within the miospores following taxa 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 spores, a very rich and differentiated phytoclasts assemblage was observed. The phytoclasts assemblage changes in agreement with the increase of the distance from the continental source area, which is caused because of inherent resistance to the destruction. I order to investigate the changes in phytoclasts distribution, following features were considered: edges translucency, translucent colour, form/symmetry, angularity and outline. The ratio of opaque and non-opaque in all sections was similar, the translucent phytoclasts strongly dominated. They were mostly brown to dark-brown, with sharp outline, the angular shape was the commonest, so in case of all sections the transport was relatively short and the rate of sedimentation was high. The ratio of equant and lath-shaped opaque phytoclasts suggests the deposition close to the fluvio-deltaic source area. Additionally, high amounts of cuticles supports this idea. Moreover, the phytoclasts were not degraded, which is a feature of proximal, oxic environments removed from the areas of active redeposition. In summary, the depositional environment may be described as marginal-marine/alluvial.

Moreover, those sections were analysed using portable gamma-ray spectrometer *Georadis* GT-32 BGO, which assays concentration of potassium, thorium and uranium (12 data points were measured). Based on gamma-ray spectrometry we are able to tentatively estimate paleooxygen levels, because the enrichments in uranium is observed in anoxic conditions. The values of Th/U ratios in investigated siltstones are high (from 3.35 to 4,96) which is indicative for oxic conditions. However, other data such as pyrite framboids, trace-metals, as well as biomarker will be necessary to unequivocal decipher redox conditions during sedimentation the level with well-preserved plants.

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O085

PALYNOLOGY OF THE MIDDLE DEVONIAN OF NORTHERN SPAIN: EFFECTS OF THE KAČÁK EVENT ON AN ENDEMIC ISLAND BIOTA

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Northern Spain contains an extensive sequence of Devonian marine strata. These accumulated as an onshore-offshore transect across a shelf that extended away from a group of relatively large islands (Armorican Terrane Assemblage). These islands were relatively isolated and situated between the continents of Euramerica to the northwest and Gondwana to the southeast. The Middle Devonian sequence consists of a clastic unit sandwiched between two extensive developments of carbonates. The clastic unit is classified as the coeval Naranco, Huergas and Gustalapiedra formations of Asturias, León and Palencia provinces, respectively. Conodonts recovered from the bounding limestones provide secure biostratigraphical age constraints.

A comprehensive palynological survey of the clastic unit yielded rich palynomorph assemblages including marine (acritarchs, chitinozoans, scolecodonts) and land-derived (spores) forms. The marine palynomorph assemblage is unusual as both acritarch and chitinozoan assemblages contain unexpected species for the Middle Devonian and the chitinozoans are often surprisingly abundant and diverse. Similarly, the land-derived palynomorph assemblage is unusual, lacking taxa that are abundant in coeval material from Euramerica (e.g. spores with grapnel-tipped processes belonging to *Ancyrospora* spp.) and northern Gondwana (e.g. *Rhabdosporites langii*). The isolated location of the islands may explain the presence of endemic and relict taxa, as well as the exclusion of various marine plankton and terrestrial plants.

The Kačák Event is a globally recognised extinction event, occurring at the Eifelian-Givetian boundary, and characterised by marine anoxia. One hypothesis posits that it was caused by an increasingly monsoonal climate that increased terrestrial runoff, marine stratification and sediment supply to the nearshore environment. The Naranco, Huergas and Gustalapiedra formations have been described as representing the Kačák Event. Clearly, the Spanish sequence reflects a period of acute environmental change with cyclical sand and silt deposition temporarily supplanting background limestone deposition. The recovered palynomorph assemblage is lower Givetian in age, later than the Kačák Event, but it occurs in the upper half of the sequence. The lower part is dominated by thick sands and preserves no silt horizons, but may represent increased nearshore sediment input.

Both the marine and terrestrial palynomorphs are diverse, but distinctly different from those from older late Emsian deposits, indicating a high degree of turnover. Due to the isolated nature of the islands, this may reflect predominantly post extinction recovery in endemic biotas of the islands rather than immigration. The results presented here chronicle an exceptional palynological community and shed light on it's habitat's response to a major environmental crisis.

O086

THE TERRESTRIAL RECORD OF THE END DEVONIAN MASS EXTINCTION EVENT

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The End Devonian Mass Extinction (EDME) is often referred to as the 6th mass extinction. However, EDME differs from most of the Big 5 as it was driven by a short intense glaciation and deglaciation. As such it remains our best analogue for extinctions that will accompany a collapse of the present glacial system. However, EDME still remains poorly understood and particularly its terrestrial expression. We report on 3 sections, on a proximal to distal transect, from East Greenland- the interior of the Old Red Sandstone Continent. Here the D-C boundary is marked by a double (?precessional) lacustrine cycle. Below the boundary lake the palynological assemblage is dominated by *Retispora lepidophyta*, a very distinctive spore that was globally distributed, but restricted to the latest Devonian. Immediately beneath the boundary the spore diversity increases markedly (LN* spore zone) as the climate became less arid and the lake encroached. But as the lake develops there are progressive extinctions. Above the lake spores return, but as a very simple assemblage following the extinction of many long lived Devonian forms. *Retispora lepidophyta* disappears (the ultimate ruderal plant) which indicates the ecological severity of the crisis. We have integrated a palaeobotanical record by counting the abundance and size of plant stems. These show the disappearance of large forest trees coincident with the boundary and the change in spore assemblage also show loss of the understorey vegetation. It was the loss of these keystone taxa that collapsed the terrestrial ecosystem.

O087

POST-EXTINCTION RECOVERY OF TERRESTRIAL VEGETATION FOLLOWING THE END DEVONIAN MASS EXTINCTION: INTEGRATED PALYNOLOGICAL AND PALAEOBOTANICAL 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, with quantitative abundances of key spore taxa enabling 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 flora, followed by increasing spore diversity. The vegetation then became dominated by the creeping lycopod *Oxroadia conferta* (*Anaplanisporites baccatus*), including abundant megaspores (*Setispora pannosa*). This was replaced by an assemblage dominated by *Prolycospora claytonii*, which new evidence suggests had an affinity with the seed plants. The palaeosols indicate 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. But these were not lepidodendroid lycopods as they appeared significantly below the inception of *Lycospora*. A considerable increase in the abundance of *Spelaeotriletes crustatus* towards the top of the section, reveals a further change in the dominant vegetation to the ?progymnosperms. Significantly, the eight-fold subdivision of the Tournaisian can now be mapped onto long Milankovitch cycles identified in shallow marine sections.

O088

EARLY PLEISTOCENE VEGETATION AND ENVIRONMENTAL HISTORY FROM LAKE OHRID (SE EUROPE)

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Palynological data from the Lake Ohrid DEEP record corresponding to the Early Pleistocene (Marine Isotope Stages 43 to 35) confirm that the Ohrid catchment fostered numerous subtropical species during this interval. Tree species such as *Cedrus, Tsuga, Carya, Pterocarya, Cathaya, Parrotia, Liquidambar, Taxodium* and *Eucommia* formed important constituents of the Early Pleistocene flora of the Ohrid catchment (such as *Cedrus* and *Tsuga* with up to 40% and 20% respectively). Pollen percentages of relict tree species (i.e. absent in modern flora of the region) indicate continuous presence in the catchment during interglacials, which are characterized by a remarkable species diversity. These findings are in good agreement with pollen records from Southern Italy and point to the refugial characteristics of the Italian and Balkan peninsulas. Ongoing palynological analyses of the Ohrid DEEP core suggest receding populations of these trees within the catchment throughout the Mid-Pleistocene Transition (MPT) and they become extinct gradually during post-MPT high amplitude climatic cycles.

There is an increase of conifer tree percentages observed over the study interval with pines dominating pollen spectra during the MIS 38 and MIS 36. Pollen and biomarker data suggest a rather forested landscape with relatively limited erosion activity during interglacial and glacial intervals of the Early Pleistocene. Maxima in tree pollen and fern spore concentrations in MIS 41 and MIS 35 suggest high terrestrial productivity within the catchment that led to the accumulation of significant plant biomass and to an increased fire frequency within these intervals. Aquatic vascular plant concentrations also show maxima in MIS 41 and MIS 35, but green algae values indicating lake productivity are higher within the older half of the study interval (i.e. MIS 43 and MIS 41). Maxima of aquatic vascular plant, herb (mostly grasses including reeds) and green algae concentrations indicate changes in the littoral zone and a higher lake productivity most likely linked to changes in nutrient availability and lake-level fluctuations.

These findings support the working hypothesis presented in the original proposal, namely that a shallower Lake Ohrid is most likely characterized by an extensive littoral zone and more eutrophic conditions in comparison to the deeper oligotrophic lake described in the Late Pleistocene. Pollen and biomarker findings suggest that Lake Ohrid during the early stages of its existence was an entirely different ecosystem resembling the one found in the Prespa catchment: shallow, with more extended littoral zones, including wetlands, and significantly more productive.

O089

IMPACTS OF CLIMATE ON THE VEGETATION AND FIRE HISTORY DURING THE LAST TWO INTERGLACIAL-GLACIAL CYCLES AT LAKE VAN, TURKEY

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Promoted by the potential of the sedimentary sequence for investigating the paleoecological and paleoclimate development of the Near East, a deep drilling operation was carried out in 2010 supported by the International Continental Scientific Drilling Program (ICDP). The continuous sedimentary archive of Lake Van adds significantly to the picture of long-term climate variability and millennial-to-centennial scale oscillations during the last two interglacial-glacial cycles (ca. 10-250 ka, MIS 2-7). A unique multiproxy study, derived from pollen and microscopic charcoal data, black carbon analysis, stable oxygen isotopes, and XRF measurements, provides the opportunity to examine different paleoenvironmental indicators, e.g., vegetation communities, fire activity, erosion processes, evaporation rates, and moisture availability in the catchment area. We are able to evaluate how climate triggers the activity of vegetation fires in a long continental sediment record.

The integration of all proxies shows two temperate intervals, the penultimate interglacial complex (MIS 7; ca. 193-242 ka BP) and the last interglacial (MIS 5e; ca. 111-131 ka BP), with high effective soil moisture availability. This is evidenced by the predominance of oak steppe-forested landscapes similar to the present interglacial vegetation in this sensitive semiarid region. Furthermore, we found that biomass productivity, precipitation, and seasonality were major controls of fire activity. Intensive fire events were recorded during temperate/humid periods and did not necessarily occur during dry climates. More specifically, the beginning of each temperate interval can be assigned to the grassland dominating landscape, which provided considerably more fuel availability than during glacial steppe vegetation.

O090

LONG-TERM ECOSYSTEM DYNAMICS DRIVEN BY CLIMATE OSCILLATIONS AND FIRE-REGIME CHANGES DURING THE LAST 18K YR CAL BP IN THE CANTABRIAN REGION (LA MOLINA PEAT BOG, PUENTE VIESGO, SPAIN)

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The study of long-term fire regimes has demonstrated to be one of the most interesting tools for interpreting landscape dynamics since it allows discussing the role of climate oscillations and human perturbations on mountain areas. One of the European regions with more known paleolithic sites is Cantabria (northern Iberian Peninsula), but only a few sedimentary records enable the study of climate and landscape dynamics during the Tardiglacial-Holocene transition.

The sequence obtained from La Molina peat bog in Puente Viesgo is one of the most interesting paleobotanic records from this region. The multiproxy study of the sequence has been based on the analysis of macroremains, pollen and non-pollen palynomorphs, % of organic matter and sedimentary charcoal (<150 µm). These proxies provide information about vegetation, climate and fire regimes at a local scale and help to understand the significant changes occurred during the last 18K years. A period of particular interest is the Late Glacial-Holocene transition since it allows assessing the role of human activity before the Neolithic in the northwest part of the Iberian Peninsula.

The results of this study showed that charcoal peaks (0.5-1 mm^2/g) coincided with organic matter decreases from the Late glacial to the Holocene (18k to 9.500 years BP). A significant increment of organic matter was observed after 12K years BP, which coincides with the beginning of the postglacial times. At 9.500 years BP there was a very intense charcoal peak (20 mm^2/g) which also follows the pattern. However, between 8.500 and 8.000 years BP there was the first charcoal peak that did not, coinciding with the 8.200 cold and arid event. From 8.000 to 6.000 years BP charcoal peaks decreased in intensity (1-2 mm^2/g) and again coincide with organic matter decreases, suggesting that the fire regime was mostly influenced by climate fluctuations. However, from the Neolithic (c. 6.000 years BP) to present, charcoal peaks were very intense (20-40 mm^2/g) and were closely related to the human occupation in the Cantabrian region. Previous investigations showed that the intensity and effects of wildfires are related to the biomass and controlled by climate factors.

In summary, La Molina peat bog sequence shows a good correlation with the rapid climate changes during the last glacial–interglacial transition. Abrupt events observed were identified as cold and arid periods in relation to the fire events until Neolithic period. Then, fire regimes were linked to the cultural landscape.

O091

HOLOCENE-SCALE FIRE DYNAMICS FROM SPRUCE-BEECH TEMPERATE FORESTS OF CENTRAL EUROPE

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Fire is one of the most important disturbance agents in forested ecosystems, yet there remain gaps in understanding the long-term role of fire, its drivers, and species responses to fire in central Europe. To fill in this knowledge gap, we applied a high-resolution, multi-proxy paleoenvironmental approach to sediments collected from Prášilské jezero (Šumava Mountains, Czech Republic) using macro- and micro-charcoal, pollen, plant macrofossils, and charred plant remains. Using pollen influx and macroscopic charcoal area data, we investigated species responses to increasing biomass burning through the Holocene using a Generalized Additive Model. Our results illustrate that at the regional-to -subcontinental-scale, synchronized biomass burning throughout central Europe suggests climate was the dominant driver of fire between 11,500 – 6500 cal yr BP. Vegetation composition and structure acted as a secondary driver of fire influencing fuel type at both the regional- and local-scale. Species response curves demonstrate a strong positive relationship ($p < 0.01$) between fire resister species such as *Pinus, Corylus*, and *Betula* and increased macroscopic charcoal (CHAR). Norway spruce (*Picea abies*) established ~10,000 cal yr BP during peak biomass burning. Species response curve for *Picea* demonstrates a slight negative relationship between increasing CHAR, which perhaps counters the view that this fire avoider species was heavily impacted by fire. When climatic conditions became more favorable for fire sensitive species (e.g. *Fagus sylvatica*) ~6500 cal yr BP, regional biomass burning decreased dramatically. Species response curves support this demonstrating a strong negative relationship ($p < 0.01$) between *Fagus* and increasing CHAR. However, while regional biomass burning decreased dramatically beginning ~6500 cal yr BP, the reduction in local fire frequency was less so. Thus, either human activities and/or rare fire-promoting climatic events were important in shaping the fire regimes of central European spruce-beech forests at local-scales after 6500 cal yr BP. Fire activity peaked and parallels increases in anthropogenic pollen indicators ~2500 cal yr BP demonstrating the importance of humans in temperate forests of central Europe. As temperate mountain ecosystems from central Europe become more susceptible to mortality with increasing temperature and drought frequency, mountain ecosystems may also become more vulnerable to the increasing risk of wildfire. Response curves infer that *Picea* in temperate forests of central Europe may not be as impacted by fire as once previously thought, but that beech forests in the Šumava Mountains may be the most negatively impacted by projected increases in occurrence of wildfire.

O092

ROOTS, STEMS, LEAVES, AND COMMUNITIES: A WHOLE PLANT ECOSYSTEM PERSPECTIVE ON LATE CARBONIFEROUS ARIDIFICATION

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Water flux from the vegetation component of the soil-plant-atmosphere continuum (SPAC) is limited by tissue and organ level organization affecting liquid water available for evaporation from the interior of leaves. While leaf water is the endpoint of soil water transport, roots and stems also restrict replenishment of water to the leaves that varies by species. Reorganization of plant communities during the Late Carboniferous has been inferred to be driven by top-down climate aridification. However, while global aridification can be attributed to changes in hydrologic cycling due to lower greenhouse forcing, regional aridification may also occur through forest composition changes reducing plant water use. During the Late Carboniferous, tropical forests were dominated by *Lepidodendron* spp. that were eventually replaced by stem group marattialean tree ferns. Other plants associated with these communities included medullosan seed ferns, cordaitaleans, and woody sphenophytes. Utilizing fossil-derived morphological measures of stoma size and density, leaf vein to stoma distances, stem tracheid diameters and cell wall thickness, and soil root distribution and diameters, we modeled hourly transpiration and root/stem hydraulic flux for a tropical, central Pangean location for these different plants types to represent limits on physiological function of these different extinct plant types imposed by their respective morphological combinations. We found that roots distribution differences among modeled plants were not significant in changing simulated tissue water flux, rather restrictions imposed by both stem and leaf conductivity coupled with stomatal conductance reduced transpiration. *Lepidodendron* spp. and medullosan seed ferns had approximately 3 to 4 times the maximum mid-summer transpiration of tree ferns, cordaitaleans, and spenophytes, with almost 10 times the cavitation potential within their stem tracheids. Leaf conductivity, accounting for both vein density and apoplastic pathways, were not consistently different among these groups, though *Lepidodendron* spp. had the highest value and tree ferns the lowest, attributed to stomatal densities. From modeled transpiration (latent heat), above canopy atmospheric stability—evaluated as the inverse of the Monin-Obukhov length or the ratio of canopy heat and momentum flux—was calculated for each plant type. Using community composition of well-characterized sites with good age data, we found that weighted average transpiration decreased and atmospheric stability increased between 306 to 298 million years ago. These estimates correspond to overall global aridification. This indicates that plant community changes favoring species with higher water use efficiency can reduce water vapor amount and convective transport, positively reinforcing rates of regional aridification.

O093

PALEOBOTANICAL RECORD OF A JURASSIC VOLCANIC ISLAND IN THE PROTO-LIGURIAN TETHYS OCEAN (NE IBERIAN PENINSULA).

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During Early and Middle Jurassic times, the proto-Ligurian Tethys Ocean developed an intense volcanic activity. Such activity can be observed from the volcanoclastic deposits of the El Pedregal Fm (Iberian Ranges, NE Iberian Peninsula), where an intrusive phenomena caused an ephemeral insular input in on this area of the proto-Ligurian Tethys Ocean. These terrestrial levels contain abundant plant megafossil remains and a well preserved palynoflora.

Here we show the dispersed palynomorph assemblages of six different sampling sites including, e.g., *Klukisporites* spp., *Manumia* sp., *Perinopollenites* sp., *Cycadopites* spp., *Cerebropollenites* spp., and species of *Cyathidites* (among others). Fungal spores and other marine elements, such as prasinophyte algae, acritarchs, foraminifers and scolecodonts are also observed. Plant macroflora is characterised by a rich bennettitalean diversity formed by long leaves and fertile structures together with some types of ferns. It has also been identified some plant-animal interactions (e.g., marks of leaf-mining insects or bio-erosive interactions in trunks).

Moreover, palynological and stratigraphic data suggest a late Aalenian-early Bajocian (Middle Jurassic) age for sampled levels. This well-preserved terrestrial diversity represents one of the most comprehensive mid-Jurassic floras of the Iberian Peninsula. This discovery provides an excellent scenario to explore the patterns and processes involved in the floral dispersal and colonisation of isolated environments.

O094

FOLIAR ADAPTATIONS OF A NEW OLIGOCENE *RHUS* SPECIES. PALAEOCLIMATIC IMPLICATIONS

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The lower Oligocene palaeobotanical site of Cervera (Catalonia, Spain), located in the eastern Ebro Basin, contains one of the richest beds in *Rhus* leaves from Europe. The leaf features indicate that it corresponds to a new species. It is composed of three leaflets. The apical leaflet is symmetric with serrate margin, decurrent base, pinnate primary venation, craspedodromous secondary venation and irregular reticulate tertiary veins. In contrast, the lateral leaflets contain asymmetric base with rounded shape in the distal part of the lamina and straight or concave in the proximal part. Additionally the lateral leaflets have a basal secondary vein. The comparison with extant species indicates that *R. aromatica* leaves are most similar to this new fossil species. Nowadays, *R. aromatica* grows in sunny dry environments of a wide range of latitudes in N. America whilst the new fossil species was restricted to the endorrheic Ebro Basin. Small differences in the leaf characters of both species would indicate distinct palaeoclimatic and palaeoecological adaptations: (1) The lateral leaflets of the *Rhus* sp. nov. show a reduced leaf area. (2) *Rhus* sp. nov. bears a gland at the tip of teeth while *R. aromatica* leaves are devoid of glands. These two characters would reflect an adaptation to prevent a high evapotranspiration and that *Rhus* sp. nov. would probably grow under higher water stress than *R. aromatica.* (3) *Rhus* sp. nov. contains fewer teeth with a larger tooth-area than *R. aromatica* suggesting that *Rhus* sp. nov. would grow under less-contrasted seasonal conditions. A recent sedimentological and taphonomic study of the Oligocene flora from Cervera indicates that *Rhus* sp. nov. would form part of an open savannah-like woodland located distally from a lake (Tosal and Martín-Closas, 2016; Review of Paleobotany and Palynology, 233, 93-103). These results fit well with the subtropical paleoclimate interpreted by former authors to occur in the Mediterranean Tethys bioprovince during the Oligocene. To sum up, *Rhus* sp. nov. appears to be a reliable indicator of the arid and warm bioprovince of the South-European Oligocene along with other indicators such as *Zizyphus zizyphoides* or *Comptonia schrankii*.

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O095

TRENDS IN DEEP-TIME (TRIASSIC-JURASSIC) PLANT ECOLOGICAL FUNCTIONING UNDER ELEVATED ATMOSPHERIC CARBON DIOXIDE

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Anthropogenic climate change will likely alter the ecological functioning of future ecosystems, yet the magnitude and direction of such changes are difficult to quantify. Here we evaluate the impact of a well constrained CO_2 induced global warming event in the geological past on the ecological functioning of forested ecosystems. We use leaf mass per area (LMA), a widely used trait in modern plant ecology, to infer the palaeoecological strategy of fossil plant taxa and the relative abundances of different ecological strategies to assess overall palaeoecosystem function. Palaeo-LMA is determined from leaf cuticle thickness based on a highly significant positive scaling relationship between LMA and cuticle thickness of 39 extant gymnosperm taxa. Application of this new palaeo-LMA proxy to 121 fossil gymnosperm leaves spanning the Triassic-Jurassic (Tr-J) transition of East Greenland reveals a significant shift in the dominant ecological strategies of the palaeo-ecosystems. A comparison of our method with two other Palaeo-LMA proxies each based on petiole width-leaf area and epidermal cell-density shows that our proxy is robust. We show that Late Triassic forests, dominated by 'fast-return' low LMA taxa, were replaced in the early Jurassic by species-depauperate forests dominated by 'slow-return' high LMA taxa. The low to high LMA strategies observed at an evolutionary timeline mirrors that seen for individual taxa on experimental time scales when plants are grown in simulated Tr-J atmospheric conditions. Although taxon-specific ecological responses to elevated CO_2 may be highly individualistic and opposing in sign, we demonstrate that extreme CO_2-induced global warming selected for taxa with high LMA associated with a stress-tolerant strategy and that post-warming ecological success may be attributed to adaptive plasticity in leaf functional traits such as LMA.

O096

BIOGEOGRAPHIC ORIGIN OF EAST ASIA FLORA

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The East Asian Flora (EAF) is a well-known global hotspot of biodiversity but its origin remains poorly understood. In our study we compiled data of 213 clades, representing 203 genera and 81 families (two gymnosperms and 79 angiosperms) of seed plants, evenly distributed throughout the Angiosperm Phylogeny Group (APG) phylogenetic tree. Several major clades were sampled, covering 36 of the 64 orders. Using these data in combination with palaeobotanical information as well as the geological history, we analyzed the origin of the EAF. Our results showed that the biogeographical origin of the EAF is multiple and a large part of the present taxa (48%) originated in situ. For the remaining taxa, closest relationship is with Laurasian floras including those of North America (11%), the Tethyan area (10%) and tropical Asia (9%); for 14% of the taxa the place of origin is unknown. Besides, 8% of the allochthonous taxa originated from continents which originally belonged to Gondwana. Most of these clades originated since the Miocene which indicates that the EAF might be relatively young.

O097

ENDOCARPS OF *PARINARI* (CHRYSOBALANACEAE) FROM THE MIOCENE OF THAILAND

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An assemblage of fruits and seeds was recently discovered in a commercial sand pit in Nakhon Ratchasima Province, Northeastern Thailand, in a layer thought to be late middle or late Miocene in age. The specimens include fruits or seeds of Chrysobalanaceae, Vitaceae, and possibly Cornaceae. One fruit type is an endocarp, transversely broadly elliptic, 2.0 cm high, 2.4 cm broad, and 1.2 cm thick, with 2 elliptic plugs, 1.1 cm long by 0.6 cm wide, each covering a locule. The endocarp wall is thick, and the 2 locules are separated by a septum. Two small openings between the 2 plugs, presumably for vascular bundles, suggest that the plugs are basal. These fruits can be placed in the genus Parinari of Chrysobalanaceae. This genus is at present pantropical, with 44 extant species occurring in tropical America, tropical Asia, northern Australia, and Pacific islands. Based on studies of the plastid genome, Bardon and colleagues suggested that the genus originated in Africa, subsequently spreading to Southeast Asia during the Miocene, and from there to the Neotropics. Fossil endocarps are known from the early to middle Miocene of Ethiopia and early Miocene to Pleistocene in Central and South America. Although leaves of Parinari and wood of Parinarioxylon have been reported from the Miocene of India, and Parinarioxylon from the Pliocene of Java (Indonesia), fossil endocarps have not been reported from Asia. The discovery of endocarps of Parinari in this study allows greater confidence of the presence of Parinari in Asia during the Miocene, as the endocarps can be identified to genus level, whereas fossil leaves and wood are difficult to assign with certainty to a particular genus within Chrysobalanaceae.

O098

THE PLIOCENE FLORA OF FRANKFURT/M (GERMANY) - NOVELTIES AND PALAEOENVIRONMENT

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The Pliocene flora of Frankfurt/M, Germany is a key reference flora for the European late Neogene. We summarize most important data and document additional material of foliage recovered after the Second World War, now housed in the department of palaeobotany, Senckenberg Museum at Frankfurt/M. and specimens of the original material housed in the Swedish Museum of Natural History, Stockholm. Gymnosperms are represented by Ginkgo adiantoides and various conifers (Picea latisquamosa, Larix europaea, Keteleeria loehri, Pinus sp. div., Pseudotsuga, Abies sclereidea, Tsuga europaea, Sequoia abietina, Taxodium dubium, Calocedrus pliocaenica, Sciadopitys tertiaria, Cephalotaxus pliocaenica, Taxus, and Torreya). Angiosperms dominate the assemblage in diversity - Magnolia liblarensis, Sassafras cf. ferretianum, Laurophyllum, Smilax, Fagus kraeuselii, Castanea, Quercus roburoides, Quercus pseudocastanea, Quercus praecastaneifolia, Cercidiphyllum crenatum, Parrotia pristina, Liquidambar europaea, Salix denticulata, Populus balsamoides , Populus populina, Carya, Pterocarya paradisiaca, Carpinus grandis, Corylus , Alnus gaudinii, Betula, Ulmus pyramidalis, Ulmus carpinoides, Zelkova zelkovifolia, Celtis, Eucommia, Gleditsia, Caesalpinites, Malus, Prunus, Crataegus, Rosa,

Sorbus, Spiraea, Tilia, Dombeyopsis lobata, Hibiscus cf. splendens, Aesculus, Buxus pliocaenica, Pachysandra, Acer subcampestre , A. platanoides, A.integerrimum, Acer spp., Fraxinus angusta, Trichosanthes, Viscophyllum pliocaenicum, Viscum miquelii, Ilex geissertii and some morphotypes awaiting a more detailed study, e.g."Juglans" acuminata, Dicotylophyllum spp. (cf. Diospyros, cf. Lonicera, cf. Styrax). Preliminary palaeoenvironmental data suggest that the flora of Frankfurt represents humid temperate forest vegetation. Several relict taxa present in the flora have East Asian and to a lesser degree North American biogeographic affinities.

O099

BIOGEOGRAPHIC DISTRIBUTION: PATTERN AND PROCESS IN ROSACEAE FROM THE EARLY EOCENE OKANOGAN HIGHLANDS FLORA, BRITISH COLUMBIA, CANADA, AND WASHINGTON, USA.

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Cretaceous and Cenozoic plant localities in western North America provide the opportunity to explore the distribution of taxa through time and at differing latitudes. However, another factor that comes into play is elevation. The Okanogan Highlands flora of British Columbia and Washington is a Northern Hemisphere, higher elevation site with taxa that we recognize today as temperate, and in many cases the earliest known. Many plants in this flora have Asian relatives today. At the same relative time and latitude, coastal floras in Washington include megathermal "tropical" elements (e.g., palms & tree ferns in the Chuckanut flora near Bellingham).

The Okanogan Highlands flora, best known from Republic, Washington, is a lacustrine site of latest early Eocene, that contains a combination of 1) fossils that show features suggesting modern generic affinities and 2) mosaic taxa. Wolfe & Wehr (1987) noted that Rosaceae were particularly well represented. Present day Rosaceous taxa that occur in the Republic flora show several biogeographic distributional patterns today: 1) cosmopolitan (*Prunus*, *Rubus*); 2) Asian (*Photinia*); 3) Pacific Coastal endemics (*Omelaria*, *Stonebergia-Chamaebatiaria-Lyonothamnus* group); 4) chaparral Rosaceae (*Vauquelinia, Hesperomeles*, *Cercocarpus*; and 5) the unusual disjunct distribution between Mt. Shasta, California and southeastern North America of *Neviusia*, part of the mostly Asian Kerrieae.

We are interested in the driving evolutionary forces enabling these and other taxa to radiate and obtain today's distributions. They include: hybridization (e.g. *Sorbus*), dormancy mechanisms (*Cercidiphyllum*; *Zizyphoides, Tetracentron*); nitrogen-fixing bacteria *Frankia* (*Alnus*, *Lyonothamnas*) and extensive vegetative reproduction (e.g., *Rubus*). As we look at distribution patterns in modern Rosaceae we see that some herbaceous lineages have radiated into the tropics where they are represented by woody invasive plants. We have also noticed that not all fossils originally thought to be roseaceous may actually represent other important families including Anacardiaceae, Sapindaceae and Urticaceae. Taxonomic identification is critical to the understanding of biogeographic distribution.

O100

NAMING OF WHOLE PLANTS IN PALAEOBOTANY – CASE STUDY FROM CRETACEOUS

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Naming of whole fossil plants still remains as a problem in palaeobotany. Several solutions are used with particular difference between approaches in Cenozoic palaeobotany and Mesozoic and Palaeozoic palaeobotany. Nomenclatural solutions are difficult and typically not functioning in the later cases, particularly when the principle of priority does not work. I use here one of the ideas of Bill Challoner who suggested the names should be informal staying out of the nomenclatural rules. A case study on Cretaceous whole plants is going to be performed using this informal naming with the only **principle of taxonomic importance** – a criterion indicating the importance of the organ for systematic positioning of the "whole plant" in the tree of life (it will usually be the name of reproductive structure or anatomically preserved stem). In other words, the first taxon in the list should bear the highest number of diagnostic characters that are important for its classification, and allow the most precise attribution of the "whole plant" to a certain systematic group.

O101

THE INEVITABLE SEED: A CRETACEOUS PERSPECTIVE

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A multitude of fossil seeds, mostly derived from angiosperms, but also from a variety of gymnosperms including Bennettitales, Erdtmanithecales, Gnetales and many conifers, provide evidence of reproductive biology in seed plants during the major ecological turnover that followed the Early Cretaceous radiation of angiosperms. Seeds from Early and Late Cretaceous mesofossil floras were studied for external and internal features using synchrotron based X-ray microscopy. In these floras, seeds of angiosperms are typically small and show great morphological and anatomical disparity already in the Early Cretaceous. Angiosperm seeds are typically bitegmic with the protective tissue in the outer integument. Cretaceous seeds belonging to the chlamydospermous clade have a functional similar protective outer layer, but it is developmentally distinct in these non-angiospermous seed plants. The small seed size of early angiosperms coupled with their tiny embryo and strongly limited nutrient storage tissue corroborates suggestions that early angiosperms most likely had an r-type reproductive strategy colonising open disturbance-prone terrain and that this strategy was part of the initial success of angiosperms, while angiosperms with K-type reproductive strategy developed later and most obviously in the early Cenozoic. There is an interesting parallel with Chaloner and Pettitt's (1987) suggestion that the major force behind the evolution of the seed and consequent initial radiation of seed plants was competition for survival in Devonian and Carboniferous plant communities with a pressure for larger food storage and a shift from r-type reproductive strategies in spore-bearing plants to K-type reproductive strategies among early seed plants.

O102

DIVERSITY AND HOMOLOGIES OF CORYSTOSPERM SEED-BEARING STRUCTURES FROM THE EARLY CRETACEOUS OF MONGOLIA AND CHINA.

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New discoveries of corystosperm seed-bearing structures from the Tevshin Govi locality in the Early Cretaceous (Aptian–Albian) of Mongolia document that the individual ovulate units of *Umkomasia mongolica* were borne in a loose cone, as also documented for the very similar reproductive units of *Doylea tetrahedrasperma* Stockey & Rothwell. New material from the Tevshin Govi locality also documents two further species of *Umkomasia* that most likely grew in a slightly different environment to *U. mongolica*. It is likely that these species had simple leaves referable to *Pseudotorellia*. The occurrence of three different *Umkomasia* species in the Early Cretaceous of Mongolia, together with specimens preserved in a recently discovered Early Cretaceous chert from Inner Mongolia, as well as other records from the Early Cretaceous of the Northern Hemisphere, indicate that previous concepts of corystosperms, based mainly on material from the Southern Hemisphere, need to be significantly revised. The consistent reproductive architecture of the seed-bearing structures in all of the corystosperm materal from Mongolia and China, with a bract subtending a variously modified axis bearing ovules, is similar to the situation several previously described fossils, as well as extant *Ginkgo,* conifers and Gnetales. These underappreciated architectural commonalities among the reproductive structures of several major groups of seeds plants are likely significant for a deeper understanding of seed plant evolution and require further exploration.

O103

FRENELOPSIS, A SWISS-KNIFE PLANT PROXY OF CLIMATE AND TERRESTRIAL ECOLOGY DURING THE CRETACEOUS

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How to gain insight into past climate and ecology from plant fossils has been a major concern of palaeobotanists during the last decades. Prof. Chaloner was one of the main leading minds in this field, leaving a heritage of innovation and creative thinking in the use of plant fossils as palaeoproxies. His legacy has inspired numerous research lines focused on the establishment of relationships between plant traits and a wide range of environmental factors, the amelioration of traditional proxy methods, and the extraction of valuable information on climate evolution during the Earth's history. We centre our efforts in reconstructing terrestrial ecosystems and climate evolution during the Cretaceous based on the fossil conifer *Frenelopsis* Schenk. The genus had a worldwide low-latitude geographic distribution along a wide diversity of ecosystems, during most of the Cretaceous (*ca*. 75 Myr). It survived several critical climate change events and the Cretaceous Terrestrial Revolution (KTR; 125–80 Mya) that was associated with a marked biodiversity turnover and, particularly, the rise to dominance of angiosperms. *Frenelopsis* represents, thus, an opportunity to draw valuable conclusions on the feedbacks between ecosystem and climate evolution all along one of the most critical periods of the Phanerozoic, from just one Swiss-knife plant proxy. We perform an integrative multidisciplinary approach based on taxonomy, plant ecology, functional morphology and stable isotope geochemistry to fine-tune *Frenelopsis* as a proxy and to use it to reconstruct plant community dynamics and atmospheric CO_2 evolution during the Cretaceous.

O104

NEW INSIGHT OF THE MORPHOLOGICAL VARIATION IN MIOSPORES WITH MICRORETICULATE-FOVEOLATE SCULPTURE

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Morphological differences between miospores with microreticulate and foveolate sculpture often seem to be ambiguous. This is due to the high diversity and variability of sculptural types within and between species. Traditional descriptive morphological terms such as "scrobiculus", "foveola", and "lumen" are without strict definition and can be confused. A lack of precise understanding of the morphological variation within some genera and species has resulted in the doubtful taxonomic status of some of these miospore taxa. In order to define quantitative boundaries for qualitative terms (e.g. of sculpture types) a numerical typification has been applied. This approach was introduced by Vezey and Skvarla (1990, 1994) who used image analysis to segregate perforated exines of angiosperm pollen grains.

Material for the present study was a monotypic assemblage of miospores of the *Microreticulatisporites*-type from the Upper Visean of the Moscow Syneclise, Russia. Analysis was carried out using combined methods of optical light microscopy (LM), scanning-electron microscopy (SEM) and confocal laser microscopy (CLSM) for the first time. Observed miospore specimens demonstrate a range of features of the "microreticulate" exospore. There are numerous circular perforations ("scrobiculae") on the surface of the exospore. LM and SEM photomicrographs show that these perforations have diameters of 0.2 (0.48±0.09) 1.0 µm. The distance between the edges of perforations is 0.54 (0.89±0.16) 1.35 µm. The average diameter of the perforations is less than the average distance between perforation and thus, the studied miospores do not have a microreticulate sculpture. They therefore do not belong within the genus *Microreticulatisporites* which is defined as microreticulate or reticulate. The SEM photomicrographs show that the polygonal depressions (meshes) are formed by the junctions of tapered muri. The average diameter of the depressions is variable, being 1.3 (1.8±0.27) 2.8 µm wide. The average diameter of the depressions is greater than average width of the muri meaning that the large depressions should be considered as true lumina. Each circular peforation ("scrobiculus") is enclosed in a polygonal depression ("lumen"). Virtual cross-sections and reconstructions provided by CLSM show the existence of funnel-shaped "tunnels" that are clearly preserved in the deeper part of the exospore bearing the complex sculpture.

Differences between the microreticulate and foveolate sculpture patterns have been defined using quantatitive and qualitative parameters. As a results of our studies, a new sculptural type has been identified. This aids in separation of microreticulate and foveolate sculptures.

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0105

CORRELATION OF PALYNOMORPH DARKNESS INDEX (PDI) TO OTHER THERMAL MATURATION INDICES SUCH AS VITRINITE REFLECTANCE (R_o) AND SPORE COLOUR INDEX (SCI)

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Palynomorph Darkness Index (PDI) results are presented for three palynomorph groups, the acritarch *Veryhachium* spp., and the miospores *Lycospora* spp. and small *Punctatisporites* spp. All samples investigated are of known vitrinite reflectance (R_o), permitting basic correlation of these two techniques. Much larger datasets would be needed in order to establish precise PDI and R_o relationships as it is clear that, like palynomorph colour, PDI is a function not only of thermal maturity but also of palynomorph morphology and probably chemical composition. The PDI of two commonly used schemes for the qualitative assessment of palynomorph colour was also investigated; the Spore Colour Index (SCI), and the 'Pollen/spore Color Standard'. The former is calibrated by means of sets of individual palynomorphs, each typifying one of the points on the SCI scale, whereas the latter is based on a stated Munsell Colour for each step on its scale. PDI values for the 'Pollen/spore Color Standard' scale were calculated from the relevant Munsell Colours via equivalent Red/Green/Blue intensities (RGB), allowing approximate correlation of these maturity indices. However, determination of the PDI of each of the designated palynomorphs in a set of SCI standard slides revealed major anomalies, with some of the SCI steps in the incorrect sequence in terms of their measured darkness (PDI).

O106

CHANGES IN SPOROMORPH APPEARANCE WITH INCREASING MATURITY: A CASE STUDY FROM SOUTHWEST IRAN.

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This study focuses on the thermal maturity assessment of Permian sediments from the Zagros Basin, Southwest Iran, comparing optical and geochemical analyses of palynomorphs. The investigated surface and subsurface sections, Darreh Yas and Well-8 respectively, comprise the Faraghan Formation. This formation, widely distributed in the Zagros area, generally consists of shale intercalated with sandstone and pebble conglomerate, with thin carbonate intercalations near the top. The thermal maturity of organic matter from the Faraghan Formation was estimated using organic geochemistry (e.g. Rock Eval Pyrolysis; microRAMAN spectroscopy, etc.) and optical methods (Thermal Alteration Index - TAI. Spore Color Index - SCI, Palynomorph Darkness Index – PDI, Vitrinite Reflectance - VR). This study aimed to evaluate the effectiveness of PDI, a recently described, easy method for defining the thermal maturity of organic matter, based on the use of a transmitted light microscope with digital imaging capacity and software capable of simple image analysis. Rock-Eval Pyrolysis analysis from Well-8 showed that all core-samples fall within the oil window while the organic matter from samples of the Darreh Yas section is overmature with respect to oil generation. Similar results were obtained with MicroRaman spectroscopy and Vitrinite Reflectance determination. PDI values were calibrated with Rock-Eval Pyrolysis data from both the Darreh Yas section and Well-8. When all the data are plotted, PDI shows a generally positive linear correlation with Tmax, consistent with the increase of PDI with increasing maturity. PDI values are also consistent with the MicroRaman spectroscopy and Vitrinite Reflectance data. These results confirm the value of PDI as an independent, rigorous and easy method for the estimation of the thermal maturity of organic matter.

O107

BIOSTRATIGRAPHY AND DEPOSITIONAL SETTING OF PERMIAN DEPOSITS IN AJABSHIR AREA (CENTRAL IRAN BASIN).

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This study aims to a biostratigraphical and palaeoenvironmental characterization of a Permian stratigraphic succession cropping out in the Ajabshir area (North-western Iran). The continue and well-exposed section comprises the Vazhnan, Surmaq, Abadeh and Hambast formations. The Vazhnan Formation is characterized by quartzarenite with siltstone and shale intercalation. The overlying Surmaq Formation mainly consists of fossiliferous, dark limestone. Similar lithological features were recognized in the basal part of the overlying Abadeh Formation. The middle part consists of calcareous beds with silty intercalation. The Hambast Formation is characterized by an alternation of marly limestone and shales. The uppermost part of this formation is marked by the "Boundary Clay" representing the P/T horizon. Facies, microfacies and palynofacies analyses suggest that the Vazhnan Formation deposited in a coastal marine environment, the Surmaq Fm. and basal Abadeh Fm. in the inner and middle part of a mixed carbonate siliciclastic ramp, the upper Abadeh Fm. in the outer ramp and the Hambast Fm. in a more distal basinal setting. An integrated study based on palynomorphs and foraminifers has been carried out throughout the section. Only the Vazhnan Formation yielded a well preserved and diversified palynological assemblage. The microflora is marked by the presence of pollen grain as *Alisporites nuthallensis*, *Alisporites* spp., *Corisaccites alutas*, *Distriatites insolitus*, *Hamiapollenites dettmannae*, *Striatopodocarpites* spp., *Sulcatisporites ovatus* and *Florinites flaccidus, Plicatipollenites malabarensis*, *Potonieisporites novicus* and. palynomorph as *Reduviasporonites chalastus* is common. Trilete spore rarely occurs. Palynological assemblage shows close morphological similarities with OSPZ5 documented from the Upper Gharif Member in Oman and attributed to Roadian-early Wordian. No palynomorphs, with exception of the upper Hambast Formation, were recorded in the remain part of the succession. Nevertheless, the Surmaq and Abadeh formations were biostratigraphically characterized by the foraminifer content. The Wordian fusulind *Dunbarula simplex - Codonofusiella shubertellaeformis* Assemblage Biozone marks the overlying basal Surmaq Formation. The middle part of the Abadeh Formation records the *Ichthyofrondina palmata* Biozone. The most part of the Hambast Formation results to be barren both for foraminifers and palynomorphs. Only from the upper part of the formation, close the P/T boundary, *R. chalastus* has been found. The present biostratigraphic and sedimentological results provide new data for reconstructing the paleogeographic position of the Central Iran during this time interval, confirming recent studies considering the Central Iran as located close to Northeastern margin of Gondwana palaeocontinent during Guadalupian and at sub-equatorial latitudes during Lopingian.

O108

RESPONSE OF FIRE ACTIVITY TO HOLOCENE RAPID CLIMATE CHANGES, INFERRED FROM HIGH-RESOLUTION EUROPEAN CHARCOAL RECORDS

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Although generally perceived as climatically stable, the Holocene was characterised by a succession of abrupt, centennial-scale shifts, also known as rapid climate changes (RCCs). At mid to high latitudes, RCCs are described as cool events, often associated with a decrease in moisture and suggested to occur with periodicities of 1470 ± 500 years. However, evidence from multiple records indicates a wide-ranging manifestation of RCCs in Europe, with contrasting spatial characteristics and impacts. Yet, this evidence does not investigate the spatial sensitivity of fire activity to short-term Holocene climatic variations. Fire is one of the key natural disturbance agents, influencing terrestrial ecosystems and biodiversity, vegetation distribution and structure. Because climate is a dominant control on fire activity, regulating vegetation productivity and fuel moisture, here we sought to investigate linkages among fire and RRCs, using 7 high-resolution macroscopic charcoal records accross Europe. Information on vegetation and climate dynamics was extracted from published literature.

We address the following questions: i) Are there changes in burning patterns associated with the RCCs? Are these changes region-specific and/or site-specific? ii) To what extent the response of fire to RCCs is enhanced by local drivers such as vegetation composition, land-use change and/or humans? iii) Is there any statistical periodicity in the fire signal at the sites?

We found regional contrasting trends in fire activity, with northern regions burning more during the 10.3, 9.4, 5.9, 4.2, and 2.8 ka BP events, whereas continental regions during the 11.1, 8.2 and 1.4 ka events. This would suggest a strong forcing of the large-scale climate through changes in moisture availability, likely by a shift towards more southerly westerlies during the 10.3, 9.4, 5.9 and 2.8 ka events, and a weakening of westerlies during the 11.1, 8.2 and 1.4ka events. Fire response to RRCs in low fuel availability regions, such as C-E European lowlands, was stronger when fuel was more abundant, whereas in N and NE Europe the response was stronger when vegetation was dominated by more flammable species and with increasing openness. At the Holocene scale, spectral analysis results suggest there is a statistical periodicity in the fire signal, similar to the 1400 ± 500 year RCC cyclicity reported for the North-Atlantic Area. This periodicity was found in the 1300-1800 year band for the Early Holocene, the 700-1100 year band for the Late Holocene respectively.

Our findings provide new insights for understanding teleconnections in fire activity during RCC events.

O109

HOLOCENE FIRE HISTORY OF THE BRITISH ISLES

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Fire is part of the natural disturbance dynamics of many systems. Understanding of fire history and the key drivers of fire are increasingly important for those involved in conservation and management, including sites in the British Isles. There are many records from across the British Isles which record fire activity throughout the Holocene, however limited work has been done to assess if there are any spatio-temporal trends and the implications these may have for our understanding of fire as a natural disturbance mechanism. This study uses existing sedimentary charcoal records from across the British Isles to reconstruct Holocene fire history. This reconstruction will seek to address a key question asked by palaeoecologists and archaeologists about the nature of fire in the Holocene environment, specifically whether it is driven by anthropogenic activity or climatic change. Spatio-temporal analysis of this data provides evidence of a changing fire regime, with limited burning in the early Holocene, likely to have been driven by climate. The mid- to late Holocene reveals an increase in burning across much of the British Isles, followed by a marked decline in the last 500 years, indicative of anthropogenic influence.

O110

REGIONAL, LOCAL AND ANTHROPOGENIC VEGETATION AND CLIMATE CHANGES IN NORTH-WESTERN RUSSIA DURING THE HOLOCENE

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The new pollen, plant macrofossil and radiocarbon data from three peat bogs located in the area of the Polistovo-Lovatskaya Mire System (Pskov Region, northwest of the European Russia) were used for reconstruction of the Holocene vegetation history on local and regional levels. The mean annual temperature and precipitation were reconstructed from pollen data using the Best Modern Analogue technique. The obtained results show that the development of the Polistovo-Lovatskaya Mire System included several stages: 1) 10500-10000 cal yr BP, paludification of shallow lakes; 2) 10000-9400 cal yr BP, existence of floating mats and eutrophic mires; 3) 9400-6500 cal yr BP, mesoeutrophic mire complexes terminated with junction of separate peatlands to entire massive; 4) 6000-4000 cal yr BP, slow vertical peat growth; 5) 4000-1500 cal yr BP ombrotrophication process; 6) 1500 cal yr BP– present, the rapid vertical peat growth.

According to high resolution pollen records the study area was covered by birch and pine-birch forests between 10500 and 7700 cal yr BP, then the broadleaved forests occupied the region. The broadleaved trees reached the maximum abundance between 3500 and 2500 cal yr BP. During the Late Holocene spruce forests become dominant, the maximum of *Picea* pollen were detected at 2000, 1800-1000 and 800-400 cal yr BP.

The climatic reconstruction revealed several features, characteristic for Holocene in Europe such as “event 9400”, “event 8200” and considerable fluctuations in the Early Holocene. On the other hand, the Middle Holocene was stable warm until 2500 yr cal BP without expected cooling at ca. 5500 cal yr BP. The transition from mid-Holocene thermal maximum to the next period appears to be without considerable climatic transformations.

Evidences of human induced vegetation disturbance were identified in follow periods: 1) the Neolithic, 4,200-4,000 cal yr BP, first appearance of Cerealia pollen without increase of landscape openess; 2) the Bronze Age, 2,500-2,300 cal yr BP - the regular appearance of Cerealia pollen accompanied with the decrease of *Picea* and broadleaved tree pollen values; 3) the Early Medieval time, ca. 1000 cal. BP - the Slavic colonization with expansion of agriculture and continued degradation of primary forests; 4) the Late Medieval time, 400-500 cal BP, maximum of Cerealia pollen value and noticeable disturbance of the plant cover.

This work was supported by the Russian Foundation for Basic Research, grants 14-04-01405 and 17-04-01034

O111

THE VALUE OF COMPARING MULTIPLE SITES IN RECONSTRUCTING LANDSCAPE HISTORY: CLIMATE, VEGETATION AND HISTORY FROM TWO LAKES IN THE RIETI BASIN, CENTRAL ITALY

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The Mediterranean area is intensively affected by anthropogenic impact from human activities (i.e. grazing, forest cutting and fire), which started to alter natural systems over 10000 years ago. At the same time, human society has been influenced by natural climatic change. This mutual influence results in a complex interaction between humans and the environment that contribute to the development of vegetation history. During the last millennium, central Italy has been affected by intense human activities and climatic change that led to severe impact on the landscape. We present the reconstruction of the landscape history in the Rieti Basin through multi-proxy records such as pollen, non-pollen palynomorphs (NPP), charcoal, rock magnetism, palaeomagnetism, sedimentology, and geochemistry of cores from Lago Lungo and Lago di Ripasottile. The two lakes are remnants of an ancient bigger lake, *Lacus Velinus*, reclaimed by a system of artificial channels opened by the local population since the Roman period. The lakes are only 2 km apart and have been periodically connected by the channel system. Despite their close proximity and periodic connection, these lakes preserve different records of landscape change, potentially because Ripasottile has received higher inputs from the major river in the area, the Velino, and potentially because land-use practices were spatially highly variable. The Lungo sediments span 2700 years in 14.37m while Ripasottile has a higher sedimentation rate; 1300 years in 12.40m. The higher sedimentation rate in Ripasottile together with a higher percentage of chestnut pollen than Lungo, suggests greater inputs of fluvial sediment and pollen originating at higher elevations through the Velino River. Both lakes show a dramatic decrease in forest taxa percentage during the Medieval period (900-1400CE) and an abrupt increase during the early modern time starting around 1450CE. In contrast, the disturbance taxa, mostly related to agricultural and grazing activities, reveal a different human impact on the lakes. Ripasottile pollen spectrum is characterized by a high percentage of grass and disturbance taxa throughout the entire period of analysis, whereas the Lungo core shows phases dominated by woodland, phases dominated by grass and disturbance taxa, particularly during the Medieval period. The comparison between these two lakes confirms that human impacts on the environment are spatially heterogeneous, and multiple sites in addition to a multi-proxy approach are important to fully understand the dynamics and the response of the vegetation to climatic and human-induced change in a highly impacted environment such as the Mediterranean region.

O112

SEEING THE TREES FOR THE WOODS: DIVERSITY VS. DISPARITY IN MISSISSIPPIAN LIGNOPHYTE TREES.

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The Mississippian sees a major increase of the number of trees within the lignophytes, the clade that includes the now extinct progymnoperms and the seed plants. While they were only represented in the Devonian by the emblematic progymnosperm *Archaeopteris*, about 15 genera have to date been described in the Mississippian, mostly in volcanically influenced environments of the tropical belt. This informal and likely paraphyletic group of trees encompasses a great range of cortical and vascular anatomies and is a good candidate to compare systematic diversity and morpho-anatomical disparity in the plant fossil record. In this talk, we will more specifically explore some systematic, evolutive, and functional questions raised by the disparity of their wood anatomy.

We will first provide an overview of the significant wood disparity among these trees. They show a significant range of variation for important characters (tracheid diameter, radial pitting, ray size, etc), and some possess unique combinations of characters. In some cases their wood fits in the "classic" morphogenera *Agathoxylon* or *Dadoxylon*, others like *Dameria* or *Protopitys* are more comparable to Mesozoic morphogenera of uncertain affinities. The wood with small diameter tracheids and large rays up to 8 cells wide and over 100 cells high of large Mississippian trees such as *Pitus* or *Megalomyelon* has no equivalent among extant seed plants.

In a second step, we will look at these diverse wood anatomies in combination with other characters that have a stronger taxonomic value, especially primary vascular anatomy, and discuss how this raises important questions about plasticity, convergence, and biases in estimating plant diversity from isolated wood fragments. Different species within a genus of Mississippian lignophyte tree can have a different type of wood, especially in terms of ray size. On the other hand, several genera that differ widely in their primary vascular anatomy display a comparable wood anatomy. For example there are several genera that have a wood comparable to that of the different species of *Pitus* but that differ widely in terms of primary xylem strands number, size, maturation, as well the mechanism of leaf trace production, leaf trace anatomy and phyllotaxis, and/or bark anatomy.

Finally, we will discuss how this disparity compares to that of coeval non-arborescent lignophytes taxa and present future avenues of research investigating the functional properties of these woods.

O113

AFFINITIES AND HYDRAULIC PROPERTIES OF LATE DEVONIAN ARCHAEOPTERIDS FROM ANTI-ATLAS, MOROCCO

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The progymnosperm *Archaeopteris* (Archaeopteridales) formed widely-distributed forests in the Late Devonian and was the first arborescent genus showing a dense conifer-like wood. Nineteen species of *Callixylon* (a form-genus for anatomically preserved roots, stems, and branches of *Archaeopteris*) have been described to date based on wood characters, especially the structure and dimensions of the rays. It is believed that the success of *Archaeopteris* is partly associated with its well-developed wood which played a significant role in both water conduction and mechanical support. Here we investigate the relationships between the anatomical, systematic, and functional diversity of *Archaeopteris* through the study of a collection of specimens of *Callixylon* from the Famennian locality of Mader el Mrakib in Anti-Atlas (south-eastern Morocco). The affinities of two specimens showing sclerotic nests in the pith were examined using qualitative and quantitative data obtained from light microscopy and image analysis. While the two specimens show small anatomical differences interpreted as intra-specific variability, they share a combination of traits not found previously in *Callixylon*. They are assigned to *Callixylon wendtii*, a new species that falls within Orlova and Jurina's '*erianum*' group. This additional species reported from Mader el Mrakib suggests favorable conditions for the establishment of a diverse community of *Archaeopteris/Callixylon* trees in this part of Gondwana during the early Famennian.

Parallel to the systematic study, the hydraulic traits of the two specimens of *C. wendtii* were investigated using an analogy between hydraulic properties of conductive tissues of a plant and electric properties of an electronic circuit. We first used Wilson's mathematical model that assesses the conductivity of single tracheids based on anatomical measurements such as tracheid length and diameter, pit morphology and density. In a second step, putting some virtual tracheids together, we developed an extension of this model to the tissue scale. This new model allows us to take into account anatomical differences not visible at the single-tracheid level, such as tracheid density and the presence of rays of variable size. Indeed, while the hydraulic properties of a single tracheid are close between the two specimens of *C. wendtii*, application of the new model yields differences due to their intra-specific anatomical disparity. The comparison of hydraulic properties of the different species of *Callixylon* occurring at Mader el Mrakib suggests that the anatomical disparity of the wood resulted in a functional diversity within the genus, providing *Archaeopteris/Callixylon* trees the plasticity to adapt to various environmental conditions.

O114

ABIES: A DATABASE FOR SOFTWOOD IDENTIFICATION

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Softwoods constitute an important part of the plant macro-remains that are found within the Carboniferous to the most recent fossil deposits. Their taxonomical study is mostly made possible thanks to classical references (Philips 1948, Greguss 1955, Esteban 2004, Philippe & Bamford 2008). As for hardwoods, in addition to similar standard publications, a dedicated database has started being developed seven years ago (Insidewood - Wheeler 2011). Today, Insidewood constitutes a very useful and indispensable tool, which allows online identifications for extant and fossil hardwoods. Despite their abundance in fossil deposits, no tool dedicated to softwoods has been developed yet.

To fill this gap, we initiated the implementation of a softwood database, ABIeS, on the biodiversity collaborative management platform Xper3 (Ung et al. 2010). The descriptive model is mainly based on IAWA list of softwood features (IAWA committee 2004) but, we also propose original features linked for instance to cell size and cross-field characteristics. As a first step, we tried as much as possible to illustrate the softwoods diversity using local resources. Therefore, extant species were chosen among the one hosted at the MNHN-xylarium, Paris, whereas fossil species where chosen from the collection Boureau (UPMC, Paris).

We finally carried a global analysis of the database in order to better understand the softwood variability regarding systematics and ecology.

This project, although initiated within the CR2P in Paris has a collaborative aim. We invite all the researchers who are interested by the wood anatomy of extant and fossil conifers to join us.

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O115

DIVERSITY IN CENOMANIAN FORESTS : AN EXAMPLE FROM THE ENVIGNE VALLEY (VIENNE, FRANCE)

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In the last years, thousands of silicified wood fragments were collected from the middle Cenomanian of two localities in the Envigne valley, western France. These two plant fossil assemblages are exceptional for both the high species diversity and the exquisite tissue preservation as well as their association with animal remains. For instance, wood commonly found in contemporaneous deposits is there often preserved with medulla, bark or both. Teredinid bivalves with soft parts emerging out of some wood specimens were also observed.

As far as taxonomy is concerned, conifers are the most abundant and diversified with at least five taxa belonging to Araucariaceae, Cheirolepidiaceae, Podocarpaceae, and Pinaceae. They represent around 89% of the megafossils. They consist of large trunks transported into an estuarine or a nearshore environment. Besides less abundant, being around 11%, and of smaller diameter, Angiosperms have a higher diversity with at least seven taxa. In particular, a vessel-less angiosperm closely resemble the living Winteraceae. A few specimens, around 0.1%, correspond to the emblematic Cretaceous tree fern *Tempskya* Corda.

Although angiosperm pollen grains and leaves have been frequently reported from the Cenomanian of western France, contemporaneous wood described so far mostly consists of lignite and conifer genera. These two new plant fossil assemblages are thus of great interest in our knowledge of the record and rise to dominance of Cretaceous angiosperms in Europe and worldwide.

O117

FOSSIL *CERCIS* L. (LEGUMINOSAE) FROM THE EOCENE OF WESTERN NORTH AMERICA AND THEIR PHYTOGEOGRAPHIC AND PALAEOCLIMATIC IMPLICATIONS

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Improved understanding of the fossil record of *Cercis* L. provides the basis for reconstructing the evolution and the radiation of Caesalpinoideae. The genus can now be traced back to the late Eocene of western North America on the basis of fossil fruits and foliage from Oregon and Colorado.

We present a new occurrence of *Cercis* leaf fossils from Teater Road, Oregon (~36 Ma), that conforms to the species *Cercis parvifolia* Lesquereux, previously recognized from Florissant, Colorado (~34 Ma). Associated pods of *Cercis herbmeyeri* sp. nov. represent the earliest confirmed fossil fruits of *Cercis*. In their indehiscent pods with a winglike flange along one margin, the fossils correspond to the main clade of *Cercis* rather than to the phylogenetically distinct extant species *Cercis chingii* Chun. The late Eocene records have a lamina shape consistent with a mesic habitat but relatively small leaf size, which might indicate adaptation for more seasonal conditions.

A review of other occurrences that we accept from the literature indicates that *Cercis* was established by the late Eocene and that the genus was widespread in the Northern Hemisphere by the Miocene, although some earlier paleobotanical reports must be rejected.

O118

EXTRACTING BIOGEOGRAPHIC/ECOLOGICAL SIGNAL FROM PAPILLATE CUPRESSACEAE (FORMER TAXODIACEAE) POLLEN – POSSIBILITIES AND LIMITATIONS

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The subfamilies Sequoioideae, Taxodioideae, and Cunninghamioideae within the Cupressaceae are frequently found as dispersed pollen in the Cenozoic record. Today, the genera of these subfamilies occupy distinct ecological niches and therefore are considered reliable environmental proxies. Moreover, they show highly disjunctive extant distributions. It has long been known that the modern distribution is relictual and therefore the presence of these taxa in the fossil record has limited biogeographic information. In contrast, it is commonly assumed that (i) papillate cupressaceous pollen can be identified to genus level and (ii) that ecological niches of extant taxa can be extrapolated to fossil taxa. Studies by Schneider (1992) and Dolezych & Schneider (2007) on *in situ* wood and dispersed cuticle samples from Miocene lignite mines indicated that *Cryptomeria*, *Sequoia*, and *Cunninghamia* thrived in habitats not realized by their extant relatives. Further, in this study, pollen of extant Cunninghamioideae [*Cunninghamia konishii* Hayata, *C. lanceolata* (Lamb.) Hook], Sequoioideae [*Metasequoia glyptostroboides* Hu & W.C.Cheng, *Sequoiadendron giganteum* (Lindl.) J.Buchholz, *Sequoia sempervirens* (D.Don) Endl.], and Taxodioideae [*Cryptomeria japonica* D.Don, *Glyptostrobus pensilis* (Staunton ex D.Don) K.Koch, *Taxodium distichum* (L.) Rich., *T. mucronatum* Ten.] was investigated using LM and SEM. The main aim was to document the highly uniform pollen morphology of this group of papillate pollen and, secondly, to compare the observed patterns of morphological variability with the fossil record. So far my studies showed that unambiguous determination to the genus level of dispersed fossil papillate pollen, even when investigated with SEM, is in most cases impossible. A few exceptions are exceptionally well preserved pollen. Hence we have to conclude that the biogeographic and ecological signals of fossil papillate taxodiaceous pollen is broad and not as well defined as commonly assumed. This needs to be taken into consideration when using taxon based methods to infer palaeoenvironments and biogeographic patterns.

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O119

THE EARLY MIOCENE (BURDIGALIAN) FLORA OF KIMI (EUBOEA) REVISITED: BIOGEOGRAPHY AND PALAEOECOLOGY

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The Burdigalian flora and fauna of Kimi (Kumi), municipality Kimi-Aliveri, Euboea, Central Greece, have been intensively studied by vertebrate palaeontologists and palaeobotanists. The age of the plant-bearing strata is well-constrained by micromammals and is considered to be Burdigalian in age. While the carpological record (fruits and seeds) of the Kimi-Aliveri Basin has been investigated in more recent times, the macrofossil record (dispersed leaves) has not been revised since the early publications by Unger and Saporta in the 19th century. A preliminary revision has been undertaken while preparing a field guide for the 6th EPPC in Athens in 2002. Here, I present newly excavated material from the Burdigalian Kimi section. I describe the Kimi flora in terms of abundance of different taxa, taphonomy, and broad biogeographic affinities of the plant taxa determined at least to family level. In particular, I focus on rare elements in the flora (cycads, Smilax, Berberis Group Orientalis, Mastixia, Tilia etc.) and how they are biogeographically connected to other Oligocene and Miocene floras of western Eurasia.

O120

POTENTIAL AND CONSTRAINTS OF TREE-RING RESEARCH IN LATE PALEOZOIC FOREST ECOSYSTEMS

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In modern forest ecosystems, tree-ring research encompasses a large field of analytical methods, which contribute to the understanding of plant physiological functions, forest growth dynamics, environmental disturbances and climatic variations, both in space and time. In the fossil record, dendrochronological and –ecological methods can be potentially applied, if 1) the trees were growing in a distinctly seasonal palaeoclimate triggering tree-ring formation, and 2) the fossil assemblage was formed within a short time period, e.g. T^0 assemblages. Two study sites from the early Permian Northern Hemisphere equatorial Pangaea are presented, located in South-eastern (Chemnitz Basin) and Western Germany (Saar-Nahe Basin), which fulfil the preconditions mentioned above.

The Chemnitz Fossil Forest represents a true, volcanically preserved T^0 assemblage of predominantly hygrophilous vegetational elements, which once grew in a "wet spot" ecosystem on an alluvial plain under seasonally dry conditions. Tree-ring analysis revealed plant-specific variations of ring morphology probably indicating different plant-physiological adaptations to seasonal droughts. Ring width variations suggest moderate environmental stress to the plants, but show significant periodical fluctuations in a scale of 10.6 yrs, which is interpreted as a signal of the 11-yr solar cycle. Additionally, scars in several stems shed light on various kinds of growth interruptions caused by severe environmental impact.

The second study site is part of the early Permian Donnersberg Formation in the Saar-Nahe Basin, and thus of similar age as the Chemnitz Fossil Lagerstätte. Petrified plant axes are preserved within a clastic mass-flow deposit with volcaniclastic components. The taphonomic situation is still under discussion, but comparison of tree-ring sequences seems to point to a T^0-like character. Compared to the Chemnitz Fossil Forest, tree-ring variations seem to reflect increased environmental stress during tree growth, which could be traced back to a variety of factors, such as water availability, sedimentary regime or topography.

In conclusion, results from both study sites show that tree-ring analysis can be an additional promising tool in environmental reconstructions of fossil terrestrial ecosystems.

O121

PALEOTRAITS AND PALEOPROXIES – THE LEGACY OF BILL CHALONER

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Bill Chaloner was a revolutionary in palaeobotany, particularly in the development and application of palaeoproxies. He was instrumental in the development of fossil charcoal proxies to reconstruct atmospheric oxygen content, stomatal density as a proxy for atmospheric CO_2 level and the use of wood anatomical traits as palaeoclimatic indicators. All of these palaeoproxy approaches rely on the observation and quantification of a fossil plant trait which has a known relationship with some abiotic factor, such as mean annual temperature, CO_2 concentration, seasonality etc. TRY, a neobotanical database of plant traits defines a trait as "morphological, anatomical, biochemical, physiological or phenological features of individuals or their component organs or tissues". The traits of plants and how they are geographically distributed and respond to climatic gradients are increasingly being used in a neobotanical context to better predict how ecosystems are likely to adapt to future global change. The majority of trait-climate studies use climatic gradients in geographic space as an analogue for temporal changes in that climate parameter. This approach is limited by the fact that concurrent changes in atmospheric composition cannot be captured in 'space for time' studies. The burgeoning development of palaeoecological traits which correlate with leaf-level or whole plant function, such as palaeotrait proxies for leaf mass per area and maximum stomatal conductance (G_{max}) are beginning to open up the possibility of investigating how ecological traits can adapt on evolutionary time scales and alter ecosystem function in response to climate change directly via phenotypic trait plasticity and/or indirectly through an alteration in the relative abundance distribution of species bearing those traits. This presentation will provide a review of recent advances in the development and application of palaeoecological traits and a demonstration of how they can be used in conjunction with palaeoatmospheric proxies to examine past ecosystem function, stability and change.

O122

STOMATAL FREQUENCY OF *QUERCUS GLAUCA* SAMPLES FROM THREE SOURCES SHOW THE SAME NEGATIVE RESPONSE TO pCO_2: A POTENTIAL PROXY FOR PALAEO-CO_2 CONCENTRATIONS

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The inverse correlations between atmospheric CO_2 partial pressure (pCO_2) and stomatal frequency [expressed as stomatal density (SD) or stomatal index (SI)] in many species of C_3 plants have been widely used to infer palaeoatmospheric CO_2 (palaeo-CO_2) concentrations. However, the results obtained have been quite variable. The application of multiple palaeo-CO_2 proxies to stomata of related fossils is essential to improve the robustness of palaeo-CO_2 estimates.

This study attempts to find a potential new proxy to estimate palaeo-CO_2 concentrations by analysing stomatal frequency in *Quercus glauca* (belonging to *Quercus* subgenus *Cyclobalanopsis*, Fagaceae), an extant dominant species of East Asia subtropical forests with abundant fossil relatives. The samples were collected from three sources: extant field samples collected from five individuals at each of 14 sites at altitudes ranging from 142 to 1555 m, i.e. pCO_2 32.89-38.84 Pa; historical herbarium samples collected from 18 specimens spanned a time period from 1930 to 2011, i.e. pCO_2 27.50 to 33.86 Pa; and seedlings growing for one year in the climatic chambers for CO_2-elevated experiment (four chambers with ambient air and CO_2 concentrations of approx. 400, 700, 1000 and 1300 ppm, respectively). A significant negative correlation between stomatal frequency and pCO_2 was found respectively for *Q. glauca* samples from these three sources. Moreover, calibration curves constructed by combined stomatal frequency of extant field samples collected along an altitudinal gradient and historical herbarium samples showed higher regression quality (SD = $-20.33pCO_2 + 1308.05$, R^2=0.652, P < 0.001; SI = $-0.32pCO_2 + 22.93$, R^2=0.645, P < 0.001) than the separate ones because the combined curves expanded pCO_2 range.

There have been few studies to use these three sources of plant samples to investigate the responses of stomatal frequency to pCO_2. *Quercus glauca* shows the same response for samples from these three sources, indicating that it is sensitive to changes of pCO_2 and is a good potential proxy for palaeo-CO_2 levels. *Quercus* subgenus *Cyclobalanopsis* plants are very common in the Cenozoic of East Asia; they have successive fossil records from the Eocene to Pliocene and have become one of the dominant taxa in East Asia subtropical forests since the Miocene. These fossils provide ideal material to use the combined inverse SD/SI-pCO_2 correlations in *Q. glauca* to reconstruct palaeo-CO_2 concentrations during the middle to late Cenozoic.

O123

USING PLANT GAS-EXCHANGE PRINCIPLES TO RECONSTRUCT CO_2: EXPLORATION OF A METHOD AND APPLICATION TO THE END-CRETACEOUS AND EARLY PALEOCENE

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Franks et al. (2014, *Geophysical Research Letters* 41: 4685-4694) developed a method for estimating atmospheric CO_2 that harnesses the feedbacks that link leaf assimilation rate, leaf conductance, and the CO_2 gradient between the atmosphere and intercellular spaces. The three required measured inputs are stomatal density, stomatal size, and leaf $\delta^{13}C$. Advantages of the method include: it is explicitly mechanistic; most stomatal-bearing vascular species can be used, including species where one or more of the measured inputs is insensitive to CO_2 (e.g., stomatal density); and uncertainties in the CO_2 estimates remain well-bounded, even when estimated CO_2 is high.

Here we test in living plants model performance. The average error rate among 54 species of ferns, gymnosperms, and angiosperms, 11 of which we grew at both ambient and elevated CO_2, is ~20%. This compares favorably to other paleo-CO_2 methods and is smaller than the propagated uncertainties associated with individual estimates (typically around +35% / -25% at 95% confidence). Leaves that grew in the lowermost 1-2 meters of closed forest canopies (tropical and temperate) often yield high CO_2 estimates. This is because in these microenvironments—relative to global values—air $\delta^{13}C$ is lower and CO_2 concentration is higher. Using a two-end-member mixing model, we show that the model is working as expected for these leaves. Finally, we test the sensitivity of the model to air temperature, which can affect assimilation rate and the CO_2 compensation point; the latter is used in the model to help calculate the relationship between atmospheric CO_2 and assimilation rate.

We use the model to reconstruct CO_2 across the end-Cretaceous extinction event. Fern leaves from the "fern spike" layer (10^2-10^3 years after the bolide impact) record a 200 ppm spike in CO_2 relative to pre- and post-extinction values. The magnitude of this spike is consistent with carbon cycle models that simulate various carbon release scenarios (e.g., volatilization of carbonate bedrock from the Chicxulub region, global wildfires, and Deccan volcanism). We also use the model to reconstruct CO_2 from the early Paleocene (64.5 Ma) Castle Rock rainforest near Denver, Colorado. Estimates from three species are ~700 ppm and are similar to estimates based on two other methods (liverwort $\delta^{13}C$ and a different plant gas-exchange method). These elevated CO_2 values are in keeping with the known global warmth at this time.

O124

VEGETATION-FIRE FEEDBACKS AND THEIR INFLUENCE ON PALAEOATMOSPHERIC OXYGEN

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In 1989 Bill Chaloner published a paper in the Journal of the Geological Society that linked the oxygen dependence of combustion to the occurrence of wildfires over the long evolutionary history of plants. He commented that "If the oxygen content of the atmosphere ever fell below this [13-15% oxygen], wildfire presumably would have ceased". He went on to suggest that fossil charcoal therefore provided "a constraint on palaeoatmospheric oxygen levels". The presence of fossil charcoal has since been used to test (e.g. Belcher and McElwain, 2008) and constrain (Glasspool and Scott, 2010; Belcher et al., 2010) model estimates of palaeoatmospheric oxygen. This fire-oxygen linkage has led Earth system modellers to propose that the global regulation of atmospheric oxygen depends on carbon burial which is in part linked to the dependence of fire on pO_2 and its suppression of land vegetation (Watson and Lovelock 2013; Lenton, 2013). In this talk I will present work that builds on Bill's insight in which we show that major evolutionary changes in ecosystems and their influence on fire regimes has altered the strength of 'fire feedbacks' thus affecting atmospheric O_2 levels. We focus on the shift from gymnosperm to angiosperm-dominated ecosystems, which occurred during the Cretaceous period, and which have been shown to have altered wildfire dynamics (Belcher and Hudspith, 2016). We show using biogeochemical modelling that this led to tighter regulation of atmospheric pO_2, reducing its long-term variability through to the present day.

O125

PALYNOLOGICAL DATING OF THE KAROO SEDIMENTARY ROCKS OF THE MOATIZE - MINJOVA BASIN (N'CONDÈZI REGION) IN MOZAMBIQUE

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Karoo sedimentary rocks are well represented in Mozambique in various sedimentary basins, located along the Zambezi River valley in Tete Province, Central-West Mozambique. The Moatize-Minjova Basin is one of these basins which sedimentary successions are regarded as the key stratigraphic sections for the Lower Karoo Supergroup in Mozambique, including from base to the top the Vúzi, Moatize and Matinde formations. This basin is also important due to its world-class coal resources and reserves present in the Moatize Formation. However, the palynology from the Lower Karoo successions in Mozambique has not been comprehensibly studied and only few published papers are known (Pereira et al., 2016; Götz et al., 2017). In this work we present preliminary palynological data obtained from an extended stratigraphic section (ca. 1000 m thick), in borehole A1TM-058 drilled for coal exploration in the N'Condèzi region, of the Moatize-Minjova Basin. The entire borehole consists of interbedded shales, carbonaceous shales, coals seams and sandstones. This borehole is one of the deepest drilled in this region and penetrated at the base the Mesoproterozoic gabbros and anorthosites of the Tete Suite making the basement rocks. Therefore, the core of the borehole may represent all the stratigraphic units of the Lower Karoo in the Moatize-Minjova Basin. We studied shales and carbonaceous shales of the first 100 m at the top of the borehole, which yielded well-preserved palynomorphs characterized by pollen grain as *Guttulapollenites hannonicus*, *Lueckisporites virkkiae* and *Weylandites lucifer*, *Polypodiisporites* spp. and verrucated monolete spores. This palynological assemblage let to refer the succession to Lopingian age.

Due to this unique condition, the extended section preserve in the core of this borehole, offers a rare opportunity to know not only the age of the stratigraphic units of the Lower Karoo in this basin, but also may provide and important record of the environmental and climatic changes that occurred during the time span of the Lower Karoo. For example, these studies may provide a better understanding of the palaeoenvironments of the coal facies and time constraint the end of the Late Palaeozoic glaciation in this region.

Keywords: Karoo, Mozambique, Palynology, Coal, Permian

O126

EARLY PENNSYLVANIAN-EARLY PERMIAN (BASHKIRIAN-ASSELIAN) MIOSPORE ASSEMBLAGES OF THE CZECH PART OF THE INTRA-SUDETIC BASIN

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The stratigraphical interval covers Serpukhovian to Gzhelian strata, i.e. 25 million years. Palynological data in the Žacléř, Odolov and Chvaleč formations that span radioisotopically constrained ~ 21 Ma long interval; middle Bashkirian to early Asselian times, (between 318 and 297 My). The miospore assemblages are characteristic by occurrences of stratigraphically important genera (e.g., *Waltzispora, Radiizonates, Tripartites, Kosankeisporites, Gillespieisporites, Cadiospora, Angulisporites, Latensina, Lueckisporites, Spinosporites*). In all, 77 genera and 317 species have been identified. These are mostly miospores; pollen of seed plants are very rare, represented mainly by cordaitaleans, walchian conifers and rare peltaspermalean and/or gingkoalean plant producers. Pollen of other pteridosperms (e.g. medullosaleans) are absent, although these plants dominate in abundancy and diversity compression floras associated with coals.

Two main trends through the profile can be recognised. The first is increased percentage of monolete miospores and pollen from the Yeadonian to the Autunian and the second is prominent increased number (not appearance) of smallest monoletes within the Jívka Member. The boundary between the Svatoňovie and Jívka members represented the most important change because dispersed spore and pollen assemblages significantly differ mainly in appearance of coniferalean and gingkoalean pollen together with rapid abundance of marattialean miospores.

Some groups of miospores and pollen increased from the Lampertice to the Jívka members, i.e. sphenopsid, marattialean, coniferalean, cordaitalean, gingkoalean and unknown affinity and others have decreasing curve, i.e. spores of lycophyte, zygopterid and botryopterid genera.

Yeadonian to Duckmantian represents ~ 6 My coal-bearing interval of ecological and species stability when wetland habitats including peat swamps dominated basin lowland. Changes in species composition between neighboring cyclothems were mostly below 5% of all miospore taxa. Arborescent lycopsids were on maximum of their diversity and abundancy. Diverse were also pteridosperms and ferns. There are no indications of presence of dryland floras in this interval neither in miospores nor in plant compressions. Proportion of dryland habitats in coal-bearing interval increases during Late Pennsylvanian. Dryland flora is first recorded in miospores by presence of *Vittatina* pollen in the Bolsovian strata. Earliest evidence of conifers is from plant impressions in late Asturian red beds. In the Saberian coal-bearing window conifer shoots and pollens occur in sediments directly associated with coals.

Palynological data indicate possible survival of lepidodendroid lycopsids into early Asselian times, although they remains have not been found so far.The research was supported by Research Program of the Institute of Geology ASCR (RVO 0679858231).

O127

BRITISH ZECHSTEIN PALYNOMORPHS SUGGESTS A WETTER LATE PERMIAN ENVIRONMENT

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The Zechstein Sea was a semi-isolated inland sea that occupied the Southern Permian Basin during the Late Permian (~255Ma). The sea endured at equatorial latitudes for 5 to 7 million years during which time it underwent five cycles of evaporation. In the context of an increasingly arid Late Permian climate, classic Zechstein reconstructions show cyclic regressions accompanied by evaporative down draw leading to hypersaline conditions. This resulted in dramatic short term reductions in biotic abundance and diversity in both the marine and terrestrial realms. However, it is hypothesised that transgression phases experienced sufficient precipitation to allow ecosystem recovery in both marine and terrestrial environments.

Palynological investigation of borehole material from northeast Yorkshire has yielded unexpected palynomorph abundance from the Carnallitic Marl Formation in the fourth cycle, and a similarly abundant assemblage from the Boulby Halite and Brotherton Formation of the third cycle. The palynomorph assemblage is dominated by taeniate and striate bisaccate pollen accompanied by monosaccates and trisaccates. Typical Late Permian taxa have been identified: *Lueckisporites*, *Protohaploxypinus*, *Taeniaesporites, Nuskoisporites*, *Perisaccus*, *Klausipollenites*, *Vittatina*, *Labiisporites*, *Vestigisporites* and *Illenites*. These taxa lend support to a transient gymnosperm-dominated late Zechstein Euramerican vegetation, dominated by phylogenetically advanced conifers, one to two species of ginkgophytes, and rare cycads, pteridosperms and pteridophytes.

Ongoing quantitative analysis of these assemblages is revealing changes in the vegetation structure throughout the Zechstein sequence. Analysis will reveal how the vegetation changed both in response to ariditisation within each cycle (intracycle responses), and to the effects of repeated cyclicity and overall Late Permian climate trends (intercycle responses). In addition, TEM analysis of pollen wall ultrastructure is underway to elucidate parent flora affinities for key pollen taxa. Not only will this allow for a more accurate ecological reconstruction but it will also contextualise the Zechstein vegetation with regards to the floristic changes occurring at the Palaeozoic-Mesozoic boundary.

The presence of such an abundance of palynomorphs questions previous assumptions that Late Permian equatorial climates were continuously arid. These findings suggest the climate was at times damp enough to support extensive gymnosperm forests despite the impending Permian-Triassic extinction event.

O128

LATE PERMIAN PALYNOFLORAL ASSEMBLAGES FROM THE *DAPTOCEPHALUS* AND *LYSTROSAURUS* ASSEMBLAGE ZONES, KAROO BASIN, SOUTH AFRICA: TAPHONOMIC WINDOWS INTO CLIMATE OSCILLATION

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The Karoo Basin of South Africa is reported to preserve the terrestrial ecosystem response to the "Mother" of mass-extinction events. Here, a reported turnover in vertebrate-assemblage zones, from assemblages dominated by *Daptocephalus* to those in which *Lystrosaurus* diversified, is envisioned as having been a consequence of increasing aridification and collapse of the Glossopteris community. The purported loss of plant fossils across the transition in vertebrate assemblage zones has been shown to be an effect of plant taphonomy, both lateral and vertical variability in depositional successions, and sampling efforts. *Glossopteris* leaves and fructifications are now known from the *Lystrosaurus* assemblage zone, indicating not only their persistence in the basin but also the presence of a seasonally wet climate. Higher resolution shifts in vegetational variance over the transitional interval, though, may be possible to resolve with palynofloras.

Previously published palynological assemblages from the upper *Daptocephalus* and lower *Lystrosaurus* zones are dominated by taxa produced by Glossopteridales (e.g., *Weylandites, Protohaploxypinus,* and *Striatopodocarpites*) and Sphenopsidales (*Columinisporites* and *Calamaspora*). These assemblages co-occur where megafloral remains of these clades are preserved in channel-fill sediments or associated with wetland paleosols. Background taxa, those occurring in low percentage, include Peltaspermales and Corystospermales (e.g., *Alisporites* and *Falcisporites*), and Conifers (e.g., *Lunatisporites* and *Lueckisporites*).

New palynological assemblages have been recovered from the Upper *Daptocephalus* assemblage zone in which the first calcic Vertisols from this stratigraphic interval are recognized. These palynofloras are not associated with any macrofloral assemblage. And although these exhibit a similar systematic distribution of representative taxa, preliminary data indicate that these clades differ in their proportions when compared with coeval assemblages. Nevertheless, all assemblages are comparable to that of the lower part of the western Australian *Protohaploxypinus microcorpus* zone, which is of Late Changhsingian age.

O130

ALNUS POPULATION DECLINE AND ITS CAUSES AT THE END OF THE FIRST MILLENNIUM CE IN EUROPE

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We report pollen-stratigraphical evidence for an abrupt, episodic, and widespread population decline of alder (*Alnus*), one of the most common boreal tree genera, during the Medieval Period in Europe. Decline of alder pollen values can be observed in tens of high-resolution pollen records from the North European Plain to Northern Europe, both in lake sediment and peat cores. The data suggest that the decline was roughly synchronous and most probably took place between the 9th to 10th century. Human impact is an unlikely cause of the decline because the decline is specific to alder and there is no evidence for a concurrent episode of human impact. It is possible that the decline was caused or influenced by a severe drought. Another potential cause is a sudden, widespread pathogen outbreak, especially as alder is known to be sensitive to the impacts of fungal pathogens, such as the oomycete *Phytophthora*. However, this suggestion remains inconclusive until direct evidence about the pathogen can be presented. The study provides an insight into vulnerability of the alder (mainly *A. glutinosa*) population in Europe, showing that a dramatic population decline can happen concomitantly over a large geographical region when the magnitude of external stressor exceeds a critical threshold.

O131

SOCIO-ECONOMIC CHANGES LEAVE THEIR FINGERPRINT ON A POLLEN DIAGRAM FROM HALKIDIKI (NC GREECE)

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The first inland palynological record from Halkidiki (NC Greece) constitutes a fine example of the interplay between archaeology/history and palynology. The palynological record from the coastal marsh of Tristinika situated near the town of Toroni, once one of the most important trade centers of ancient Times, reveals a continuous pastoral and farming (e.g. olive groves, cereals) activity. Pastoralism of ancient times up to the early Byzantine era provides feed sources for herds of goats and sheep through a regular burning of heath vegetation which proliferates on the acidic soils characterizing the area. Extended pastoralism accompanied by olive groves and crop farming sustains the prosperous city of Toroni (contributing and its peak one of the highest taxes in Delian League). The major humanitarian crisis of the Justinian plague (mid 6th- mid 8th century AD), spread through maritime commerce, strikes Toroni and the city eventually declines. Population flees to mountainous regions and human activity collapses. Mediterranean pine forests expand in areas previously grazed as both grazing and logging cease. The establishment of the monastic state in Athos mountain in the aftermath of the plague coincides with a feudal organization of the rural economy. Pastoralism shifts from sustaining large sheep and goat herds to small numbers of domesticated animals which are also fodder-fed thus weakening fire management of vegetation. Vegetation shifts from heaths to a more diverse state where oak forests play an important role as sources of fodder and charcoal. These oak forests retreat under the growing need for charcoal of the extended mining activity in north Halkidiki. In the mid-late Ottoman occupation pastoralism acquires a state close to that of ancient times as seminomadic settlers use fire to regenerate heaths and renew feed sources for their herds. Grazing takes place also around the marsh on arable fields owned by the monasteries. Olive groves and cereals constitute major farming activities while evidence of viticulture is sparse and most obvious during the Ottoman occupation. Both olive and vine products are well integrated in the religious rituals and customs of both settlers and monks justifying a general expansion of these groves.

O132

CLIMATIC AND LAND-USE CHANGES IN THE SOUTH CARPATHIANS: LATE BRONZE AGE ALPINE GRAZING AND SUBATLANTIC TIMBERLINE SHIFT

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Over the last decade, multiproxy paleoecological studies of four mountain lakes in the Retezat Mountains led to an unprecedented climate and environmental historical record of the South Carpathians for the last 16,000 years. These results have been summarized recently in Quaternary International. Building on them, this presentation focuses on the onset of alpine grazing in the Retezat Mts as inferred from the study of pollen, plant macrofossil, macrocharcoal, microcharcoal and sediment chemistry. We quantify the past intensity of grazing pressure by comparing surface pollen assemblages collected under different human-disturbance regimes in the mountains. A total of 10 relevés were surveyed and 19 surface pollen samples were collected from moss polsters and lake surface sediments. The human disturbance index (HDI) of each relevé was calculated according to the formula of Liu (2006). CCA analysis of the surface pollen assemblages suggested that HDI is mostly associated with Poaceae, Chenopodiaceae, *Filipendula*, Filicales and *Pteridium* in the surface pollen assemblages. Using this relationship, human impact indicator pollen types were determined in the fossil pollen assemblages and their relative frequency curves were used in conjunction with the macro- and microcharcoal curves and the geochemistry inferred erosion intensity records to evaluate human disturbance on both slopes.

Our results suggest that treeline and timberline decreased in the Retezat at ~3000 cal yr BP mostly triggered by July mean temperature decrease between 3300-2800 cal yr BP (inferred by chironomids). On the other hand, human impact became an important driver in both terrestrial vegetation and sediment geochemical changes over the last ~3400 years in the alpine zone of the northern slope, and since around~ 4200 cal yr BP in the alpine zone of the southern slope. On both slopes human impact indicator pollen types increased earlier in the alpine zone suggesting that mountain grazing started earlier in the naturally open alpine meadows, during the Late Bronze Age, and proceeded downslope in the Iron Age, from ca. 2650 cal yr BP. A period of frequent fire episodes occurred around 1900-1300 cal yr BP on the southern slope, suggesting that P. mugo shrubs were burnt to enlarge mountain pastures. One main conclusion of this research is that the exploitation of the mountain pastures started later in the South Carpathians relative to the Alps. Forest clearance by burning to increase grazing land was subdued in comparison to other European regions.

O133

THE LANDSCAPE HISTORY OF THE IMPERIAL HARBOUR OF ROME

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The ancient port built along the Tyrrhenian coast by Roman Emperor Claudius (mid of 1st Cent. AD) and enlarged by Emperor Trajan (beginning of 2nd Cent. AD) was Rome's principal maritime port. The remains of the port and of the town raised in the close vicinity are at present ca. 3 km away from the present coastline, in the Tiber delta. Historical sources report that the imperial harbour was excavated both in *terra firma* and in lagoons. The harbour town named *Portus* developed together with the port itself and expanded in the following centuries.

The study concerns two cores drilled in the dock and canale Trasverso of the Claudius harbour (Mazzini et al., 2011. J. Paleolimnol. 46: 243–256; Pepe et al., 2013. Quat. Int. 303: 73-81; Sadori et al., 2010. J. Archaeol. Sci. 37: 3294-3305) and one core taken in the centre of Trajan harbour, at present an artificial hexagonal-shaped lake. The chronological framing of the cores was carried out using magnetostratigraphy, radiocarbon dates, archaeological evidences and historical sources. The three cores, partly overlapping, cover different periods of time of the port history, from the middle of the first century onwards. Detailed sediment analyses were carried out on Trajan core.

Pollen, Non Pollen Palynomorph (NPP), microcharcoal and plant macroremain analyses are integrated by dinoflagellate cysts, ostracod and foraminifer analyses to provide a detailed reconstruction of the air and water environments.

The dock core shows the first phases of the harbour activities, recording first a marine and then a brackish environment. The plant landscape is typical of a coastal environment and appears rather preserved. The human presence is clear, but not of great impact outside the port area. The channel core (spanning a time period more recent than that of the dock core) records mainly a brackish water environment and a strong human impact related to the presence of Portus, the port town. The lake Trajan core shows the clear evidence of the huge works for the port excavation and records the history of the area also after the abandonment of the port and its isolation from the sea, even recording the reclamation of the area occurred in the early twentieth century.

The combined use of the different paleolimnological analyses allowed to disentangle between natural and human induced changes in the port management and in the history of Lake Trajan.

O134

POLLEN, SEEDS AND CHARCOAL AS EVIDENCE OF LOCAL ENVIRONMENT AND SUBSISTENCE AT THE EARLY MEDIEVAL STRONGHOLD AT POHANSKO NEAR BŘECLAV (CZECH REPUBLIC)

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Analyses of pollen, plant macro-remains and wood charcoal from archaeological contexts at Pohansko (CZ) were studied to supply information on the past subsistence and paleo-environment of this one of the central sites of the Great Moravian Empire. The site is today situated in the forested wetland environment (site is situated near the confluence of the rivers of Dyje and Morava ca 155 m a.s.l.) what facilitated hypothesis about its dependence in food supply from the farming hinterland.

Combined results of pollen and charcoal analysis indicate the presence of a mosaic of forested and opened landscape of mesophilous oak and the hardwood alluvial woodlands. Our evidence shows that these woodlands were exploited by man and were relatively opened. This is suggested by relatively high ubiquity of (both charcoal and pollen) shrubs of forest edges and forest opening (*Cornus*, *Euonymus*, *Corylus* and Pomoideae). The finds of charcoal of *Picea/Abies* and *Fagus,* species typical for higher altitudes regions are interpreted as probable collection of driftwood for fuel.

The pollen grains of *Juglans,* tree not native to the region, are constant in samples from this site. However, the absence of wood charcoal of *Juglans* does not (at present) support its local cultivation.

Despite intensive sampling for seeds, the recovered assemblage is limited and in majority formed by seeds of cultivated crops. Among them finds of cereals like millet (*Panicum miliaceum*), rye (*Secale cereale*) and wheat (*Triticum aestivum*) are the most numerous. Less common are oat, barley, lentil and flax. The SEM study of pollen grains proved and determined the same main types of cereals (*Triticum, Secale, Hordeum, Avena* and *Panicum*).

Very unique discovery represents recovery of pollen and charcoal of *Vitis*. The radiocarbon dating of the *Vitis* charcoal is 1225 +30 BP. Yet, it remains unclear whether the wood originate from wild or cultivated subspecies as it can not be distinguished based on wood or pollen morphology. If cultivated, this find would represent the earliest evidence of cultivation of grape vine in the Czech Republic. If wild, it would document the presence and native occurrence of *Vitis vinifera* subsp. *sylvestris* in the Czech Republic

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O135

COMPARATIVE MORPHOLOGICAL ANALYSIS OF *CEIBA* MILL. (BOMBACOIDEAE, MALVACEAE) POLLEN THROUGH FESEM, CLSM AND LM: A SACRED PLANT OF MAYA (MESOAMERICAN) CIVILIZATION

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Ceiba, used for ornamental landscaping in tropical regions of the world is a large tree found in tropical areas, including Mexico, Central America, South America, the Caribbean, West Africa and Southeast Asia. The present work communicates the detailed pollen morphology of four *Ceiba* species growing in India including one hybrid, *C. speciosa* (A.St.-Hil.) Ravenna, *C. insignis* (Kunth) P. E. Gibbs & Semir, *C.* x *insignis* (cross between *C. insignis* and *C. speciosa*) and *C. pentandra* (L.) Gaertn., using Field Emission Scanning Electron Microscope (FESEM), Confocal Laser Scanning Microscope (CLSM) and Light Microscope (LM) that may furnish the taxonomic characterization of these species as well as employ their finer morphological details to correlate them with other *Ceiba* spp., growing around the world. Pollen grain is 4-5-colporate, brevicolpate; sub-oblate to prolate-spheroidal to subprolate; sexine reticulate (muri provided with scattered spinuloid excrescences, lumina reticolumellate) and mostly thicker than nexine. The closely associated genus of *Ceiba* like *Bombax ceiba* (L.) is similar in pollen morphology as far as sexine pattern is concern with distinct pollen shape and size. Thus, an attempt has been made to correlate the pollen morphometry of the above species of *Ceiba* with red and yellow flower varieties of *B. ceiba* belonging to common subfamily, Bombacoideae. The multivariate principal component analysis (PCA) was applied on *Ceiba* and *B. ceiba* to quantified data obtained from pollen morphometrical analyses that clearly revealed a significant variation between different genus and species. A pollen key, based on these micromorphological data (especially pollen aperture and size of muri), is also presented for the *Ceiba and B. ceiba*. The study will improve precise identification of *Ceiba* pollen grains recovered in sediments, thus aid in pollen analysis of the Quaternary and pre-Quaternary deposits in India and also in other tropical and subtropical regions of the world. Besides, pollen preservation, evolutionary trend and palaeoecology are the other important implications of this study.

Key-words: *Ceiba*, *Bombax*, Pollen morphometry, Ornamental; Lucknow; India.

O137

CARPOLOGICAL AND LEAF PALAEODIVERSITY FROM THE PLEISTOCENE PORTO DA CRUZ SEDIMENTS (MADEIRA ISLAND, PORTUGAL): PRELIMINARY RESULTS

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Well age-constrained and taxonomically determined plant fossils are crucial for providing independent minimum ages for molecular phylogenetic dating. In oceanic Islands these are especially useful for taxa that evolved in insular ecosystems. In Macaronesian Islands, recent studies propose molecular dating for several plant families and genera, but these lack palaeobotanical support, due to the scarceness of palaeobotanical and paleopalynological studies. Here we reinvestigate the plant fossil bed of Porto da Cruz on Madeira Island (Portugal). This bed was discovered by J. Y. Johnson in 1859, and its flora was described by Oswald Heer (1809-1883); he discovered and described *Rubus* sp. leaves and *Carex* sp. leaves and fruits. In this study, we have revisited the fossil plant bed to gain a better understanding of preserved plant palaeodiversity. The flora is preserved within a sedimentary deposit that is overlain by a mugearitic lava flow 1.5 Ma-old (K-Ar dating). The deposit was explored for leaf and carpological fossils. Organic rich sediment was collected, dried overnight at 60°C, deflocculated with 3% H_2O_2, washed through a 300 µm sieve, and the remaining residue dried at 60°C. Plant fossils were hand-picked using a binocular microscope. Selected mesofossils were then washed in HF and imaged using a scanning electron microscope (SEM). Furthermore, X-ray micro CT (µCT) scanning was performed on selected mesofossils to visualise internal tissue preservation. Preliminary results reveal that >20 distinct carpological morphotypes are present in the sediments, many showing affinities to Chenopodiaceae, Urticaceae, Caryophyllaceae, Brassicaceae, Rubiaceae, Theaceae and Rosaceae. Leaf fossils include impressions and adpressions of Lauraceae, *Rubus* sp., *Equisetum* sp., *Woodwardia* sp., and three unidentified dicots morphotypes. µCT results indicate differential preservation, where external hard parts of seeds are preserved with tissue and cellular-level preservation, but endosperm and embryos are absent or poorly preserved. Further palaeobotanical and palynological exploration of this deposit coupled with $^{40}Ar/^{39}Ar$ dating of the underlying and overlying lava flows, will allow an age constraint for this flora, and provide important insights to Madeiran Pleistocene flora.

O138

NEW INSIGHTS INTO THE OCU FOSSIL FORESTS, PANAMÁ

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Understanding the vegetation of Panama prior to late Miocene is critical to evaluating the ecological consequences of the Great American Biotic Interchange. However, few studies have been conducted in that region apart from those associated with the Panama Canal expansion project and the Panama Canal Basin. One of the areas particularly rich in plant fossils is the Ocu town in the northern Azuero Peninsula. To date, only three studies have examined woods from Ocu. Stern and Eyde (1963), published the first account of the woods, and they reported three genera *Vantanea* (Humiriaceae), *Tetrathylacium* (Flacourtiaceae) and *Hernandia* (Hernandiaceae), with informal age data, inferred from geological maps of Azuero. Later, Herrera et al. (2014) erected a new Humiriaceae fossil wood genus and species, *Humiriaceoxylon ocuensis* gen nov. sp. nov. based on the same material that was identified as *Vantanea* by Stern and Eyde. Jud *et al*. (2017), identified ten new morphotypes documenting the first fossil evidence of Lauraceae and *Ficus* (Moraceae) from Panama. Other identified specimens include Arecaceae (*Palmoxylon*), Fabaceae (*Andiroxylon*), Euphorbiaceae, Sapindales (Burseraceae/Anacardiaceae) and Sapotaceae and two types with uncertain affinity, probably in the order Ericales. Previous studies have suggested the Ocu fossil forests were perhumid to superhumid tropical forest, contrasting with the drier (MAP < 1000 mm) regions of Panama that dominate the peninsula today. Recent fieldwork in the Azuero Peninsula evidenced the Ocu woods as detrital fragments of the clast-supported conglomerates from the Macaracas Formation (~ 30 Ma). We are developing a project funded by the Panama Secretary of Science to study wood systematics and to perform radiometric and biostratigraphic dating for the first time in the region. We have recently explored a new locality in Los Pozos, Herrera a little town ~37 km from Ocu centre. The exposures show subhorizontal agglomerates with clasts composed by chert, volcanic rocks and fossil woods *In situ*, suggesting the parental rock is part of the Macaracas Formation with estimated Oligocene age. We note that the distinctive pattern of axial parenchyma seen in *Andiroxylon barghornii* Jud et Dunham has been observed in several hand specimens found in the region. We have also identified a few specimens related to other Fabaceae, Anacardiaceae, Moraceae and a new Arecaceae different from the previously reported in other studies, documenting on the diversity of those enigmatic forests.

O139

NEW RESULTS ABOUT CAINOZOIC FOSSIL WOODS IN GREECE (EASTERN MEDITERRANEAN).

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During our recent palaeobotanical study of the Eastern Mediterranean (Lesbos and Lemnos Islands, Greece), new results on the Cainozoic fossil woods, both angiosperms and conifers, came out: a new methodology/identification key for the identification of lauraceous woods and especially *Laurinoxylon* species and their botanical affinities after the application of a series of criteria the last of which is the exact occurrence of the idioblasts (oil &/or mucilage cells); new types of *Laurinoxylon* and *Cinnamomoxylon*: *L.* aff. *czechense*, *L.* cf. *daberi*, *L.* aff. *diluviale*, *C. seemannianum*, and *L.* cf. *ehrendorferi*; the first identification of the genus *Cryptocaryoxylon* for the Neogene of Eurasia as revealed from the microscopic characteristics of two specimens from Lesbos and Lemnos Islands and especially from the distribution of their idioblasts. *Cryptocaryoxylon* has been reported in the literature only three times: a) with the species *Cryptocaryoxylon gippslandicum* from the Upper Eocene–Oligocene (39 Mya) of Australia, b) with the species *C. hancockii, C. meeksii* and *C. radiporosum* from the middle Eocene of Oregon, USA and c) with the species *C. oleiferum* from the late Pleistocene of Argentina.

Moreover our research has revealed new information about the palaeoenvironment of each locality regarding the a) palaeoaltitude of the fossiliferous localities in relationship with the findings, and b) the different types of fossilization and preservation.

The recognition of the remaining inconsistencies related to the material described over 100 years ago (from Lesbos Island) resulting in problems concerning the nomenclature and validity of the already known species, due to the lack of accompanied illustrations, type material (holotype), informative (detailed) descriptions and evidence about stratigraphy and exact location of the fossiliferous sites. This recognition was used as the corner stone for the first accurate interpretation of *Cedroxylon lesbium* from Sigri (Petrified Forest area, western peninsula of Lesbos Island), hosted at the collections of the Natural History Museum of Vienna, Austria, its comparison with *Cedroxylon*, with the living *Cedrus* species and the recently proposed combination: *Taxodioxylon lesbium*. The first reports of woods of taxodiaceous Cupressaceae from Lemnos Island have been also documented.

O140

NOVEL SUITE OF TRAITS REFLECTING HEMIPARASITISM IN THE WOOD OF XEROPHYTIC *KRAMERIA LAPPACEA*: PRELIMINARY RESULTS

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Krameria lappacea is a hemiparasitic shrub thriving in the high-elevation cold deserts of Peru. Also known as the Peruvian rhatany, this shrub is a keystone species in an extremely arid habitat. Despite its economic value in the cosmetic and medicinal trade, little is known about this species, especially about its growth rate, longevity, and reasons for its ecological success. Here we show through the study of growth rings and anatomy in *Krameria lappacea* wood that its hemiparasitic habit likely has the greatest influence on its growth dynamics. In the wood of eight shrubs, cell dimensions and densities were measured, and standard dendrological indices were calculated using thin sections and macerations. The wood of *K. lappacea* has short vessel elements (mean length of 117 µm, n=30) and narrow vessels (mean tangential width of 20.25 µm, n=60), like most woody xeric plants. However, *K. lappacea* lacks the helical thickenings and grouped vessels that are found in other clearly xerophytic woods. Comparisons of growth ring widths in *K. lappacea* showed no significant correlation with mean annual temperature and precipitation for the 25 years under investigation (1985-2010), indicating a decoupling of *K. lappacea* growth and climate. In *K. lappacea*, the dendrological features of hemiparasitism are reflected in the indistinct or partially distinct growth rings, solitary vessels, and the absence of helical thickening or sculpturing, which are atypical of xerophytic woods. The wood anatomy of other dry-habitat hemiparasitic species, such as *Santalum album*, *S. spicatum*, *Olax madagascariensis*, *O. lanceolata*, and *Krameria cytisoides* is compared to that of *K. lappacea*. The dendrological suite of characters that these species share with *K. lappacea*, as well as the idea that this novel suite of traits could be indicative of hemiparasitism will be discussed.

O141

CRYPTOGAMIC GROUND COVERS—MODELS FOR EARLY SOIL ECOSYSTEMS?

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Cryptogamic Ground Covers (CGCs) are photoautotrophic communities that grow on the surfaces of soils, rocks and plants. They are made up of variable proportions of bryophytes, lichens, algae, fungi, and cyanobacteria, and they host various groups of animals, predominantly arthropods. Capable of tolerating widely varying environmental regimes encompassing extremes of aridity, temperature, and UV flux, CGCs are widespread today where they are thought to be responsible for an estimated 7% of net primary productivity and almost 50% of nitrogen fixation globally. They are increasingly regarded as models for the earliest soil ecosystems.

We are investigating the nature of CGCs and their impacts on the environment and soil formation during what is arguably the acme of their development. This followed the origins of land plants, recently estimated to lie in an interval between mid-Cambrian (~515.2 Ma) and early Ordovician (~473.5 Ma), and preceded the evolution of forest ecosystems during the mid-Devonian (~385Ma). Early plant-bearing deposits are mostly allochthonous, so we are focusing initially on the 407 million-year-old Rhynie cherts (Scotland, UK) because this biota is fossilised more or less *in situ* and the preservation of the organisms and their associations is exceptional.

The Rhynie cherts preserve a soil community that contains many of the components of modern CGCs, including small-stature cryptogamic plants with rhizoidal rooting systems, fungi, cyanobacteria, green algae, fungus-like oomycetes, and associated animals, including nematodes and a diverse community of arthropods. There is limited evidence for lichen-like associations, but more compelling fossils have recently been documented at contemporaneous sites elsewhere. Plant growth forms and symbiotic associations with fungi indicate that moss dominated CGCs—and especially peat forming systems—are not the best modern analogues. Liverworts are a more appropriate model for the plant component. Other key differences from many modern CGCs include the absence of annelids and ants; also absent were the most aggressive white rot lignin decomposing fungi of the Agaricomycetes, implying that there were key differences in the recycling of soil organic carbon. Myriapods and hexapods were primary detritivores, but the roles of many organisms in the formation of ancient CGC soils remain largely unknown. We are developing an approach to characterizing the Rhynie CGC based on comparative analysis using modern CGCs and a suite of analytical methods combining *in situ* imaging by X-ray micro-computed tomography and synchrotron tomography.

O142

SOILS OF THE PROTEROZOIC: THE INFLUENCE OF EARLY TERRESTRIAL MICROBIAL ECOSYSTEMS

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The Proterozoic was a time of great atmospheric, biospheric and climatic change on Earth: there was a transition to an oxygenated atmosphere in the Palaeoproterozoic, numerous 'Snowball Earth' events in the Mid-Late Neoproterozoic, and the evolution of the multicellular Ediacaran biota in the latest Neoproterozoic. The 'Boring Billion', a period spanning the entirety of the Mesoproterozoic, is termed so because of the apparent stability of environmental and tectonic processes, and the seeming lack of biological and atmospheric events. However, numerous recent studies have called this rather simple interpretation into question, and highlight the impact of a changing biosphere in the Mesoproterozoic: the evolution of the first eukaryotes around 1850 Ga, a high point of stromatolite diversity and abundance at 1200 Ma, extensive colonisation of microbial organisms into non-marine systems by 1000 Ma, and the controversial evolution of fungi and proto-lichens into the terrestrial realm by 900 Ma. But how did a developing and diversifying terrestrial biosphere affect weathering and palaeosol development, and, ultimately, Proterozoic palaeoatmospheres and geochemical cycles?

One such example comes from palaeosols associated with the failed 1100 Ma North American Midcontinent Rift. Sediments were deposited in fluvial, alluvial, lacustrine and debris-flow settings during syn- and post-rift depositional phases associated with the failed rifting event. Today, these sedimentary rocks, often interbedded with basaltic lava flows associated with rift volcanics, outcrop in the Lake Superior region of the USA. They contain evidence of weathered floodplain units, which includes decimetre to multi-metre palaeosols that developed during periods of depositional quiescence in low-energy alluvial settings. The paleaosols have physical and chemical characteristics similar to Phanerozoic Entisols, and display weak-to-moderate physical and chemical weathering features. In addition, there is physical and geochemical evidence of a truly terrestrial biosphere within the sedimentary units: microbially-induced sedimentary structures (MISS), calcitised remains of non-marine microbialites, as well as $\delta^{13}C_{org}$ isotopic signatures indicative of photosynthetic carbon fixation from thin organic laminations. Mass balance calculations using palaeosol geochemical data indicate palaeoatmospheric CO_2 was low at 4-6x pre-industrial atmospheric levels, and suggests that Mesoproterozoic CO_2 trends are mimicked by palaeosol weathering trends. Despite these interpretations, ascertaining a biologically-mediated origin as the driver of weathering remains complex. Could the (seemingly low) atmospheric CO_2 levels have been the driver of exaggerated hydrolysis reactions which resulted in abiotic mineral weathering (via acid rain-like processes), or could an expanding Mesoproterozoic terrestrial biosphere provide an example of early biologically-mediated weathering and soil development?

O143

CHARACTERISATION OF EARLY SOILS BENEATH A MIDDLE DEVONIAN FORESTED ECOSYSTEM FROM NEW YORK STATE.

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The evolution and radiation of trees during the Devonian has often been hypothesised as being one of the driving forces behind major changes in global biogeochemical cycles at this time, including increased weathering rates, nutrient fluxes to the oceans and ultimately the sequestration of CO_2 from the atmosphere. Challenges in testing this hypothesis include limited data on the nature of the first tree-sized plants from the fossil record, especially the morphology and depth of their rooting structures, and obtaining quantitative data on the nature and degree of influence these early roots had on weathering and the development of soils.

Middle Devonian (Givetian) palaeosols exposed at a quarry near Cairo, New York State, have provided a unique opportunity to study the *in situ* roots of an early, mixed forest ecosystem. The top surface of a palaeosol is well exposed across the quarry floor, capped in places by a siltstone rich in fish fragments. The morphology and distribution of exposed mouldic root structures have been mapped by Stein et al., providing a footprint of the forest floor. They identified at least two main root types as likely belonging to archaeopteridalean progymnosperm (*Archaeopteris*) and pseudosporochalean cladoxylopsid (*Eosper-matopteris*) trees.

An assessment of the depth and morphology of rooting structures, as well as the nature of root-soil interactions and the subsequent degree of weathering, can be obtained from detailed sedimentological and geochemical studies of the palaeosols beneath this horizon. Cores were drilled, up to 3m in depth, beneath the bases of eighteen trees that were selected to represent different tree types of different sizes. All cores revealed at least two pedotypes, either stacked directly on top of one another or separated by parallel-bedded fine-grained heterolithics. The uppermost palaeosol is approximately 1.65m thick, interpreted as a well-developed palaeo-Vertisol, with a clay-rich B horizon comprising of wedge-shaped peds with slickensided clay skins. Numerous rhizoliths are preserved throughout, mostly as rhizohaloes, although some possess a central carbonaceous strand or clay-rich cast. The nature and dimensions of these roots from the two main tree types will be presented. All soil profiles were spot sampled for whole rock geochemical analysis using ICP-MS and XRF, and mineralogy using XRD. Elemental distribution and molecular ratios will be presented as proxies for various weathering and pedogenic processes.

O144

ROOTING SYSTEMS PRESERVED IN THE RHYNIE CHERT

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Rooting structures were one of the key adaptations essential for the conquest of the land by plants and they provided the essential functions of anchorage, nutrient uptake and water absorption. There are two types of rooting structures in extant land plants: gametophyte rhizoids and sporophyte roots. Rhizoids carry out the rooting function of the free-living gametophyte stage of the life cycle. Specialised rooting axes (roots), carry out the rooting function on the free-living sporophyte stage of the life cycle. The evolution of sporophyte roots was a key adaptation during the rise to dominance of vascular plants and roots develop on almost all extant vascular plants. However, none of the plant sporophytes described to date from the 407 million-year-old Rhynie chert formed roots. Since plants preserved in the chert occupy key phylogenetic positions at the base of the vascular lineage the Rhynie chert sporophytes therefore provide insights into the earliest stages of root evolution. The work presented here is an overview of ongoing research on rooting systems in the Rhynie chert. We highlight recent findings on the structure of the rhizoid-bearing sporophyte axes that carried out the rooting function in the common ancestor of vascular plants and report the discovery of apices of the rooting axes of *Asteroxylon mackiei*.

O145

DIVERSITY AND ECOLOGY OF MID DEVONIAN FORESTS

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Recent discoveries of fossil forests and exceptionally-preserved plant fossils have pushed the origin of trees and forests firmly down column into the Middle Devonian. The main small tree-size plants to appear were cladoxylopsids, aneurophytalean and archaeopteridalean progymnosperms, and lycopsids. This talk will summarise latest knowledge of these plant groups, their rooting structures, the varied ecology of Mid to early Late Devonian forests, and their effect on local sedimentation, based on field examples from New York and Svalbard.

O146

FUNGAL DIVERSITY IN EARLY TERRESTRIAL ECOSYSTEMS

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As decomposers or plant pathogens, fungi have invasive growth and powerful enzymes to reduce plant tissues to humus. Fungi are perhaps also the most important mutualistic symbionts in modern ecosystems. Although fungi have played these roles for over 400 million years, direct fossil evidence remains rare. Exceptional geological conditions are required to preserve cellular details and such conditions first occurred in the 407 million-year-old Rhynie chert (Scotland, UK). Our objective is to document the early fungal diversity at this site and to understand the nature of the fungal interactions. We are working principally with historical collections of thin sections. We first examined the fossils with standard light microscopy but have recently found that a combination of tools can be very effective. We use light microscopy with z-stacking montage, confocal laser scanning microscopy (CLSM) and digital 3D reconstructions obtained from the CLSM data with iso-surfaces digitally rendered using SPIERS and animations created in Blender™. This investigative approach allows us to characterize structures with a resolution of <1µm and to compare resulting images with relevant living groups and appropriate life history stages. Here we present an overview of our current knowledge regarding early fungi on land. Evidence from the Rhynie chert shows that fungi were already diversified. Symbiotic associations (arbuscular mycorrhizae) attributable to Glomeromycotina have long been known and have been described in both stages of the life cycle of a Rhynie chert plant. Other plants were colonized by Glomeromycotina but did not show all the characteristic features of symbiosis. Zoosporic fungi were diverse with Chytridiomycota occurring in organic-rich sediments in wetter parts of the landscape while Blastocladiomycota were mostly associated with plants or plant debris. We recently demonstrated the occurrence of multiple colonizations of a plant by different types of mycorrhizal fungi (Glomeromycotina and Mucoromycotina) and described fossil Blastocladiomycota, one of which is the earliest known fungal clade to develop hyphae, which likely served as a saprotrophic adaptation to patchy resource availability. A fossil Chytridiomycota has also been found showing that zoosporic fungi were likely important to the mobilisation of nutrients in early aquatic foodwebs. One of the driving forces behind the diversity of the early fungi could be the environments encountered. In the Rhynie chert, these ranged from terrestrial to fully freshwater and saline. This early fossil record is beginning to reveal fungal diversity and the important roles that fungi were playing in the earliest land communities.

O147

LINKS BETWEEN THE EARLY EVOLUTION OF SOILS, GLOBAL BIOGEOCHEMICAL CYCLING, AND CLIMATE

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The global biogeochemical cycles of carbon, oxygen and phosphorus regulate the composition of Earth's atmosphere and oceans over geological timescales. These cycles depend greatly on terrestrial weathering processes, and are thought to have been drastically altered in response to the evolution of soil ecosystems and vascular plants throughout the late Precambrian and Early Phanerozoic. It has been proposed that such changes might explain deep glaciations in the Neoproterozoic and late Paleozoic, and a two-step rise in atmospheric oxygen that has been linked to the evolution of the first animals and the subsequent rise of large predators.

This talk examines these ideas through the lens of Earth System modelling, focusing on two key techniques. The first, 'forwards modelling', lets us reconstruct the ancient climate by making assumptions about soil processes and weathering at different times, and lets us compare the model predictions with available proxy data. The second, 'inversion modelling', allows us to use known information about isotope records and tectonic processes to back-calculate the required rates of weathering and productivity.

Using these approaches we will develop a general view of climate evolution through the late Precambrian and Early Phanerozoic, and the role of soils and associated organisms in driving these changes.

O150

AFFINITIES OF NEMATOPHYTES AND THEIR ROLES IN EARLY TERRESTRIAL VEGETATION REVISITED.

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It is 80 years since Lang (1937) united *Nematothallus* with *Prototaxites* in a new 'class', the Nematophytales, which he speculated intermediate between algae and higher plants. Evidence from more recent research has pointed to a fungal affinity (Hueber 2001), a relationship which supports the hypothesis of Church (1919) postulated almost twenty years earlier for *Prototaxites*, and which now, based on reproductive characters, is considered a polysporic ascomycete (Honegger et al 2017). On vegetative architecture, however, neither *Prototaxites* nor members of the *Nematothallus* complex find counterparts in extant fungi, and whether or not they were early lichens remains conjectural. Regardless of affinity these organisms are considered significant components of early land vegetation in Siluro-Lower Devonian times and played an important role in global carbon cycling.

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O151

COOKSONIA BARRANDEI SP. NOV. THE OLDEST POLYSPORANGIATE LAND PLANT

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The colonization of land by plants is an extremely important phase in Earth's life history. This key evolutionary process is thought to have started during the Ordovician and continued through the end of the Early Devonian interval (485-393 Myr) of the Palaeozoic Era. *Cooksonia barrandei* from the *Monograptus belophorus* Biozone (Motol Formation, middle Sheinwoodian, Wenlock) Silurian of Barrandian area, Czech Republic, provides moderately well-preserved details of macro and micro- morphologies including *in situ*-spores and stomata.

Cooksonia barrandei resembles most *C. pertonii* ssp. *apiculispora* in having similar whole plant habitus and similar spores in situ (genus *Aneurospra*). Spores found in sporangia of *C. barrandei* show crassitate trilete monad with crassitate proximal surface. *Cooksonia barrandei* resembles also *Concavatheca banksii* in having similar shape of terminal subtending axes with characteristic rim. The above mentioned taxa are distinguished from *C. barrandei* in having smaller size of their axes and sporangia and having different *in situ* spores.

C. barrandei represents the oldest known macrofossil evidence of land plant diploid generation - sporophytes (~432 Myr). Their robust size makes them one of the largest known early polysporangiate land plants. This would mean not only that the plant was photosynthetically autonomous, but that the sporophytes might have been able to sustain a relatively gametophyte-independent existence. In the context of this record it might be therefore reasonable to consider again both - antithetic vs. homologous - hypotheses for the origin of land plant sporophyte.

O152

A LYCOPSID FOREST WITH NEW TYPE ROOTING SYSTEM FROM THE UPPER DEVONIAN OF SOUTH CHINA

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The evidence of the earliest forests is restricted to two Devonian localities in Laurussia palaeocontinent, including the Gilboa cladoxylopsid (a group of fern-like plant) forest from the Middle Devonian of New York, USA and the Spitsbergen lycopsid (clubmoss) forest from the Upper Devonian of Svalbard, Norway. Recently, we found another Late Devonian (ca. 370 Ma) lycopsid forest, which was distributed at four outcrops in northern Zhejiang Province, southern China. These outcrops are spaced hundreds of meters apart. There are numerous well-preserved *in situ* lycopsid rhizomorphs or stems. The lycopsids may represent the same genus and be monospecific.

Three layers of *in situ* stumps were discovered in the mudstone after continuous excavation at one of the outcrops. The forest in this outcrop is comparatively complex, and its canopy and understory are composed of the lycopsid trees and the sphenopsid (horsetail) herbaceous *Eviostachya*, respectively. The trees have the density of more than 30/m^2. The lycopsid is characterized by a cormose-like rhizomorph but bearing a lot of radiating lateral branches at the edge. Dense rootlets bifurcate 1-2 times and occur in helices along the lateral branches of the rhizomorphs. The trunks could reach 21 cm in diameter and dichotomize in the mid-upper part of plant, and their heights are estimated to be over 10 m. Our findings add to the diversity of early lycopsid rooting systems, and expand the palaeogeographical distribution of the earliest forests with complex ecospaces.

O153

RECONSTRUCTING CATHAYSIAN CORDAITALES FROM THE PERMIAN OF SHANXI (CHINA) BY THE MEANS OF CUTICULAR ANALYSIS

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Cathaysian floras are mainly characterised by elements like *Tingia*, *Cathaysiopteris*, *Emplectopteris*, *Fascipteris* and *Lobatannularia*, but *Cordaites* is an abundant element as well (Hilton et al., 2001). The taxonomy of Cathaysian Cordaitales is mainly based on macromorphological criteria and often only parts of sterile leaves are preserved, though few studies of coal ball floras have allowed whole plant reconstructions (Hilton et al., 2009). Cuticular analysis is a very useful tool if only small parts of the plant are preserved: it not only allows a precise definition of individual taxa, but allows the reconstruction of growth habits and provides important information on the palaeoeceology and -climate. Cordaitales are also common in the Permian strata of the Palougou section in Shanxi (China). The Lower Shihhotse formation (Roadian-Wordian) yields well-preserved macrofloras with abundant Cordaitales accompanied by typical Cathaysia elements such as *Tingia*, *Yuania*, *Cathaysiopteris*, *Protoblechnum*, and *Emplectopteris*. Several different species of *Cordaites* can be differentiated based on cuticular features and especially bulk samples yield exceptionally well preserved cuticles of complete *Cordaites* leaves, *Cardiocarpus* seeds and completely preserved *Cordaitanthus* cones. Similarities in their epidermal pattern, particularly their stomatal architecture, as well as *in situ* pollen grains of the *Florinites* type recovered from pollen sacs and ovules allow a correlation of these different organs to one Cordaitalean plant. This allows us to draw conclusions on its growth habit, reproduction mechanism and ecology and enables comparisons to known Cordaitales from Cathaysia and Euramerica.

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O154

REVEALING THE INTRICACIES OF A PERMIAN HIGH LATITUDE PEAT SWAMP FOREST

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Deposits from the central Transantarctic Mountains of Antarctica provide considerable insights into the biodiversity and ecology of high-latitude Permian ecosystems. At Skaar Ridge, near the head of the Beardmore Glacier, pristinely preserved impressions from local lacustrine deposits, and permineralized peat, which had been transported down river from eroded peat mires, present an abundance of data to reconstruct this unique ecosystem. To date, reports about material from Skaar Ridge span from anatomical descriptions of plants and fungi to physiological responses to a high–latitude environment. This paper will serve as a collation of published data along with new research to present a comprehensive reconstruction of the Skaar Ridge ecosystem. Research on the peat has revealed the dominance of either *Vertebraria* or *Glossopteris* with additional glossopterid structures and understorey plants anatomically preserved throughout. This supports the hypothesis that the peat was transported as two distinctive organ assemblages (*Glossopteris* vs. *Vertebraria* dominated) indicate that at least two separate peat sources at Skaar Ridge. Detailed examination of fungal wood decay has revealed intricate plant-fungus interactions through; mycorrhizal associations, glomoid spores and development, and numerous saprotrophic fungi. Skaar Ridge's lithology indicates the presence of a meandering river system with a high water table producing numerous backswamps. Evidence of the glossopterids growing in this swampy environment include; 1) the production of epicormic shoots, revealing the ability of these trees to produce opportunistic shoots, possibly in response to frequent and extensive flooding, 2) a thick insulating bark which allowed the cambium to resist significant temperature changes, and 3) unique architecture in *Vertebraria*, indicating the ability to grow in a heterogeneous substrate such as peat. Impression specimens have provided indications of growth responses of glossopterids to a high-latitude environment which has no modern analog. Although leaf venation density of extant plants is closely related to leaf hydraulic conductance and maximum photosynthetic capacity, this was not the case for *Glossopteris* from Skaar Ridge. Their leaf venation density trend remains undetermined, suggesting that these plants had other physiological adaptions to a high-latitude environment. Additional evidence of a polar growth habit include seasonal shedding of reproductive organs and dormant bud scales, suggesting a response to rapid conditional changes promoting dormancy. The abundance of material from Skaar Ridge and the continuing research ranging from descriptive studies to paleoecology will help create a more complete picture of a high–latitude glossopterid environment.

O155

MID-CRETACEOUS SEED PLANT DIVERSITY IN BURMESE AMBER.

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Several groups of seed plants had their rapid diversification in mid-Cretaceous. In the ~100 mya Burmese amber, we found plenty evidence for these fossil floras, including conifers, yews, Gnetales, Bennettitales, and early angiosperms. Some well preserved specimens indicated that flowers, fruits and leaves of angiosperms, ranging from basal to higher taxa of monocots and eudicots, may have reached great diversity at that time, and some extant clades may have originated earlier. Their emergence brought major changes into plant reproductive biology, and affected dinosaurs, insects, mammals and other organisms in their evolvement and evolution. Traces of insect activities were also observed on the fossil floras, which provides new insights into the co-diversification of seed plants and their associated fauna. We'd like to share our findings in Burmese amber concretely in the presentation, and collaborate on the study with paleontologist and botanists allover the world.

O156

A COMPARATIVE PALAEOBOTANICAL STUDY OF AMBER USING IR-SPECTROSCOPY, WITH SPECIAL ATTENTION FOR THE CRETACEOUS OF MYANMAR

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In recent years, amber from Myanmar (Burma) has yielded a wealth of both botanical and entomological fossil inclusions. Due to the exquisite preservation of the fossils and the proposed mid-Cretaceous age of the amber these inclusions are highly significant palaeontological discoveries. However, the exact age of Burmese amber and botanical origin of the resin are still a topic of much debate. Due to the difficulty in accessing the mining locations, the study of Burmese amber has been largely limited to pieces with little to no definitive geological context, that were obtained from museum collections or through local intermediaries. This has resulted in several competing theories regarding the age and botanical origin of Burmese amber. The significance of these fossils calls for a clearer understanding of the origin and context of amber from Myanmar. In this study we applied FTIR-spectroscopy to analyse the chemical composition of samples from a large private collection with the aim to classify the different varieties of Burmese amber. Furthermore, we also described some of the botanical inclusions found in the studied pieces of amber. Finally, we compared the new spectroscopic data from the Burmese amber with IR-spectra from amber from other parts of the world. This new dataset on Burmese amber provides a further background for palaeobotanical and palaeoentomological studies, and also forms a new step towards revealing the botanical origin of Burmese amber.

O157

DIVERSITY AND ANALYSIS OF AMBER FROM THE (APTIAN) CRATO FORMATION, NORTH-EAST BRAZIL

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The Early Cretaceous (Aptian) Crato Formation of north-east Brazil is well known for its diverse and well preserved fossil assemblage, mostly pertaining to its insect and vertebrate fauna. However, the formation also yields a diverse flora including Isoetales, Polypodiopsida, Bennettitales, Coniferales, Gnetophyta and several angiosperms. In addition, sedimentary amber clasts and amber within the fossil plants has been reported.

The Crato Formation is a heterolithic sequence of clays, fine sandstones and laminated limestones, the lowest of which, the Nova Olinda Member, is a fossil Konservat Lagerstätte deposited in a saline basin with input from freshwater systems. The flora represents an allochthonous assemblage with plants of riparian origin deposited alongside vegetation from the lagoonal hinterland and includes several arid adapted species.

Many Crato macrophytes contain in situ amber, its location within the plant tissue varying between taxa. In the conifer *Brachyphyllum obesum* amber is located in either the main stem or possibly trapped between the stem and leaves. In *Lindleycladus*, *Pseudofrenelopsis* and *Welwitschiophyllum* it is situated within the leaves; in canals in *Welwitschiophyllum* and in so-called resin plugs in *Pseudofrenelopsis*. In addition, three different cones have in situ amber.

Analysis, including ATR and micro-FTIR on ambers from the cones and from *Brachyphyllum obseum* demonstrates coniferalean affinities. Whereas analysis of the 'amber' in *Welwitschiophyllum* reveals a highly distinctive spectrum, unlike that of any fossil resin. The analysis shows the amber of the Crato Formation is more diverse than previously thought.

O158

PLANT ASSEMBLAGE AND AMBER FROM THE CONIACIAN–SANTONIAN OF VERNASSO, FRIULI-VENEZIA GIULIA, NORTHEASTERN ITALY

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Bozzi (1888, 1891) reported a rich plant assemblage collected from "Senonian" limestone boulders contained inside a giant megabed belonging to the lower Eocene Flysch exposed at Vernasso, northeastern Italy. Based on calcareous nannofossil content, Gomez et al. (2002) indicated that these megafossils are Coniacian–Santonian in age. Bozzi (1888, 1891) described conifers (*Araucaria macrophylla* Bozzi, *Cunninghamites elegans* Endl., *Cyparissidium gracile* Heer, *Frenelopsis königii* Hosius, *Sequoja ambigua* Heer, and *Sequoja concinna* Heer) and rarer angiosperms (*Arundo groenlandica* Heer, *Myrica vernassiensis* Bozzi, *Phyllites proteaceus* Bozzi, *P. platanoides* Bozzi, and *Rhus antigua* Bozzi). They mostly consist of impressions covered by orange to brown limonite powder, and rarely compressions with brown to black carbonized matter and without preserved cuticle. A revision of this fossil flora is needed. Roghi et al. (2004) drew attention to amber associated with two conifers of Vernasso amber, which constituted the first Cretaceous amber record in Italy. Since, we have surveyed five Vernasso collections housing over 800 hand rock specimens and including all specimens described by Bozzi (1888, 1891). Amber is present in association with *A. macrophylla*, *C. elegans*, *Frenelopsis* sp. (= *Frenelopsis königii* of Bozzi), *Geinitzia* sp. (= *S. ambigua* + *S. concinna* of Bozzi). This observation confirms that resins of most Cretaceous conifer families could fossilized as amber, and suggests that analyses have to be made on more materials in order to ascertain the amber-source plant or plants of a given amber locality.

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O159

AMBER-BEARING DEPOSITS OF EASTERN MARGIN OF THE PRE-NORTH SEA EPICONTINENTAL BASIN

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The Upper Eocene and Lower Oligocene amber-bearing sediments, which occurred in the proximal south-east part of the pre-North Sea Basin are the mother rocks for the richest - apart from the Sambian-Cassubian area in the Northeast - amber deposits *in situ* in marine Paleogene deposits in this basin. These deposits have been preserved until today in form of two selected areas - North Lublin (Poland) and Volyn (Ukraine) ones. Both these areas are separated by a bare zone in the area of West Volyn, where the younger Paleogene deposits were removed by Quaternary erosion, as in the large valleys of Wieprz, Bug and Horyn' rivers.

Results of stratigraphic research display, that amber bearing sediments in the both part of the studied region are not contemporary – these from the western (Polish) part are Late Eocene (Priabonian) of age, corresponding to the D12 dinocyst zone, and those from the eastern (Ukrainian) part are mostly Early Oligocene (Rupelian) of age, corresponding to the D14 dinocyst zone. On the Volyn area, deposits representing to the D13 dinocyst zone (Lowermost Rupelian) has been not confirmed. This is probably a result of marine regression separating the two large Paleogene pan-European transgressions from the pre-North Sea basin during Oligocene and Eocene. Extremal concentration of amber in younger sediments in Volyn suggest, than there are not primary amber deposits and they were probably multiple re-worked - older (Eocene) sediments and multiple re-deposited in high-dynamic sedimentary environment in coastal part of the marine basin embedded in the cristalline craton of Ukrainian Shield during Early Oligocene.

The amber-bearing deposits of the eastern margin of the North Sea basin are without any exception dated as the younger ones than the EECO – (Early Eocene Climatic Optimum) time (52-50 Ma BP). During the EECO, lush resinous, highly thermophilic vegetation developed rapidly, whose composition can be defined after studying of micro- and macroflora amber inclusions. Amber origin should be probably related to the MECO (Middle-Eocene Climatic Optimum) final phase with climate changes unfavorable for the development of forest vegetation - abundant resination should be a reaction to stress related to the deterioration of vegetation conditions. The resin what was then creating abundantly has been re-deposited after into younger sediments (Priabonian and Rupelian).

O160

SHORT- AND LONG-TERM CHANGES OF PLANT DIVERSITY DURING THE PALEOGENE GREENHOUSE IN CENTRAL EUROPE

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Long-term greenhouse periods and short-term warming events are well known from different periods of earth history. They may be the subject for detailed studies on the reaction of plant communities to global warming on different timescales. The Early and Middle Eocene climatic optima and the superposed short-term warming events are especially suited for comparisons to the presently developing greenhouse since fauna and flora in many respects were already similar to today. Pollen and spores are suitable proxies for the recognition of plant communities and the reconstruction of spatial and temporal changes in vegetation and biodiversity.

Short-term changes of palynological diversity and floristic composition have been revealed by a high resolution study of 680 samples from the Lower to Middle Eocene maar lake at Messel (Southwest Germany). The data show that taxonomic diversity increased rapidly during recolonization of a volcanically devastated area around the lake. With the establishment of a climax vegetation at the end of recolonization the maximum in palynological diversity was reached in the crater area. During the following 640 kyr alpha and gamma diversity decreased up to 35% which can be related to the establishment of an equilibrium stage within the climax vegetation that led to the dominance of an assemblage of self-replacing species. Time series analysis of alpha diversity changes within the climax vegetation reveals that orbitally controlled climate change on the Milankovitch and Sub-Milanovitch scale influenced the diversity of the vegetation resulting in a rise of beta diversity. Our analysis now proves that Eocene paratropical plant diversity increased during periods of slightly higher temperature and precipitation. Therefore, both composition and diversity of the vegetation was highly susceptible to minor-scale short-term changes in climate even during equable greenhouse conditions.

Long-term changes in diversity across the Paleogene greenhouse are in the focus of a recent project on the well-dated and more than 200 m thick sedimentary succession of the Helmstedt Mining District (Northern Germany), which is almost continuous from the latest Paleocene to the middle Eocene in an area of marine-terrestrial transition. The use of an extraordinary archive of samples and the detailed study of the palynomorph assemblages shall reveal if the vegetation has been influenced in terms of diversity and composition by the known short- and long-term climate change of the Paleogene.

O161

RECONSTRUCTION OF THE PALEOCENE CLIMATES OF CENTRAL EUROPE USING FOSSIL LEAVES

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Overall the Paleocene epoch is considered to have been a greenhouse world with CO_2 levels similar or higher than today (300 – 800ppm). The Paleocene is an interesting time in earth's history with regards to environmental change because it occurs directly after a mass extinction, and is also a time of fluctuating climate. Although there has been some research on reconstructing Paleocene climates for the Polar Regions and the Southern Hemisphere, there is still little known about climate during this epoch especially for the mid-latitudinal regions of the Northern Hemisphere. This pilot study aims to address this issue by attempting to reconstruct Paleocene climates of Central Europe using fossil leaves from three locations (Gelinden, Menat and Sézanne). Climate signals were obtained from morphometric analysis of the leaves (Trait Combination Types (TCTs), leaf tooth measurements, leaf mass per area (LM_A) and shape factor) and a physiognomic approach (CLAMP). TCTs refer to a number of leaf anatomical traits that are sensitive to climate and naturally co-occur together in different combinations. It had been observed that 16 TCTs (A, B, C, D etc.) naturally occur in extant leaves. CLAMP is a statistical method that infers the climate of a fossil locality, based on the relationship between morphology and climate in extant floras. Both TCTs and CLAMP results suggest sufficient water availability and seasonal climates for all three fossil sites. The most common TCT is F which is characterised with non-looped secondary venation and a toothed margin. Growth season precipitation range obtained with CLAMP is 137 – 190 cm over 8 – 9 months. Leaves with toothed margins from Menat have a high number of teeth (mean = 41, range 15 – 79) and tooth area values (median = 0.034, range: 0.014 – 0.056) which indicate temperate climate conditions. So far the interpretation of tooth analysis results for the Gelinden is difficult due to small sampling but the leaves have a low number of teeth (15 teeth) suggestive of more favourable conditions than Menat. CLAMP analyses suggest higher temperatures and precipitations for Gelinden. The LM_A results for Menat and Sézanne suggest a shorter growing season than the Gelinden, possibly there was variability in a growth limiting factor (e.g. water). The results from all three locations so far reveal that in general climates during the Paleocene were warm-temperate with sufficient water availability in the mid-latitudinal regions of the Northern Hemisphere.

O162

THE TROUBLE WITH TREES: LOOKING AT GRASSLAND AS A CONSERVATION PRIORITY

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Reforestation has been recommended worldwide as a way for landscape restoration to mitigate climate change in areas where climate can sustain forest. We argue that this target threatens valuable grassland ecosystems and results from wrong assumptions about the origin and confusion over the substantive differences between ancient grasslands and their anthropogenic counterparts. Here, we have used multiple lines of evidence (palaeoecological and phylogeographic) from the potential naturally forested zone of Central Europe with the aim of increasing awareness of the conservation of a primary grassland type not previously recognised. We argue that apart of the existence of primary grasslands on skeletal soils, others grasslands found under a potential forest climate, i.e., those maintained initially by natural and later also by anthropogenic disturbances have persisted throughout the last 10,000 years. We advocate that the definition of climax and zonal vegetation should be re-evaluated as they focus overly on climate and may mislead conservationists and land managers in determining natural vegetation. The misapplication of tree-promoting land management strategies in historical grassland areas will have many long-lasting, negative consequences for both people and nature. Our message may be globally relevant and provides a meaningful approach to determine primary grasslands under potential forest climate and ensure their better understanding, value and conservation

O163

FOSSIL LEAVES INDICATE THAT HOT SUMMERS FOLLOW INITIAL SPRING WARMING DURING CLIMATE CHANGE

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In northern latitudes annual seasonality is diminishing through rapid winter and spring warming, as opposed to – until very recently – moderate summer warming. Vegetation has responded with an up to one-month advance in spring onset (bud burst and vegetation greening) since the 1980's. The prolonged growing season further contributes significantly to climate change through altered albedo and hydrological pathways. In addition, earlier greening increases risk of frost damage of plants and causes phenological mismatches in ecosystems, affecting for example insect populations, migrating birds and many other animals. The ecological and socio-economic consequences of this strong phenology-climate link are far-reaching, but extremely difficult to quantify or predict due to the limited timespan of available observational data, placing the need for long-term proxy records into sharp focus. The two most recent natural warming episodes in the geological past occurred within a few decades, resembling the ongoing global warming in rapidity and spatial expression. These are the transitions from the Younger Dryas to the Holocene (~11.800 years ago) and the Late Pleniglacial to the Bølling (~14.800 years ago). For these previous, fully completed warmings we here present high-resolution palaeo-phenological records of the arctic shrub *Betula nana* from Sweden and Germany, recording spring onset with epidermal cell characteristics. We further quantify seasonal warming patterns and decipher their phase relations. Spring onset data is compared to summer temperature proxy records, and a distinct offset of about a century between initial spring warming and maximum summer temperatures is observed. The findings are discussed in relation to the ongoing climate change, for the first time with proxy data from the terrestrial realm, the most relevant to human society. The results indicate that the recent global trend of hot and extremely hot summer temperatures is here to stay.

O164

PALAEOECOLOGICAL INSIGHTS INTO ECOLOGICAL CONSEQUENCES OF MOORLAND 'IMPROVEMENT' AND DEVELOPMENT OF BASELINES FOR PEATLAND RESTORATION

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Moorlands and uplands are highly valued landscapes as they deliver a wide range of ecosystem services including: water supply to lowlands; locations for agricultural production (in particular seasonal grazing); internationally-important sinks of greenhouse gases including carbon and methane; and are locations favoured for recreational activities. They are also areas that preserve and conserve nationally-important cultural heritage, including the traces of past society. From the mid-19th century AD large areas of moorland were 'reclaimed', as part of moorland 'improvement' schemes to maximise economic production, with further enclo-

sure and improvements following the second world war. Over the last decade major programmes of moorland 'restoration' have focussed on reversing the impacts of past moorland 'improvement', but little is known about ecological baseline conditions prior to improvement. Detailed pollen, macrofossil, testate amoebae and palaeoentomological work, alongside a programme of dating has been undertaken from within a restoration area on Exmoor. The results demonstrate a complex sub-recent (<1000 years) history of moorland land use, which had direct impacts on the ecology of the area. Significant changes in fauna and flora, including the development and subsequent loss of *Sphagnum*, and state shifts in testate amoebae assemblages, can be attributed to changing patterns of grazing, burning and drainage of the moorland. The implications of this are that land use has been complex through time, and any changes in land management (including restoration) are likely to have significant impacts on the ecology of the moorland. The notion of identifying, or restoring to, stable baselines, is discussed in the light of the palaeoecological data.

O165

CENOZOIC FLORAS OF YUNNAN, WITH AN EMPHASIS ON THEIR ELEMENTS OF THE NORTHERN HEMISPHERE

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Yunnan, SW China, is one of the world's biodiversity hotspots. Even though Yunnan accounts for only 4% of the Chinese territory, it is home to more than 19,333 species of higher plants, grouped into 3084 genera and 440 families. 96.7 % of genera and 86.2% families of Chinese higher plants can be respectively found in Yunnan. Among them, 113 species, 25 genera and 9 families are gymnosperms, representing 37% of species, 73.5% of genera and 90% of families in China; and 15.951 species, 2.367 genera and 244 families are angiosperms representing 48% of species, 84.5% of genera and 98.0% of families in the country. Furthermore, more than half of these plant species are endemic to Yunnan.

Yunnan not only houses a high diversity of modern plants, but also archives rich fossil floras Totally, 386 fossil species of ferns, gymnosperms and angiosperms belonging to 170 genera within 66 families have been reported from the Cenozoic, chiefly the Neogene, of Yunnan. Angiosperms display the highest richness represented by 353 species grouped into 155 genera within 60 families, with Fagaceae, Fabaceae, Lauraceae and Juglandaceae being the most diversified. Floristic analyses indicate that in the late Miocene Yunnan had three floristic regions: a subtropical floristic region in the northeast, a subtropical floristic region in the east, and a tropical floristic region in the southwest. In the late Pliocene, Yunnan saw two kinds of floristic regions: a subalpine floristic region in the northwest, and two subtropical floristic regions separately in the southwest and the eastern center. Recent fossil findings indicate that the floristic modernization of Yunnan started as early as early 33 Ma years ago, much deeper than the Miocene initiation as previously interpreted. These fossil floras contain several taxa which widely occurred in the Northern Hemisphere, e.g. North America and Europa, such as Sequoia, Metesequoia, Cryptomeria, Dipteronia, Berryophyllum, Cedrelospermum, Palaeocarya and Podocarpium, etc. It seems that there was a strong floristic link between East Asia, North America and Europa in the Teritary. Some worldwide extinct taxa are among them, such as Berryophyllum, Cedrelospermum, Palaeocarya and Podocarpium, but some are still survived in China, such as Metesequoia, Cryptomeria and Dipteronia known as Tertiary relics. We present fossil histories of plants in Yunnan in order to understand the evolution of plant diversity and distribution as well as its response to environmental changes.

O166

CENOZOIC FLORAS IN TIBET: THE WINDOW INTO BIODIVERSITY AND ENVIRONMENT IN DEEP TIME

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Fossils are pivotal to understand histories of plant diversity and biogeography under dramatic paleoenvironmental changes in the Qinghai-Tibetan Plateau (QTP); however, fossil floras there are far from being sufficiently investigated. During recent years, we did plenty of field work and found several well-preserved fossil floras ranging from the Paleocene to the Pliocene in high altitudes of the plateau. For the late Paleocene Liuxiang flora in southern Tibet evergreen elements including Lauraceae and Moraceae are the most abundant; the late Paleocene-middle Eocene Baingoin flora in north Tibet shows relatively high plant diversity, and is quite similar to the Eocene Green River flora from western interior USA in floristic components. The late Eocene Kajun flora in eastern Tibet is dominated by Cyclobalanopsis and Betula, representing an evergreen-deciduous broadleaf forest. In the late Oligocene Dayu flora

in northern Tibet, grasses firstly occurred together with Arecaceae and Koelreuteria; whereas the Pliocene Zhada flora in western Tibet is represented by small-sized leaves. The occurrence of some extinct taxa in these paleofloras, e.g., Hemitrapa, Limbophyllum, and Cedrelospermum, as well as many taxa being still widely distributed in the QTP, e.g., Betula, Cyclobalanopsis, Koelreuteria, and Rosa, suggests that there were frequently floristic exchanges between the QTP and other parts of the North Hemisphere. Besides, the vegetation types gradually changed from the evergreen broadleaved forest to evergreen-deciduous broadleaved forest, then to open vegetation, and finally to alpine shrub and meadow. Most notably, plenty of palm fossils were discovered from the late Paleocene of southern Tibet and the late Oligocene of central Tibet, which are solid evidence for much warmer climate and lower elevations in the geological past compared to present-day. Generally, evidence based on our current plant fossils clearly indicates that the evolutionary history of the biodiversity is closely associated with dramatic paleoenvironmental changes in the QTP, which were mainly induced by the tectonic activities in the QTP and the Himalayas. In future, more fossil floras are urgently needed to better understand the evolution of biodiversity and the history of paleoenvironmental changes in this large region.

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O167

SOUTHEASTERN TIBET: SURFACE HEIGHT, CLIMATE AND BIOTIC CHANGES AT THE EOCENE-OLIGOCENE TRANSITION

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The Mangkang Flora, Markham Basin, Southeastern Tibet (29.7527 °N, 98.4327 °E), like other floras in that area, has been regarded as late Miocene because it contains many extant genera and overall has a 'modern' aspect. However, here we show based on 40Ar /39Ar dating of tuffs bounding two key assemblages that the floral succession spans the Eocene-Oligocene (E-O) transition. The lowermost assemblage (MK3) is underlain and overlain by tuffs dated as 35.5 ± 0.3 Ma and 34.61 ± 0.8 Ma respectively making the age of the assemblage latest Eocene and very close to the E-O boundary, currently dated at 33.9 Ma. Assemblage MK3 (2634 specimens divisible into four conifer species (Pinus, Chamaecyparis, Tsuga and Abies) and 36 evergreen and deciduous woody dicot leaf morphotypes (species) preserved in a buff to grey siltstone) represents sub-tropical to warm vegetation and is dominated by evergreen round cupule oaks (Quercus subg. Cyclobalanopsis) with lesser quantities of members of the Betulaceae (Alnus and Betula). CLAMP analysis returns a mean annual air temperature (MAT) of 17.8 ± 2.3 °C, a warm month mean air temperature (WMMT) of 28.1 ± 2.8 °C and a cold month mean air temperature (CMMT) of 4.8 ± 3.6 °C. By using CLAMP-derived moist enthalpy at sea level obtained from Paleogene floras in northern India we determined the MK3 assemblage represents vegetation growing at ~ 3 km elevation.

Assemblage MK1, ~90 m stratigraphically above MK3, appears more stressed in that leaf size is generally much smaller and the assemblage less diverse: 692 specimens representing 24 woody dicot morphotypes dominated by ?Salix, while Rosa, deciduous oaks and Alnus are fewer in number than in MK3. Conifers are represented by Picea. MK1 occurs in a grey siltstone bounded below and above by water-lain ash horizons dated as 34.7 ± 0.5 Ma and 33.4 ± 0.5 Ma respectively. This places the assemblage at the onset of the E-O cooling event. The floristic change from subtropical to temperate is consistent with cooling across the E-O transition, but could also be due to surface uplift. If due to surface uplift alone the MK1 assemblage appears to have been at a palaeoelevation close to the present height of the Markam Basin, which is ~ 3.9 km.

The Markham fossils show that floral modernization high on the SE flank of the Tibetan plateau was a Paleogene, not Neogene, phenomenon predating the E-O transition.

O168

NEOGENE VEGETATION IN EUROPE: A VALUABLE PROXY FOR THE EARLY HISTORY OF THE HIMALAYAN-YUNNAN BIODIVERSITY HOTSPOT?

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The Himalayan-Yunnan biodiversity hotspot accommodates not only plant groups that have had a Pliocene-Quaternary diversification but also many relic plants. These relics have a remarkable Paleogene to Neogene evolutionary history across the Northern Hemisphere and can thus be found in fossil floras in Europe, North America and Asia.

A prime example of a fossil flora containing representatives of the genera of those extant relics, as well as other relatives of Himalayan-Yunnan endemics, comes from the Neogene of Eastern Germany. The Wiesa locality is dated to an interval spanning the Mid-Miocene Climatic Optimum and local palaeoclimate is rather similar to that of today's SW China where evergreen broadleaved forest is growing. About 50% of the fossil taxa have a clear relationship to the present-day vegetation in SE Asia, many of them to endemics and relics. Based on this there is a good understanding of the fossil lowland vegetation in central Europe during the Mid-Miocene Climatic Optimum. Dissimilarities in palaeoecological requirements of the fossil plants in comparison to their extant relatives are obviously related to a decline in distinct ecological niches occupied by the relatives of those endemics and relics during their history outside the hotspot region, but not to ecological shifts.

Coeval fossil floras from Yunnan, e.g. the Wenshan flora, are rather dissimilar to the Wiesa flora in exhibiting more subtropical/tropical aspects by the record of respective taxa that are present in the extant tropical/subtropical vegetation in SW China. More similarities between the fossil record of the hotspot region and central Europe are recently recognized from the early Oligocene Lühe site in W' Yunnan.

The fossil record shows that the hotspot region underwent a complex history even in the Paleogene and Neogene and that the formation of parts of the hotspot vegetation long predates the Paleogene-Neogene boundary.

The contribution will introduce remarkable fossil key taxa from central Europe with a clear relationship to the Himalayan-Yunnan hotspot vegetation and highlight the enormous potential for future palaeobiogeographic, palaeoenvironmental and palaeobiodiversity research for elucidating the early history of the biodiversity hotspot.

O169

OLIGOCENE LIMNOBIOPHYLLUM (ARACEAE) FROM CENTRAL TIBET AND ITS EVOLUTIONARY AND PALEOENVIRONMENTAL IMPLICATIONS

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Fossil taxa, particularly those that became extinct, can provide pivotal information on the morphological evolution of organisms. The extinct genus Limnobiophyllum (Araceae) has long been considered as a tentative link between the subfamilies Aroideae and Lemnoideae. Our understanding of trait transitions amongst these groups has been limited due to the lack of preserved key structures in fossils such as infructescences. In this study, we report a new fossil species, Limnobiophyllum pedunculatum S.L. Low, T. Su, et Y.-W. Xing sp. nov. associated with infructescence and seeds from the late Oligocene of the central Tibet, China. It represents the first convincing Limnobiophyllum fossil record in the plateau as well as in East Asia. We infer its phylogenetic position using a matrix of 57 morphological characters and 5.226 gene sequences of 42 taxa. The phylogenetic inference, based on a combined matrix, suggests that Limnobiophyllum is sister to Cobbania, and this clade is also sister to the remaining extinct and living genera within the Lemnoideae. The reconstruction of the traits evolution confirms that Limnobiophyllum possesses intermediate traits especially for infructescences between the Lemnoideae and the Aroideae. Within the Lemnoideae, both vegetative and reproductive traits show clear reduction and simplification from extinct genera to living Lemnoideae. These findings shed new light on the evolutionary history of the Araceae family. In addition, the discovery of this species suggests a warm and humid lowland environment in the central Tibetan Plateau during the late Oligocene, contradicting previous studies which indicated a high Tibet since the early Paleogene. The extinction of Limnobiophyllum might have been due to both global cooling and orogenetic processes.

Key words: Tibetan Plateau; extinction; Lemnoideae; infructescence; traits evolution; Araceae

O170

DRIFTWOOD IN FLUVIAL RED BEDS: IMPLICATIONS FOR ENVIRONMENT AND TAPHONOMIC PATHWAYS OF A LATE CARBONIFEROUS UPLAND VEGETATION

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In the Carboniferous, plants experienced a remarkable progress in complexity and diversity, with considerable impacts on terrestrial ecosystems and their depositional environments. Of particular interest is the gradual establishment of vegetation in drier uplands, which is supposed to have started in the Pennsylvanian. Due to their occurrence, upland ecosystems are prone to erosion and, thus, underrepresented in the fossil record. Accordingly, alluvial and fluvial deposits containing allochthonous plant associations derived from the hinterlands remain the most important source.

The latest Pennsylvanian (Stephanian C) Siebigerode Formation of the Kyffhäuser Mountains, Central Germany, represents an up to 670 m thick succession of fluvial red beds, deposited in a marginal position of the Saale Basin close to the northern edge of the Variscan Mountains. Since 1771, these deposits have attracted attention by both collectors and researchers because of abundant silicified trunks, up to 12 m in length and 1 m in diameter. Nevertheless, their origin and systematic affiliation, as well as the depositional environment, in which they have been buried, remained uncertain for a long time. The talk summarises a multidisciplinary study based on detailed bed-by-bed documentations of 150 outcrops in the Kyffhäuser Mountains and revisions of 6 public and private collections carried out in the years 2013 to 2016. By using a broad scope of methods (palaeobotany, facies analysis, sediment petrography, x-ray diffraction, cathodoluminescence), the formation of fossil-bearing fluvial red beds of the Kyffhäuser section will be presented as a model case for anatomical preservation of driftwood. Accordingly, the Kyffhäuser section records autocyclic deposition in a bedload-dominated river system, and the burial of a basement elevation. Trunks entered the fluvial system by upland denudation and cut bank erosion. Waning transport energy after episodic floods resulted in settlement and initial burial of excorticated gymnosperm logs and rootstocks on barforms subparallel to palaeo-flow. Silica provided by kaolinised feldspar promoted a slow three-stage silicification at low-thermal conditions of embedded wood. The logs descend from up to 40 meters high cordaitaleans and conifers, which grew in the Kyffhäuser region and its hinterlands to the west. Different kinds of tree rings reflect a saisonally dry climate. Cordaitaleans, pteridosperms such as *Odontopteris* and the climber *Dicksonites pluckenetii*, calamitaleans and sphenophylls are preserved as imprints in floodplain deposits. Locally restricted swamp communities contained lycopsids and calamitaleans. Results point to the Stephanian upland vegetation as being more differentiated than previously assumed.

O171

FUNGAL ACTIVITIES IN FOSSIL WOOD

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Silicified wood is one of the most abundant plant fossils, and symptoms of fungal degradation are frequently encountered within these fossils; many fungus-infected woods contain also evidence of the causative agent in the form of hyphae, spores, etc. However, studies focusing on fungi and fungal activities in fossil wood fossil are rare. Three principal rot types (i.e., white, brown, soft) are known to occur in wood today, all inflicted by members of the Basidiomycota and, to a lesser extent, Ascomycota. It is interesting to note that accounts of fossil fungal wood decay from the Paleozoic and Mesozoic exclusively describe white pocket rot, while the other rot types have not yet been documented. This lack of evidence is probably due to the nature of the decay and resulting wood texture, rather than the absence of the other rot types from ancient ecosystems. Moreover, there is paucity in the fossil record of studies describing parasitic wood fungi and interactions between different fungi within fossil wood. The purpose of this contribution is to give an overview of fungal features and activity patterns to look for while studying silicified woods, and provide fossil examples of wood decay from Antarctica, North America, and Europe. Several Paleozoic and Mesozoic woods provide information on fungal signs and symptoms, abundant fungal remains associated with the decay, and distribution patterns are elucidated. An interesting angiosperm wood from the Cretaceous of North America yields information on ascomycete distribution pattern and interactions within the wood. Last, we present an exquisite gymnosperm wood from the Miocene of Germany that shows multiple interactions between wood rotting fungi and an intrusive fungus within a single specimen. We feel that, where preservation permits, a holistic approach in the study of fungi in fossil wood is important to secure and make available the largest possible data set for considerations on the coevolution between woody plants and fungi, character states for molecular clock calibrations, and fungi as proxies for (paleo)ecosystem cycling and functioning.

O172

SILICIFIED GYMNOSPERMOUS ROOTS FROM THE CHANGHSINGIAN–INDUAN (?) IN SOUTHERN BOGDA MOUNTAINS, NORTHWESTERN CHINA

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A silicified root, *Amyelon bogdense* Wan, Yang et Wang sp. nov., is described from the Changhsingian–Induan (?) Guodikeng Formation, south Taodonggou section, Turpan City, Xinjiang Uygur Autonomous Region, northwestern China. The root consists of diarch protostele, primary xylem, secondary xylem, secondary phloem, and periderm. Primary xylem is exarch, with helical and scalariform thickenings on tracheidal walls. Secondary xylem is *Agathoxylon*-type, with alternately bi- to tetraseriate radial tracheidal pitting, uniseriate parenchymatous rays, and araucarioid cross-field pitting. Intercellular spaces occur between tracheids throughout the secondary xylem. Phloem is commonly compact. It is composed of radially aligned thick-walled cells, axial parenchyma and parenchymatous rays. Periderm consists of phelloderm, phellogen and phellem. Phelloderm cells are distributed external to the secondary phloem, with variable morphologies and sizes. Cells of phellogen are commonly tabular and occasionally elongate. Phellem is distributed to the exterior of the phellogen, and is composed of 2–7, commonly 3–4 layers of radially arranged brick-shaped cells. Rootles are elliptical to circular, less than 4 mm in diameter. Anatomical structures of rootlet are similar to those of the root. The arrangement of secondary xylem shows wedge-shaped spokes. Spaces between the secondary xylem spokes are either empty or filled with parenchyma. Some of the roots and rootlets have lenticel-like convex bodies. Lateral roots show no specific arrangement but appear to have been borne on only one side of the primary root. This is the first detailed report of the root anatomy with xylems and bark from the upper Palaeozoic of the subangaran phytoprovince. It shows different anatomical features with the stems previously recorded in northwestern China, and provides additional information on the diversity of the subangaran flora.

O173

BURIED ALIVE IN SITU: LIFE AND DEATH OF THE MIOCENE PETRIFIED FOREST ON LESVOS, GREECE

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Although the fossil forest on Lesvos, Greece, has been a paleobotanical and cultural novelty and sensation for several centuries, our understanding of the paleoecology of the forest is still rather incomplete. Previous paleobotanical work had mainly concentrated on identifying the conifer and some angiosperm trunks found in original growth position. Recently, a new collaborative effort between geoscientists has been made to survey the stratigraphy, sedimentology, taphonomy, and floral composition of this Miocene forest. The fossil forest is located on the western side of the island, as part of the Lesvos Global Geopark, and consists four major fossil sites with standing trees: Bali Alonia Park, Sigri Park, Plaka Park, and Nisiopi Island. Of these, the largest exposure in which the silicified trees are best preserved and exposed is Bali Alonia. Here, more than 45 autochthonous trees are rooted and exposed in paleosols covering approximately 90 m of stratigraphic section. In the last seven years, stratigraphic and sedimentologic mapping of the trees, and the measurement of trunk tilt, directionality, and trunk size have allowed for the reconstruction of the size structure of the Miocene forest, as well as for its demise and burial. Preliminary growth ring analysis, along with taxonomic identification and thin-sectioning of selective woods also have been carried out. Based on the preliminary data, we show the two-dimensional spatial arrangement of the woody vegetation, describe the community and three-dimensional structure of the forest, and elucidate the number of forest horizons at the Bali Alonia Park. Our paleoecological studies indicate the presence of several stacked, mature, mixed conifer–hardwood forests that were buried in lahar horizons at this paleobotanical site. Astonishingly, dendrochronology can be carried out on fossil trees found *in situ* on the same forest floor and shows that a catastrophic environmental event took place that resulted in an extreme and prolonged stunting of the growth in the forest trees.

O175

A COAL BALL FLORA FROM THE HAUPTFLÖZ SEAM (NAMURIAN C, LOWER BASHKIRIAN, PENNSYLVANIAN) OF THE RUHR DISTRICT, GERMANY

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Coal balls are not only an excellent source of information on the anatomy and histology of fossil plants but they also give an insight in composition of the swamp-forest vegetation that accumulated the biomass that was eventually transformed into coal. Many coal ball occurrences have been described from North American coal basins, ranging from the Kanawha (upper Westphalian B, Duckmantian) in the Appalachians to the uppermost Pennsylvanian (Gzhelian) of the Western Interior. In western and central Europe, however, coal ball occurrences are fewer and mostly restricted to relatively few seams in the Westphalian A and B (Langsettian and Duckmantian) and a single older occurrence with a rather high number of endemic species in the Koksflöz Seam (upper Namurian A, Serpukhovian) in the Ostrava-Karvina Basin (Czech Republic).

Here we present a coal ball flora from the Hauptflöz Seam, Namurian C, from the former Carl Funke Mine in Essen-Heisingen. Over 200 coal ball slabs were acquired for the Münster palaeobotany collection in the late 1960s. It is estimated that the collection originally consisted of around a dozen coal balls. Altogether some 25 taxa could be identified. The preservation varies from rather poor to excellent. Calamitaleans are the most common elements and are represented by roots (*Astromyelon*), stems (*Arthropitys*), strobili (*Calamostachys*) and leaves. Also well represented are ferns, especially *Stauropteris*; less common are *Botryopteris*, *Etapteris* and *Ankyropteris*. Lycopsids are not really common and primarily represented by *Stigmaria* appendices, although these seem to be restricted to particular coal balls. Among the most common lycopsids are furthermore isolated *Lepidophloios* leaf cushions and leaves. Only a few, rather poorly preserved lycopsid stems, a couple of *Lepidocarpon* megasporophylls and few cone remains were found. A partly decayed lycopsid stem is overgrown by a dense *Stauropteris* stand. The pteridosperms of the Häuptflöz Seam include *Medullosa*, *Lyginopteris* and *Heterangium*. Together with the silicified but rather poorly preserved plants from the same coal seam from a nearby mine described in the 1950s, the flora of the Hauptflöz Seam gives an idea of the composition of the swamp vegetation in the early Bashkirian. The flora shows more or less the same diversity as the younger, Langesettian and Duckmantian coal ball floras from the Netherlands and Belgium. In contrast to these younger coal ball floras, the Hauptflöz flora is not dominated by lycopsids but by calamitaleans and to a lesser extent by ferns.

O176

ANATOMY, AFFINITIES, AND EVOLUTIONARY IMPLICATIONS OF NEW EARLY CARBONIFEROUS SILICIFIED STEMS OF *SPHENOPHYLLUM*

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Sphenophyllales are an extinct group of sphenopsids, the clade represented today by the genus *Equisetum* (horsetails). They are known from the Late Devonian to the Triassic and the genus *Sphenophyllum* is probably the best known representative of the group. Reconstructions of Late Carboniferous species show *Sphenophyllum* as a non-self-supporting plant with a scrambling or climbing habit. Unlike extant sphenopsids, *Sphenophyllum* produced secondary xylem and detailed studies of Late Carboniferous species have shown that it contained very wide and long tracheids and a unique system of vertical parenchyma cells connected to the rays.

In contrast with the numerous specimens and species reported during the Late Carboniferous, the anatomy of Early Carboniferous *Sphenophyllum* is poorly known, in part due to a smaller number of outcrops, most containing only compression/impression specimens. In Tournaisian deposits of Montagne Noire (France) and Thuringia (Germany) however, both compression/impressions and anatomically preserved specimens have been reported. In this study, we describe 6 silicified specimens of *Sphenophyllum* from these two regions. The specimens are 2-10 mm in diameter. They have a sub-triangular stele about 1.5 -2 mm wide with one protoxylem strand at the end of each arm, usually represented by lacunae. The cortex forms 6 ridges and contains elongated cells that have a decreasing diameter and increasing wall thickness towards the periphery. Leaf traces are emitted in whorls and one of the specimens branches. Some axes contain only primary tissues while others have a little amount of wood. Secondary xylem tracheids have a maximum diameter of 80 µm. Rays are present but there is no evidence of other cell type. The new specimens are compared to *Sphenophyllum insigne*, a species erected in 1895 by Williamson and Scott for Early Carboniferous stems from Scotland and that differs significantly in anatomy from younger specimens of *Sphenophyllum*. Although they represent very short portions of stems and prove difficult to compare with compression/impression material, the new specimens are interesting in that they show some variability in terms of wood development. None has lost their primary cortex and it impossible to determine whether they had the potential to grow more and produce a secondary bark as has been demonstrated in other *Sphenophyllum*.

A review of Sphenophyllales anatomy through time shows that Devonian-Early Carboniferous representatives differ significantly from the younger "classic" species, especially in terms of wood qualitative and quantitative characters which suggests different hydraulic and mechanical properties.

O177

EARLIEST SPERMATOPHYTE EVOLUTION: STATE OF THE ART AND NEW RESULTS.

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The evolution of the seed habit constitutes one of the key evolutionary step at the base of the present day land plant diversity. It nevertheless remains matter of many debates. Phylogenies remain unresolved as to know the exact relationship existing between the different Devonian representative of the lignophytes and their relations with spermatophytes. The transition from free sporing to indehiscent monomegasporic plants remains obscure. Questions such as the growth habit, dispersal or ecology of the earliest seed plants are still heavily discussed and lack fossil evidences. A Givetian origin of the group is presently hypothesized and seemingly supported by the occurrence of the "proto-ovule" *Runcaria heinzelinii* as well as several seed megaspores such as *Spermasporites allenii*. It is however in the Famennian that the fossil record of the group really starts. Since the discovery by Pettitt and Beck (1968) of the first Devonian spermatophyte *Archaeosperma arnoldii*, many taxa have been described. They were mostly found in Laurussia (Belgium, UK, USA) and more recently in localities corresponding to present day China. In this presentation, after a short state of the art presenting several remaining key questions, we describe a new ovule taxa from the Famennian of South Africa. It was collected in the so called Waterloo Farm Lagerstaten near Grahamstown. This fossil represents the first occurence of seed plants on Gondwana. Though Uppermost Famennian in age, it documents a new morphology surprisingly presenting several plesiomorphic characters that help at understanding the earliest steps of spermatophyte growth habit, ecology and evolution.

O178

GLOSSOPTERIDS LAST GASP? A REINVESTIGATION OF A LATE PERMIAN PERMINERALIZED FLORA FROM ANTARCTICA

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The *Glossopteris* flora dominated Gondwana throughout the Permian (252–299 Ma) as Earth's climate transitioned from an icehouse into a greenhouse. At the end of the Permian, glossopterid floras disappeared but no environmental/macroecological transition to the early Mesozoic *Dicroidium* flora has been documented in Antarctica. Localities in Antarctica have provided abundant data on the anatomy and morphology of glossopterids, and these clues demonstrate the diversity within the group as well as growth responses to high latitude environments. On a recent field expedition to Antarctica (2017-2018), an extensive collection of permineralized peat was gathered at the Collinson Ridge locality in the Shackleton Glacier region (85° 13.034' S, 175° 15.97'W). This material was collected from several exposed lenses as well as debris slopes. In addition to the silicified peat, permineralized logs and in situ stumps were found in abundance along a sandstone ridge. The silicified peat is dominated by various glossopterids including: leaf mats, long and short shoots, *Vertebraria*, at least three morphologically distinctive ovules, and a microsporangiate structure containing numerous pollen sacs, all of which indicates a low diversity landscape. However, initial observations hint that the plant remains at Collinson Ridge have anatomical features distinctive from other permineralized floras and illustrate that the diversity of glossopterids across Antarctica may be greater than currently known.

Earlier stratigraphic reports of material from Collinson Ridge have proposed an Early Triassic age based on the lithology demonstrated by the presence of a braided river system dominated by coarse sandstones. Conversely, paleobotanical studies of the area have indicated that while Collinson Ridge has the lithology characteristic of the lower Fremouw Formation, it is chronologically Late Permian in age based on the presence of *Glossopteris* and the absence of *Lystrosaurus*. In addition, the lithology depicts an extreme depositional environment in which the river system had evolved to infill the classic high water table of Permian meandering rivers and formed the Triassic braided rivers. This would suggest that Collinson Ridge is one of the few Gondwanan localities where latest Permian fossils may provide details on the diversity, biology, and ecology of the plants that inhabited glossopterid floras shortly before the Permian–Triassic extinction.

O179

RECONSTRUCTING HABITAT TYPES AND CLIMATE OF THE 'BALTIC AMBER FOREST': CONIFERS AND OTHER VASCULAR PLANTS

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The Baltic amber deposit is the largest amber deposit worldwide and it is particularly well-known for the plethora of arthropod inclusions it contains. The floristic composition of its source vegetation, the habitat types and climate of its source area, however, are still controversial, with differing suggestions ranging from early Eocene tropical to late Eocene temperate environments, and from lowland to montane forests. To clarify these issues surrounding the 'Baltic amber forest', we screened a vast amount of botanical inclusions and chose those inclusions of vascular plants that provide reliable information about habitat structure and climate by comparing the inclusions to fossil analogous taxa and/or their nearest living relatives.

Our study of amber inclusions from historic collections, complemented by recently discovered amber pieces, revealed the presence of a range of extant and extinct conifer genera. Conifer inclusions encompass a variety of Cupressaceae (*Calocedrus* sp., *Taxodium* sp. and *Quasisequoia couttsiae*), one representative of the Geinitziaceae (*Cupressospermum saxonicum*), several Pinaceae (*Abies* sp., *Cathaya* sp., *Nothotsuga protogaea, Pinus* div. sp. and *Pseudolarix* sp.) and cladodes of Sciadopityaceae (*Sciadopitys* cf. *tertiaria*). In addition to the diverse conifer genera, several particularly ecologically relevant angiosperm groups are represented. These include members of the Cyperaceae with affinities to *Rhynchospora* sp. and Poaceae, as well as six species of dwarf mistletoes *Arceuthobium* sp. (Viscaceae), and the first fossil record of the carnivorous plant family Roridulaceae.

These new findings hint at distinct source ecosystems within the 'Baltic amber forest' source area: coastal swamps, back swamps and riparian forests, as well as mixed-mesophytic conifer-angiosperm forests with meadows and open areas. Based on the comparison of the climatic requirements and distributions of extant and fossil analogues of the amber inclusions, a warm-temperate humid climate is assumed. Our results challenge previous hypotheses about Baltic amber deriving from lower Eocene tropical or subtropical forests.

O180

RECONSTRUCTING HABITAT TYPES AND CLIMATE OF THE 'BALTIC AMBER FOREST': CALICIOID FUNGI AND LICHENS

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The common notion that Baltic amber derives from tropical or subtropical forests has recently been questioned based on the evaluation of plant inclusions from this amber deposit which rather suggest warm-temperate forests as source ecosystems. Recent findings from fossil macrolichens are likewise most consistent with humid but relatively well-illuminated temperate forests. We aimed to provide independent data from ecologically specific fungi that hint to climate and forest structure. Screening of major Baltic amber collections revealed that calicioid fungi were diverse and probably abundant in the source forests of the Baltic amber. The polyphyletic group of calicioid fungi can be highly specific to certain forest types and climatic conditions, and the extant forms exhibit high selectivity in their microhabitat preferences. Furthermore, their abundance and diversity in modern forest ecosystems is climate and habitat dependent. As the group has a wide extant distribution and it dates back at least to the Eocene it can provide valuable information about forest conditions, past and present. The assemblage of calicioid fungi from Baltic amber demonstrates that key features in the morphology of these organisms have not changed since at least the Eocene, indicating that also their fundamental niches have remained stable. The prominent presence of calicioids among amber fossils gives strong support to the overall perception of European Paleogene amber forests as temperate forests with variable and in places open canopies. These forests provided calicioids with suitable substrate and a variety of microhabitats that combined favorable light conditions with high atmospheric humidity.

O181

PALAEOGENE LICHENS AND THEIR ECOLOGICAL ADAPTATIONS

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Lichens are highly specialized symbioses between heterotrophic fungi and photoautotrophic green algae or cyanobacteria. The mycobionts of many lichens produce morphologically complex thalli to house their photobionts. Lichens play important roles in ecosystems and have been used as indicators of environmental change. We have inspected over 160 lichen inclusions enclosed in Baltic and Bitterfeld amber using light microscopic and scanning electron microscopic (SEM) imaging. The described material multiplied the number of known fossil lichens over tenfold, showing that the European Palaeogene amber is an important, previously largely neglected source of fossil lichens, and establishes fossil lichens as indicators of fossil forest ecosystems. Most of the fossils represent extant lineages of the Lecanoromycetes, an almost exclusively lichen-symbiotic class of Ascomycota. Especially common are genus *Anzia* and some other representatives of the family Parmeliaceae.

The fossils include a wide variety of growth forms and many fine examples of morphological adaptation to the past forest environment, including adaptations that attached epiphytic thalli to their substrates, helped to combine external water storage with effective gas exchange and facilitated the simultaneous reproduction and dispersal of both partners in symbiosis. Some of the thallus morphologies are missing or rare in the extant European lichen species and suggest that the climate of European Palaeogene amber forests was relatively humid and most likely temperate.

O182

AMBER AND THE ARAUCARIAN FORESTS OF NEW ZEALAND

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New Zealand's terrestrial ecosystems are one of the notable modern global biodiversity hotspots, based on the level of endemism and distinctiveness of the biota. However, there is much debate surrounding the origin, antiquity and evolutionary history of this terrestrial biota due to the paucity of fossils. The history of New Zealand's higher plants, and in particular the Araucariaceae, has been improving through new macro- and microfossil finds, and through the exciting discovery of araucarian-derived ambers. Taken together, they provide evidence that araucarians have been important trees in the forests of Zealandia since at least the Late Cretaceous.

Our recent finds in the South Island of New Zealand have uncovered numerous Cretaceous and Cenozoic amber localities. The Cretaceous ambers are currently under investigation and their affinities are not yet known. Cenozoic ambers have been recovered from over 30 localities but are often bubble-filled and opaque, and so were thought to be devoid of fossil inclusions. Painstaking preparation of the Cenozoic amber has led to the discovery that this is the first major araucarian-derived amber deposit with biological inclusions from the Southern Hemisphere. These amber-preserved fossils comprise 10 orders and approximately 20 families of terrestrial arthropods plus nematodes, fungal groups and plants. The inclusions also encompass diverse ecologies, giving us an unparalleled glimpse into the mid-Cenozoic araucarian forests of Zealandia. Many of these fossils represent groups with either poor or non-existent fossil records in New Zealand and elsewhere in the Southern Hemisphere. Both the systematic and the ecological diversity of the biological inclusions highlight the potential of New Zealand amber for reconstructing the past terrestrial ecosystems of Zealandia.

O183

BRINGING FOSSIL WOOD INTO POLICY OPTIONS: A CASE STUDY IN INDONESIA

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Fossil woods have been found in many regions in Indonesia and commonly commercialised as a precious stone. Most cases show that generally fossil woods are traded in large sizes without further significant processing which can be categorised as raw material. On the other hand, the study of palaeobotany particularly in fossil wood is still limited due to its lack of scientific interest and expertise, whereas the comprehensive research on fossil wood in Indonesia is important to reconstruct the botanical identity of past floristic composition. The information obtained from palaeobotany study can be used to support the reforestation program in determining appropriate tree species in a certain area where the fossil woods are found. This unbalance phenomenon between the lack of research and over-exploitation triggers the fears of fossil wood extinction which means the loss of history of the ancient vegetation of Indonesian tropical forest. Therefore, it is important to bring this issue into several policy options to ensure the exis-

tence of fossil wood for future generation. Pros and cons might be faced from different perspective between conservation and economic aspects because many fossil wood manufacturers have established for a long time. In the upcoming conference, we will present our review on the research status of fossil wood research in Indonesia which show interesting fact of the extinction of certain tree species, the current status of fossil wood in Indonesia in terms of utilisations and trade, the possible policy options to solve the problem based on literature review and multi-stakeholder focus group discussion. Some policy options have been recommended such as the regulation to promote the establishment of fossil wood conservation sites and how to control fossil wood extraction for commercial purposes. During the conference, we do hope to gain knowledge and information as much as possible regarding how European countries manage their petrified wood.

Keywords: fossil wood, Indonesia, policy, conservation, extraction

O184

USING POSTGLACIAL VEGETATION HISTORY TO PROVIDE GUIDANCE ON POSSIBLE FUTURE RATES OF VEGETATION CHANGE

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The climate warming at the end of the last ice age is the most recent example of a global state shift and numerous pollen and macrofossil records document the associated changes of the terrestrial biosphere. European pollen data collected in the European Pollen Database (EPD) document that trees have spread rapidly at the beginning of the Holocene with rates that would keep up with predicted velocities of future climate change. While many pollen diagrams show strong changes at the onset of the Holocene warming others document lower rates of change and we can use these differences in response to climate change to explore factors such as soil texture that may influence possible rates of change. Comparing pollen diagrams from the Alps provides insights on the importance of the initial vegetation on the timing and dynamics of vegetation change. At low elevations a forest with boreal elements persisted during the Younger Dryas and presented an inertia for the establishment of newly arriving trees during the Early Holocene. As a result, populations of temperate trees started to grow earlier in higher locations, although at slower rates due to the generally lower temperatures. These examples document general processes with relevance to the ongoing debate on the consequences of global warming on the vegetation. Nevertheless, the palaeoecological perspective also indicates that recent land use had an as strong or stronger effect on vegetation change and at least in Europe future vegetation dynamics will largely depend on management practices.

O185

HOW RELIABLE IS THE DINOCYST GENUS *SVALBARDELLA* AS A TEMPERATURE PROXY: IMPLICATIONS FOR PALEOCLIMATOLOGICAL STUDIES OF THE LATE PALEOGENE

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Currently the dinocyst genus *Svalbardella* is represented by two formally described morphotypes: *Svalbardella cooksoniae* (type species) and *S. partimtabulata*. However, a number of informal *Svalbardella*-like species have been registered from the northern hemisphere settings. Notably, some of these *Svalbardella*-like forms show features typical for the *Paleocystodinium* genus. It is generally accepted that *Svalbardella* spp. differs from *Paleocystodinium* spp. in having bluntly rounded apical and antapical horns and indications of paratabulation other than the archeophyle.

Svalbardella is known mainly from late Middle Eocene to Oligocene deposits of northern high latitudes (e.g. 1,2). The first appearance of *Svalbardella* in the Northern Atlantic is dated to 41.9 Ma (2). The paleogeographic distribution of *Svalbardella* suggests an affinity with cold, arctic water masses (3), and thus the genus is commonly applied as a cold(er) water indicator. In addition, *Svalbardella*–rich intervals described from Early and mid-Oligocene strata have been linked with the two Oligocene glacial maxima, the Oi-1a and the Oi-2b, respectively (4,5).

However, a recent study based on organic biomarkers (6) have shown that an interval yielding *S. partimtabulata* in the Middle Eocene of Denmark corresponds with elevated sea-surface temperatures. This is just one of several examples illustrating that considering the entire genus of *Svalbardella* as a proxy for sea surface cooling may be misleading. This study aims to recognize and describe key species within the *Svalbardella* genus, and to assess their potential as paleoclimatological proxies.

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O186

CONSISTENCY IN THE RELATIONSHIP BETWEEN FIELD-MEASURED STOMATAL CONDUCTANCE AND THEORETICAL MAXIMUM STOMATAL CONDUCTANCE ACROSS FOUR BIOMES PROVIDES A NEW REFERENCE FOR PALAEOPROXIES

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A defined scaling relationship between operational stomatal conductance (g_{op}) and the theoretical (anatomical) maximum stomatal conductance (g_{max}) of plants in response to changing atmospheric CO_2 concentration is an important tool for assessing plant-climate interactions. For palaeobotanists g_{max} is an important palaeotrait proxy for inferring g_{op} and palaeoatmospheric CO_2 concentration from the fossil record to track plant macroevolution through changing climate. It is well established that under field conditions g_{op} is measured at only a fraction of g_{max}. To date however, investigations of the g_{op}:g_{max} relationship in modern plants have been geographically narrow and limited to a small number of controlled environment or single-species field experiments so that for vegetation in natural forested ecosystems it remains undefined and virtually unexplored. We investigated the present-day field-measured g_{op}:g_{max} ratios in 26 deciduous and 49 evergreen woody angiosperm species in four biomes (boreal, temperate rain-, tropical rain- and tropical seasonal forests) to explore the pattern of this relationship at species, plant functional type (PFT) and biome levels. Despite wide inter-species variability in all biomes, we determine a consistency in scaling relationship at PFT (deciduous and evergreen) and biome levels. This novel dataset could improve palaeo-climate models by providing g_{op}:g_{max} scaling factors that affect the estimated g_{op} calculated from g_{max}, which currently may be underestimated. It may also help to reduce uncertainty in g_{op} calculated from fossil stomatal geometry to assess paleophysiological plant and palaeoecosystem function and better interpret and predict their responses to climate change, past, present and future.

O187

MULTIPLE PALAEOECOLOGICAL PROXIES CONSTRAIN THE INTERPLAY BETWEEN TIBETAN PLATEAU GROWTH, THE PROTO-MONSOONS AND FLORAL DISPERSAL DURING THE EARLY INDIA-ASIA COLLISION

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The interplay between tectonics, monsoonal climate regimes, and biodiversity of the Tibetan Plateau has been the recent focus of much investigation. However, the linkages between orogeny and climate, as well as their impacts on floral diversity, are still unclear. The Nangqian Basin of east-central Tibet holds a key Paleocene–Eocene record of deformation and environmental change during the early stage of the India-Asia collision, the development of the Tibetan Plateau, and the proto-monsoons. Here, we examine new palynoassemblages recovered from this basin and apply Fourier Transform Infrared (FTIR) microspectroscopy to quantify ultraviolet irradiance based on pollen chemistry, in combination with plant leaf wax biomarkers. Although the studied section was previously assigned a mid-Cretaceous age based on ostracods, this new palynological evidence combined with magnetostratigraphy rather indicates a Paleogene age. Volcanic intrusives and extrusives crosscut the lacustrine to alluvial Cenozoic Nangqian strata, providing a minimum age constraint at ca. 37 Ma. In the context of a proto-Tibetan Plateau established early in the Cenozoic, the abundance of high-altitude bisaccates from the Nangqian section is of particular interest. It largely predates the spread of high-altitude elements to the North in Central Asia from 36 Ma, and their diversification after the 34 Ma Eocene–Oligocene transition cooling. These observations are in line with a growing body of evidence that parts of the Tibetan Plateau had attained high elevations similar to modern conditions soon after the India-Asia collision. The outward growth from this elevated central part of the Tibetan Plateau, with associated effects on the monsoons, is envisioned to have had major effects on dispersal and speciation of the Pinophyta across Asia during the Paleogene.

O189

PLANT-INSECT INTERACTIONS DURING THE LATEST EOCENE TO EARLIEST OLIGOCENE IN SOUTHEASTERN QINGHAI-TIBET PLATEAU

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Insect damage patterns on fossil leaves are an important tool to understand the evolution of plant-insect interactions and its response to climate change in the geological past. There are abundant investigations focusing on these patterns especially during the past two decades; however, only few studies have been carried out in China, where it is pivotal to understand the evolutionary pattern of plant-insect interactions.

Recently, we found plenty of fossil leaves with well-preserved damage types from the Kajun flora in Markam County, which is located in the southeast of the Qinghai-Tibetan Plateau (QTP, 29°45'N; 98°25' E). According to the latest 40Ar/39Ar dating, the Kajun flora ranges from the latest Eocene to earliest Oligocene. The entire stratum bears abundant plant fossils; among all layers, two layers (MK-1, 33.4 ± 0.6 Ma and MK-3, 34.6± 0.8 Ma) are the richest in plant fossils with good preservation, which allows for observing insect damages on fossil leaves.

Floristic components indicate that MK-1 is dominated by Equisetum and Salix, whereas MK-3 is dominated by Cyclobalanopsis and Betula. The CLAMP (ClimateLeaf Multivariate Analysis Program) result of MK-1 is 10.77±1.25°C for mean annual temperature (MAT), and MK-3 is 14.58±1.25°C (MAT). The fossil leaves from both layers show divers insect damage that can be affiliated to different damage types (DTs). Of the total of 692 leaves in MK-1, 161 leaves were damaged. We identified 18 DTs in this assemblage, among which the major damage types are hole feeding and skeletonization. Of the total of 1.909 leaves in MK-3, 787 leaves were damaged. From the 39 DTs we had identified, the richest damage types of this assemblage are hole feeding, margin feeding and galling.

Compared to MK-1 assemblage, the MK-3 assemblage has much higher damage frequency and more damage types. Together with paleoclimate reconstructions, this study indicates that the decline of temperature might be the driving force for the decrease of insect damage frequency and the plant communities of the Kajun flora. We conclude that the global climate decrease as well as the mountain uplift during the latest Eocene to earliest Oligocene should be main factors to stimulate the change in plant-insect interactions in the Qinghai-Tibetan Plateau.

O191

MORPHYLL: A MORPHOMETRIC DATABASE FOR FOSSIL LEAVES

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Various methods for palaeoenvironment reconstruction utilize leaf traits and their correlations with climate, such as the widely used CLAMP or Leaf Margin Analysis. New approaches are still being developed to extract more palaeoecological information from fossil leaves, particularly with respect to quantitative leaf trait data obtained by digitization and morphometry. An example is leaf mass per area, an important ecophysiological parameter which can be approximated by petiole leaf width and lamina area. Data availability and data quality is crucial for trait-based approaches which will therefore considerably benefit from internet resources. Recently, the database MORPHYLL was introduced which offers a web-based resource for fossil leaf trait data, including quantitative (= continuous) parameters such as leaf lamina area and perimeter as well as qualitative (= categorical) parameters, such as presence or absence of leaf teeth or lobation. Currently, data from about 6000 fossil leaves are included, from more than 20 collections of fossil leaf floras from eight European museums in five countries in Central Europe. The age range of the material spans almost the entire Paleogene and Neogene. The data are based on digital images obtained from the fossil leaf specimens by photography or scanning. Data extraction is based on reconstructing the outlines of the fossil leaves as a GIS shapefile. In this way, the fossil leaf shape is represented as a well-established geospatial vector data format for geographic information systems (GIS), allowing data processing and extraction in spatial databases using spatial SQL-queries. Both images and shapefiles are stored in MORPHYLL, together with the extracted quantitative morphometric data and various metadata (specimen accession number, fossil site name with stratigraphic position, location of repository/collection, etc.). Choosing GIS as a tool for editing leaf outlines offers various advantages such as flexibility, transparency of image processing, and easy re-analysis for further morphometric parameters. The database is accessible via http://www.morphyll.naturkundemuseum-bw.de/index.php.

O192

NON-POLLEN PALYNOMORPHS DATABASE: CHALLENGE AND IMPLEMENTATION

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Non-pollen palynomorphs (NPP) represent a large group of microscopic remains found in palynological slides besides pollen and spores. They are represented by algal remains, fungal spores, resting stages and eggs of invertebrates. Starting in the 70th of the 20th century with studies by Bas van Geel and colleagues, large numbers of new described types are published every year. In order to get an overview to the wide world of these "extra fossils" in pollen slides, we decided to create a webpage aiming to gather information about NPP, structuring it by nomenclature and where possible taxonomy and help by identification. The webpage is currently in development: http://nonpollenpalynomorphs.tsu.ru/. One of the important parts of the webpage is the database with illustrations, descriptions and ecological information about the NPP. It is developed with php and MySQL. In this talk, we will present the webpage and the NPP database and discuss challenges in implementation.

O193

STRADITIZE: AN OPEN-SOURCE PROGRAM FOR DIGITIZING POLLEN DIAGRAMS AND OTHER TYPES OF STRATIGRAPHIC DATA

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In an age of digital data analysis, gaining access to data from the pre-digital era – or any data that is only available as a figure on a page – remains a problem and an under-utilized scientific resource. Whilst there are numerous programs available that allow the digitization of scientific data in a simple x-y graph format, we know of no semi-automated program that can deal with data plotted with multiple horizontal axes that share the same vertical axis, such as pollen diagrams and other stratigraphic figures that are common in the Earth sciences. STRADITIZE (Stratigraphic Diagram Digitizer) is a new open-source program that allows stratigraphic figures to be digitized in a single semi-automated operation. It is designed to detect multiple plots of variables analyzed along the same vertical axis, whether this is a sediment core or any similar depth/time series.

The program is written in python and supports mixtures of many different diagram types, such as bar plots, line plots, as well as shaded, stacked, and filled area plots. The package provides an extensively documented graphical user interface for a point-and-click handling of the semi-automatic process, but can also be scripted or used from the command line. Other features of STRADITIZE include text recognition to interpret the names of the different plotted variables, the automatic and semi-automatic recognition of picture artifacts, as well an automatic measurement finder to exactly reproduce the data that has been used to create the diagram. Evaluation of the program has been undertaken comparing the digitization of published figures with the original digital data. This generally shows very good results, although this is inevitably reliant on the quality and resolution of the original figure.

O195

THE LIFE AND LEGACY OF THOMAS N. TAYLOR

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This symposium highlights the extraordinary scientific achievements and the exceptional impact on future scientific directions by one of the most remarkable paleobotanists of our time. The late Thomas (Tom) Norwood Taylor (1937–2016) is renowned for his prolific creative scholarship, effective teaching, generous mentorship, innovative expansion of paleobiological inquiry, tireless development of scholarly institutions, and fierce loyalty to students, postdocs, and colleagues. Perhaps most awe inspiring was Tom's ability to bring together innovative collaborations, many reflected within this symposium, that constantly pushed the discipline forward. This introduction highlights Tom's early accomplishments and contributions to Carboniferous fossil plant morphology and anatomy in the laboratory of Wilson Stewart, and his fruitful collaboration with Don Eggert at the University of Illinois at Chicago Circle, where Tom pioneered the use of scanning and transmission electron microscopy to elucidate ultrastructural features of pollen and spores. It also emphasizes his later pioneering work in the discipline of paleomycology and expansion of research emphasis to Antarctic Gondwana at The Ohio State University, and finally a culmination of his research foci on paleo-organismal interactions and interrelatedness at the University of Kansas. The presentations that follow represent a small cross section of the research areas Tom has developed, strengthened, and expanded, the new techniques he has developed, the collaborations he has forged, and scholarly careers he has influenced.

O196

NEW APPROACHES IN ELUCIDATING THE ANATOMY OF EARLY LAND PLANTS

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The evolutionary relationships between the lineages of living bryophytes and vascular plants are still not fully understood. No consensus has yet been achieved from phylogenetic analyses. To determine the sequence of early land plant character evolution it is therefore essential to study early embryophyte fossil lagerstätten. One of the oldest and most diverse assemblages of early embryophytes is from Lower Devonian strata at Brown Clee Hill, Shropshire (UK), in which plant anatomy has been preserved to cellular level by charcoalification. Studies using scanning electron microscopy spanning the last 30 years have revealed this to be a diverse assemblage of early tracheophytes and a group of plants that possess both tracheophytic and bryophytic characters. While the charcoalification process has preserved these plants exceptionally well, including their *in situ* spores, these rare specimens are minute and fragmentary, and compressed to varying degrees. Elucidating the anatomy of internal tissues within axes has proven difficult to achieve, particularly the recognition of conducting cells, including tracheids, a key synapomorphy of the tracheophytes. We have had some success in physically sectioning embedded specimens for ultrastructural studies using transmission electron microscopy (TEM). We have developed this approach further with the use of semi-thin sections (~100 µm slices) mounted on slides for optical microscopy, which provide us with smaller scale structural data, such as the arrangement of spore units within polyads and the cellular structure of sporangial and axial walls. Computed tomography provides us a non-invasive and non-destructive alternative approach. Here we present data from Synchrotron Radiation X-ray tomographic microscopy of Lower Devonian charcoalified embryophytes from the Swiss Light Source, Switzerland. In particular, we show evidence for tracheids in *Tortilicaulis* for the first time, cementing this taxon as a tracheophyte and not a bryophyte.

O197

REST WELL WITHIN A MICROBIAL MAT: EXCEPTIONAL PRESERVATION OF MICROORGANISMS IN THE LOWER DEVONIAN RHYNIE AND WINDYFIELD CHERTS, SCOTLAND

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Microbial mats were widespread in the Lower Devonian Rhynie and Windyfield environments, and comprised diverse communities of organisms, including bacteria, cyanobacteria, fungi, algae, and animals; the framework builder of these structures was a filamentous organism formally described as *Croftalania venusta* and interpreted as a cyanobacterium. However, the vast majority of other life forms that occurred in the mats have not been studied in detail to date, nor has the complexity of the mat communities been assessed. Nevertheless, it is reasonable to assume that the many different organisms present in the Rhynie and Windyfield microbial mats did not only use the mat as a habitat, but also variously interacted with each other. For example, charophyte algae that occur in Windyfield microbial mats demonstrate multiple levels of interaction with both the mat framework builder and certain microfungi, including one type that is characterized by thick-walled, epibiotic zoosporangia and multi-branched rhizomycelia. Another form possesses short-stalked, lacrimoid zoosporangia with a single discharge opening. The mostly sublime preservation of the fungi suggests that, in settings such as the Rhynie and Windyfield paleoenvironments, the mat framework had a cushioning effect on destructive mechanical forces such as water movement, and hence was effective as a conservation trap for the delicate microorganisms. Supporting this hypothesis also is a dense stand of particularly delicate organisms attached to another charophyte branch. Specimens are up to 30 µm in size and comprised of a long, narrow stalk to which is attached a funnel-shaped cell. The fossils are reminiscent of certain present-day heterokonts, lower fungi, and ciliophores. Although the systematic affinities of the long-stalked microorganisms remain unresolved, their discovery is important because it indicates that microbial mats can be important sources of new information on the evolutionary history of lineages of organisms that do not normally become preserved as fossils.

O198

HOW MUCH CARBON WAS STORED IN THE EARLY FORESTS OF THE MIDDLE DEVONIAN?

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Different models indicate that the evolution of trees and the colonization of land by forests drove significant changes in the carbon cycle and a marked drop in the atmospheric CO_2 during the Devonian. However, the contribution of early trees and forests to the terrestrial carbon has never been quantified. As a first step to resolve this challenge, we propose to calculate the above-ground biomass and carbon content stored in a Middle Devonian forest structured like the *in situ* Givetian forest reported at Riverside Quarry, Gilboa, New York State (Stein et al., 2012). Trees in this forest belong to the Pseudosporochnales. Above ground, they consist of a trunk topped by a crown of branches. *Pseudosporochnus*, the most widely distributed and best known genus of Pseudosporochnales, is chosen here to represent an archetypal tree of these early forests, and *Lorophyton* to represent an archetypal early growth stage of these trees (Fairon-Demaret & Li, 1993; Berry & Fairon-Demaret, 2002).

This communication presents the architectural modeling of a 3-m high *Pseudosporochnus* tree using the AmapSim software and its computer simulator (Barczi et al., 2008). The carbon content of the tree and of its components is calculated at any time during growth using the mean carbon density of two Carboniferous plants of comparable structure, *Psaronius* and *Medullosa* (Baker & Dimichele, 1997). The carbon content of a fully grown tree is calculated to range between 837 and 1,300 g C. At 40% of development and beyond, most of the carbon is contained in the trunk. However, when considering the cumulative amount of carbon, i.e. as if the tree had retained all its branches during growth, most of the carbon is allocated to the branches.

Given some assumptions on the density and age of the trees, the carbon content of a *Pseudosporochnus* forest is calculated to range between 4.3 and 15.5 t C/ha. It is relatively low compared to extant forests, the closest analogs in terms of productivity being either thickets of young trees or environmentally constrained forests. The accuracy of the model is discussed and any conclusion about an adaptation of pseudosporochnalean forests to constrained environments must be taken with great care. Yet, it is interesting to note that previous authors reporting forests around Gilboa suggested that they inhabited either stressed or disturbed environments (Mintz et al., 2010; Stein et al. 2012).

O199

WOODY PLANTS FROM THE EARLY DEVONIAN OF CANADA

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Several Early Devonian (Pragian and Emsian) aged plants, *Armoricaphyton chateaupannense*, *Franhueberia gerriennii,* and at least one undescribed taxon from eastern Canada, exhibit a small amount of secondary xylem much earlier than previously known. Where preserved morphologically, stems are 3-5 mm wide, and branch; anatomy shows that all exhibit P-type secondary wall patterns in some or all of the tracheids, suggesting they may represent members of a basal euphyllophyte lineage. Lateral trace emission pattern is now known for *Armoricaphyton*.

The undescribed Emsian taxon from New Brunswick includes axes with only primary xylem or both primary and secondary xylem. Lateral traces differ markedly from the first type in departing from either end of an elongated stele. A second axis type from the same locality, based on a small number of specimens, exhibits a poorly preserved region of primary xylem and up to 80 rows of aligned (secondary) tracheids. The axis divides isotomously. Recently studied specimens from Emsian strata near Seal Rock, Gaspé exhibit morphologically and anatomically preserved slender (3-5 mm) axes, some fertile, suggesting an affinity to *Psilophyton*. Anatomy is a centrarch haplostele; lateral trace departure is similar to known psilophytons. Wider ribbed axes (7-9 mm) occur in association with the *Psilophyton*- type ones, producing lateral branches similar in diameter to slender ones. Non-fertile axes 4-8 mm diam, and one clearly wide axis exhibit both primary and putative secondary xylem. This assemblage represents either two taxa, or different regions of one; if one, and if it is assignable to *Psilophyton*, it would demonstrate some of the widest (perhaps basal?) axes known for a Psilophyton and presence of probable secondary growth in that taxon.

These discoveries raise a number of interesting questions about mode and pattern of vascular cambium evolution, including in how many lineages and how many times within a given lineage has secondary tissue arisen; do these plants possess a uni- or bifacial cambium and if unifacial, why is there only a limited amount of secondary growth? What role does so-called aligned metaxylem or ground tissue play? How does the presence of a cambium in *Psilophyton*-grade Early Devonian plants relate to evolution of secondary tissues in lignophytes and/or other euphyllophytes? What are the implications in regard to evolution of different plant architectures in Early to Middle Devonian times, especially when these taxa suggest size is not the only factor driving evolution of secondary tissues?

O200

THE DYNAMICS OF AN EMERALD PLANET – LARGE-SCALE PATTERNS IN VEGETATION CHANGE THROUGH GEOLOGICAL TIME

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Based on a comprehensive dataset of plant family distributions through geological time, broad patterns have been revealed in the overall trajectory of vegetation history. It has provided firmer definitions to the traditional concepts of Palaeophytic, Mesophytic and Cenophytic floras, as well as revealing two pre-Carboniferous, "early land plant" floras termed Eophytic and Rhyniophytic. The relationships between these floras can be seen in the context of the appearance of key evolutionary innovations in plants such as seeds, secondary wood and flowers, as well as the responses of vegetation to abiotic factors such as plate tectonics and atmosphere. The much vaunted mass extinctions that have been regarded as key events in the evolution of the Earth's biotas in fact had relatively little long-term effect on the overall trajectory of vegetation history. Indeed, plant fossil dynamics suggests that the great marine biodiversity depletions were sometimes coeval with diversification episodes in terrestrial ecosystems. For instance, while we see high marine extinction rates during Late Devonian times, terrestrial life experienced the transition to a forested planet. Likewise, while the end-Triassic and end-Cretaceous extinction events triggered devastating effects on marine faunas, the land biosphere experienced the heyday of gymnosperms and the explosive diversification of angiosperms, respectively. This suggests that global extinction dynamics operate independently between marine and land ecosystems.

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O201

INTRA- AND INTERSPECIFIC VARIATION IN LEAF ANATOMY ACROSS CLIMATE GRADIENTS OF EXTANT CUPRESSACEAE AND IMPLICATIONS FOR PAST ENVIRONMENTAL NICHES OF EXTINCT TAXA

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Anatomy in plants can vary across an environmental gradient, and thus understanding the specific climatic controls on anatomical traits within modern species can lead to improved interpretation of the fossil record, with the potential to investigate climate niches and paleo-physiology from fossil plants. Cupressaceae, a family of evergreen conifers, occupy a broad range of ecological niches today, are hypothesized to have undergone little morphological evolution since the Cretaceous, and are well-represented in the fossil record, making them useful for testing the relationship between environment, structure, and habitat. Three species, *Metasequoia, Sequoia,* and *Taxodium* were chosen for initial study; in the geologic record, these taxa co-occurred in forests across the Northern Hemisphere but their ranges have since contracted to their modern restricted geographies. Cultivated and wild extant samples (n=146) were collected from 39 sites across North America, Europe, and Asia. Three branchlets from three trees at each site were sampled and leaves were sectioned using traditional paraffin embedding and sectioning techniques. Eight anatomical leaf traits were quantified: area of vascular bundle and resin canal, entire cross section area, leaf width, maximum leaf thickness, and epidermal, mesophyll, and palisade layer thickness. Anatomically preserved leaf sections of fossils from the same genera were measured for the same traits. Climate data were extracted from eleven BioClim variables. Data were analyzed using principal components analysis (PCA) and canonical correlation analysis (CCA). PCA showed all taxa occupy a distinct morphospace. *Taxodium* occupies a much smaller morphospace than *Metasequoia* or *Sequoia*, and fossils fall within the morphospace of extant taxa. The first two principal components (PC) explained most of the variation in the data (99.99%). Entire leaf cross-sectional area explained most of the variation on PC1 (99.97%) and area of vascular bundle and resin canal explained most of the variation on PC2 (0.02%). CCA analyses examined the relationship of anatomy with climatic variables. CCA results identified four main sets of climate variables that explain the variation in the data: seasonally cold and wet, precipitation seasonality, seasonally warm and wet, and temperature seasonality. Taxa largely occupy distinct climate-anatomical morphospaces, with some fossils falling outside of the modern parameter space, possibly indicating that fossil taxa were occupying different environmental niches than their modern relatives. This study demonstrates that morphological investigation of extant and extinct taxa along environmental gradients can help to quantify the relationships between niche and anatomy better, ultimately informing evolution of distributions and physiology.

O202

USING DISPERSED CUTICLES TO EVALUATE CANOPY DENSITY VARIATION IN DEEP TIME: THE LOSS OF PLANT COVER AT THE CRETACEOUS–PALEOGENE BOUNDARY (NORTH DAKOTA, USA)

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The Cretaceous–Paleogene (K–Pg) mass extinction event is associated with profound changes in terrestrial plant ecosystems. These changes are especially well documented in North America, from the Hell Creek and Fort Union Formations in the Marmarth area of North Dakota. Those sediments record a drastic reduction in plant species diversity in leaf fossil assemblages, directly coinciding with mineralogical (boundary clay, shocked quartz) and geochemical (iridium anomaly) evidence of the Chicxulub asteroid impact. This reduction in diversity can also be tracked in the palynological record with the loss of many pollen taxa and the high abundance of fern spores (the fern spike event) immediately following the K–Pg boundary, all-together indicating drastic changes in the composition of plant cover.

In addition to pollen and spores, dispersed leaf cuticles are an abundant component of palynological preparations. A correlation independent of taxonomy has been illustrated between the size and shape of leaf epidermal cells and vegetal cover density, enabling the use of reconstructed Leaf Area Index (rLAI) from cuticles as a new proxy to track changes in plant cover architecture across the K–Pg boundary. We have conducted a preliminary test on the John's Nose section, north of Marmarth, which has been sampled at ~1 cm resolution for palynological analyses across the boundary clay. Results from the cuticle analysis show a significant decrease in rLAI directly coincident with the markers of the Chicxulub impact and the palynologically defined K–Pg boundary. These results provide the first direct evidence of deforestation as a result of the impact blast and/or associated wildfires.

The temporary loss of plant cover represents a key element in the discussion of extinction selectivity and recovery dynamics following the K–Pg mass extinction event. To investigate the link between K–Pg deforestation and its impact on animal evolution, we have performed paleoecological reconstructions and ecomorphological analyses on K–Pg boundary-crossing bird clades. Our results illustrate that the K–Pg mass extinction evinced strong selectivity for the survival of non-arboreal birds across the K–Pg boundary, which may be attributable to the temporary yet widespread loss of forest habitats.

In addition to its utility for reconstructing canopy density, the use of rLAI on dispersed cuticles serves as a new independent marker to identify the K–Pg boundary at localities where other direct evidence of the Chicxulub impact is not preserved.

O203

A HIGH-RESOLUTION RECORD OF LEAF MASS PER AREA ACROSS THE CRETACEOUS-PALEOGENE BOUNDARY FROM THE DENVER BASIN, COLORADO

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Sixty-six million years ago, the Cretaceous-Paleogene (KPg) mass extinction led to immense floral turnover, yet the ecological fallout is less understood. The leaf economic spectrum (LES), a continuum of viable leaf strategies ranging from a fast return on nutrient investment to a slow return, is constructed with leaf functional traits such as leaf mass per area (LMA)—a measure of a plant's investment of carbon into its leaves. Unlike most other functional traits, which are inaccessible in leaf macrofossils, LMA can be estimated via a proxy that uses petiole width squared to reconstruct leaf mass (Royer et al., 2007).

Blonder et al. (2014) used this proxy to measure LMA across the KPg in the Williston Basin of North Dakota and found a loss of high LMA species coincident with the boundary, implying a Paleocene shift towards fast-return leaf strategies. This shift may be attributable to the selective extinction of slow-return species during an impact winter caused by the Chicxulub bolide impact. In this scenario, deciduous (fast-return) taxa would be better suited to waiting out the extended conditions of dark and cold than evergreen (generally slow-return) species.

We test this hypothesis with a new dataset from the Denver Basin in Colorado. With over 500 newly measured fossil leaves from a series of sites spanning the KPg boundary, we compare Denver Basin LMA trends to those in the Williston Basin. Preliminary results show decreasing LMA across the KPg, as well as an absence of high LMA leaves in Paleocene localities, suggesting a similar selection against slow-return species in the Denver Basin. Future work will aim to add to the Denver Basin record, and further analyze LMA by morphospecies, locality, and paleogeography.

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O204

ON THE BIOLOGICAL SIGNIFICANCE OF POLLEN AND SPORE TETRADS

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Pollen and spores occurring in tetrad configuration have attracted considerable attention during recent years. Tetrad morphology and geometry as well as their biological and ecological significance are manifold. In this presentation I will review published data and show new observations on the occurrence of fossil tetrad pollen and spores with emphasis on the Permian and Triassic periods. Increased numbers of undivided microspore tetrads of lycophyte spores (e.g. *Densoisporites*, *Uvaesproites*) have been reported from end-Permian sediments correlating with the end Permian mass extinction. These spore tetrads are formed by even sized spores and interpreted as fully developed spores that did not separate due to mutagenesis under extreme environmental stress. While lycophyte spores are also dominant in some Late Triassic palynomorph assemblages, increased numbers of tetrads during the end-Triassic mass – extinction interval have not been reported.

Late Triassic pollen that are commonly found only as permanent tetrads are *Ricciisporites* and *Froelichsporites*. The permanent tetrads are composed of 4 even sized pollen. The tetrad formation is likely related to polyembryony. However, some taxa of the Circumpollis group, which are normally dispersed as single grains can also be found in undivided tetrads. Besides even sized tetrads of *Classopollis meyeriana* also un-even sized tetrads, associated with triads and dyads have been reported from N-American Tr-J deposits. The occurrence of these un-even sized tetrads is related to the formation of un-reduced 2n pollen in polyploid hybridization. New data from Norian deposits (Hauptdolomit, Rodaun in Austria) revealed the presence of un-even sized *C. meyeriana* tetrads. It indicates that uneven sized pollen tetrads are not restricted to the Tr-J boundary interval but can be also found in older, Late Triassic populations. The findings may imply that the ability to form unreduced 2n pollen is not a mutation related to environmental stress during the end-Triassic mass extinction, but is a general evolutionary trait in this group. Forthcoming studies need to document in detail the record of tetrads in the Circumpollis group, particularly among the early forms of the Late Triassic (*Partitisporites*, *Duplicisporites*...). The evolutionary success of the Cheirolepidiaceae may be related to their ability to form unreduced 2n pollen and thus polyploid hybrids. Polyploidy may be one of the reasons why plant evolution dances to a different beat as Alfred Traverse pointed out 30 years ago.

O205

RESPONSES OF VEGETATION AND PLANT DIVERSITY TO THE YOUNGER DRYAS CLIMATE OSCILLATION IN THE HENGDUAN MOUNTAINS, SOUTHWESTERN CHINA

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The Younger Dryas (YD) is an abrupt reversal to a colder climate which occurred during the period of warming from Bolling/Allerod to early Holocene. Most reports have focused on YD cooling event at high and middle latitudes, with few studies at low latitudes such as this report on the Hengduan Mountains, a temperate biodiversity hotspot. To understand how plant diversity and vegetation responded to the YD climate oscillation and the potential ecological mechanisms involved, we present a continuous, well-dated pollen sequence (12.9-9.2 cal. ka BP) from Haligu wetland in this region. Our results reveal that the variations in plant diversity are positively correlated with relative humidity and vegetation associated with a shift from *Pinus-Abies-Picea* forest during the YD to *Pinus*-dominant forest, accompanied by an increase in taxa such as *Salix* and *Juglans,* representative of temperate conditions, in the early Holocene. Further, regional and global comparisons indicate that the response of vegetation to the YD cooling mainly reflects changes of dominant taxa and community composition at different altitudinal gradients and latitudinal zones, possibly linked to climatic forcing and geomorphology. The findings provide insights for biodiversity conservation under future warming scenarios.

O206

STARÁ JÍMKA A LATE PLEISTOCENE GLACIAL LAKE (CZECH HERCYNICUM, CENTRAL EUROPE). CLIMATIC AND VEGETATION CHANGES BASED ON POLLEN, PALEOZOOLOGY, AND ABIOTIC PROXIES.

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Two glacial cirques Stará Jímka (49.068° N, 13.403° E, 1 110 m a. s. l.) and Prášilské jezero Lake creating a step-like system occurred on the eastern slope of Poledník Mountain (1 315 m a. s. l.) (Bohemian Forest). Profile of Stará Jímka demonstrates paleoenvironment changes in the glacial lake and its catchment area during the Alleroed and Younger Dryas periods. The limnic sediment of 5 m thickness was investigated by combining pollen and paleozoology (chironomids, cladocerans) analysis with macro-climate settings (Bryson model), and abiotic proxies. Laacher See Tephra (LST) layer was discovered by phosphorus enrichment (XRF element scanning) and by volcanic glass shards for the first time in the Czech Republic beyond the respected SW-NE transect through central Northern Europe. LST had a position just above ASM 14C date 10970±50 BP (Beta-366540). The Bayesian modeled age is 12820±70 cal BP with a 95% probability range of 12970 to 12715 cal BP. That corresponds to the age range of the Laacher See eruption (LSE), (Eiffel, W Germany).

The Late Glacial vegetation development of Stará Jímka was divided into four phases (STJ 1-4). The sedimentation (STJ 1) started in cooling interval in the Late-Glacial interstadial with vegetation cover of dwarf shrub steppe (wild grasses and heliophytes; *Artemisia, Thalictrum*) of willow, which grew here before the expansion of birch woodland. In the Late-Glacial interstadial *Juniperus* expanded into the previous herbaceous vegetation (STJ 2). The forest with *Betula* domination suppressed heliophytic plants. *Pinus* pollen was in lower proportions than *Betula* which suggested reduced pine in the forests. LSE induced short-term cooling; some vegetation taxa decreased (*Betula nana*, *Betula*, Cyperaceae) while *Dryas octopetala* and *Pinus* increased. Then the restoration of *Betula* forest was rather quick. Water table was rather low, for example only *Hydrocotyle* colonized the bottom of the lake.

Last two phases were dedicated to the Younger Dryas stadial with climatic deterioration. The older phase (STJ 3) outlines not only preference to *Pinus*, *Salix, Betula humilis* and *Alnus viridis*, but also to arto-alpine herbal species. Such as period was reflected by frequent wildfires (quantitative charcoal analysis) and by the great change in paleolake ecosystem combined with the LSE and the onset of the Younger Dryas. The younger part (STJ 4) is characterized with occurrence of *Corylus, Pinus cembra* and *Betula nana*.

O207

LATEGLACIAL-HOLOCENE ABRUPT VEGETATION CHANGES AT LAGO TRIFOGLIETTI IN CALABRIA, SOUTHERN ITALY: THE SETTING OF ECOSYSTEMS IN A REFUGIAL ZONE

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Retrospective science such as palaeoecology deeply depends on the preservation of archives in sensitive places. As an example, mountains of medium altitude from Mediterranean peninsulas have long been identified by biogeographers as refuges zones allowing the survival of European temperate taxa during the ice ages, but archives to validate this hypothesis are scarce, especially in Southern Italy. Here we present a new sequence from Lago Trifoglietti (1048 m a.s.l.) in the Calabrian Mountains, which covers the Late Glacial Interstadial (LGI, corresponding to the Bolling-Allerod period in northern-central Europe) and the transition to the Holocene. The independent chronology based on seven radiocarbon dates is supported by the evidence of three tephra layers already identified in other regional sequences. During the LGI, besides the high diversity of non arboreal pollen grains, a great number of pollens of temperate forest trees are present or abundant (mostly deciduous oaks and fir). These assemblages suggest that the site was above but not far from the upper limit of diversified woodland stands. They confirm a local survival during the last glacial. The Younger Dryas is not marked by major changes, and oak percentages are even higher, suggesting a resilient expansion at lower altitude. Surprisingly the site remains above the timberline until an aridity crisis centered at 11,100 cal 14C yr PB, which is correlated with the Preboreal Oscillation (PBO). This event is immediately followed by the local settlement of a dense fir and beech forest around the lake. A comparison with other Italian key sequences aims at explaining the climate forcing factors that governed this original vegetation dynamic. Further investigations using additional proxies are needed for a more robust climate reconstruction.

O208

A HIGH-RESOLUTION POLLEN PROFILE AND POLLEN ANALYTICAL INVESTIGATION OF SURFACE SAMPLES FROM THE ARAN ISLANDS, WESTERN IRELAND PROVIDE NEW INSIGHTS INTO THE INTERPRETATION OF POLLEN DATA

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A high temporal-resolution and detailed pollen record from An Loch Mór, Aran Islands, has provided several new insights into vegetation dynamics and human impact on Inis Oírr (Inisheer) at the Atlantic fringe of Europe. The new information, which derives from thick lake sediments, relates to *in situ* survival of particular plant species during the Younger Dryas stadial (14.7–11.7 ka), early Holocene spread of thermophilous species, and the effects of climate change and long- and short-term human activity in this exceptional karstic environment (Molloy and O'Connell 2014 in: *Mind the Gap II*. Irish Naturalists' Journal, pp. 66–88). In this presentation, an overview of the main pollen results will be presented and then critiqued in the light of new information derived from pollen analysis of surface pollen samples collected on the Aran Islands in the later part of the twentieth century when small-scale cereal cultivation using traditional methods was still relatively common. The wider implications of the surface-sample pollen data for interpretation of the An Loch Mór profile and other pollen profiles from Ireland will be discussed.

O209

SUB-DECADAL RESOLUTION PALYNOLOGY OF A DISEASE MEDIATED ELM DECLINE

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The threat of devastating pathogens on a range of tree species has increased recently which prompts the investigation of the temporal dynamics of disease mediated tree declines. The mid-Holocene elm decline was a widespread and synchronous event recorded in pollen diagrams across north-west Europe. The probable drivers of this event have been debated for over eighty years but the role of disease has gathered greatest support in recent decades. In this paper we report pollen data at sub-decadal resolution from a closely sampled lake sediment core from eastern Ireland covering the last 160 years. This investigation provides data on the structure and dynamics of the surrounding woodland before, during and after the outbreak of Dutch elm disease in the 1970s. It also facilitates the comparison of this disease mediated decline with the mid-Holocene elm decline. The impact of anthropogenic disturbance and disease resulted in different woodland compositions and the adjustment of the woodland in response to these factors was rapid. The impact of Dutch elm disease on this elm population was extremely similar to that recorded in the mid-Holocene elm decline in Britain and Ireland.

O210

MAJOR PROBLEMS IN LATE PALAEOZOIC AND MESOZOIC PALYNOLOGY

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In this communication, we will discuss some of the problems we have encountered in developing a robust taxonomy for palynomorphs. Developing such a taxonomic framework, which can be shared between colleagues, is essential for the developing a firm biostratigraphical framework for correlating sequences at both local and intercontinental scales. A major problem has been that many palynostratigraphical studies do not provide illustrations of the species being used and so it is impossible to know if the proposed correlations are based on a sound taxonomic footing. A major step forward would be the establishment of an open-access database with illustrated morphological descriptions and range data for key index taxa. This would allow palynostratigraphers to work within a uniform, accepted taxonomic framework. This will be of particular value for correlations in Permian and Jurassic sequences, as the time scales in a palynological context in these periods are still not firmly established.

O211

CARBONIFEROUS MACROFLORAL BIOSTRATIGRAPHY - A NEW TOOL FOR STUDYING FLORISTICS AND BIODIVERSITY

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Biostratigraphy has been a major theme for palaeobotanical research in Carboniferous floras, largely because of the economically important coal reserves that they are associated with. From the pioneering work of Robert Kidston and René Zeiller, through the transformative work of Emily Dix, to the modern-day biostratigraphical models such as developed by Bob Wagner, we know have an increasingly clear understanding of the distribution of these fossils in the Carboniferous coal-bearing sequences. The main impetus for this work tended to be stratigraphical correlation to help with the exploration for and exploitation of the coal reserves, especially in Euramerican sequences. However, it is also now becoming evident that data revealed by this so-called "geological palaeobotany" can also be used to study the plant biodiversity and biogeography of this vegetation. It is now providing significant insights into the dynamic evolution of these wetland floras and its link with changes in Carboniferous landscapes and climate.

O212

EARLY PERMIAN (ASSELIAN) PALAEOFLORAL TRANSITION FROM THE EQUATORIAL PALAEOTETHYS (INDONESIA, SUMATRA)

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The early Permian (Asselian) palaeofloral reorganization is one of the major species turnover events in plant history. The Asselian on Sumatra is exposed along the Merangin River section cutting through the 490 meter thick Mengkarang Formation. The Mengkarang Formation consists of an alternation of volcanic and alluvial deposits accumulating at the foot of a volcano. Isotopic age evaluations of the top and the base of the Merangin section indicate an average duration for the 490 meters of sediments of 630,000 years (from 296.77 ± 0.04 Ma to 296.14 ± 0.09 Ma) and a mean sedimentation rate of 0.8 mm/y. The compilation of all assembled palaeobotanical data from the Mengkarang Formation indicates there is a change in composition from a palaeoflora dominated by cordaites, ferns or club mosses to one in which seedferns are frequent. These palaeofloral changes coincide with the third order eustatic sea level fluctuations for the indicated time interval and suggests a large scale climatic origin for this transition, where cordaites dominate during the high stand and seedferns appear during the low stand. Fossilisation of plants along the volcanic slope is not frequent enough to regularly preserve palaeobotanic sequences related to the higher order of orbitally forced cyclicities.

These palaeofloral changes from the Asselian of West Sumatra extend trends reported earlier from the Far Western early Permian low latitudes of Euramerica to the Far Eastern low latitudes of the Palaeotethys. Although the Far Western early Permian deposits are not suited for isotopic age determination, the frequency of the palaeofloral transitions and the duration of the considered time interval suggest an amplitude for these palaeofloral changes in the same order of magnitude between 0.5 and 3 Ma as the third order eustatic sea level fluctuation.

213

A NEW RADIO-ISOTOPICALLY CONSTRAINED PALYNOZONATION FOR THE PERMIAN KAROO BASIN OF SOUTH AFRICA

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The Karoo Supergroup preserves a temporally extensive palaeontological record of pollen and spores, macroplants, and fossil wood. In particular, its wealth of fossil tetrapods has enabled a very well-resolved biostratigraphic subdivision across the Permian and Triassic, which has recently been refined by new radiometric dates. These ages have now indicated that many previous palynological correlations of South African Karoo rocks to other parts of Gondwana were inaccurate. Long-ranging palynomorphs, or those present in multiple stratigraphic levels, were previously identified as shared taxa and put forward to imply a stratigraphic correlation, when there really was none. For the first time, we comprehensively reviewed and consolidated previous palynological work in South Africa, and plotted the first and last appearances of all Permian palynomorphs recovered from the main Karoo Basin (MKB) to date. Prior stratigraphic and palaeoecological interpretations from isolated localities were found to often be heavily biased by local envi-

ronmental factors including substrate, ground water availability, drainage, and elevation. Together with new palynological results from the southern proximal facies of the MKB, we identified key index taxa to develop a First Appearance Datum (FAD) palynozonation scheme based on stratigraphically restricted species. The new palynozonation comprises eleven interval zones tied to a robust lithostratigraphic framework, and is calibrated by the most recent radio-isotopic dates for the Permian succession of the southern Karoo Basin. The new zones are correlated with palynozones in Australia, South America, Antarctica, Zambia, Botswana, and India. Across these basins, concerted efforts to integrate palynology with radiometric, magnetostratigraphic, independent faunal, and strontium isotopic dating are now being made. This should significantly improve stratigraphic correlations between different Gondwanan successions, as well as proving useful for refining basin development models.

O214

A REVIEW OF THE GONDWANA TRIASSIC MEGASPOROPHYLL *UMKOMASIA*

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It is now over 90 years since Hamshaw Thomas suggested that the origin of angiosperms may lie in the ancient pteridosperms (seed ferns) such as *Caytonia* from the Yorkshire Jurassic and *Umkomasia* from the Triassic of South Africa. Since then many new early angiosperm fossils have been documented and our understanding of plants has progressed from cellular studies to exploring their phylogeny via DNA and RNA blueprints. The hypotheses of Thomas have generally not been supported in subsequent studies. However, the origin of angiosperms in their probable seed fern ancestry remains an enigma. Therefore ancient plants such as *Umkomasia* with seeds enclosed in cupules should be studied and analysed from a modern perspective. As a first step the megasporophyll genus *Umkomasia* is reassessed comprehensively worldwide. All previous records are analysed in detail and fertile structures incorrectly attributed are reclassified. *Umkomasia* is shown to be restricted to the Triassic of Gondwana and clearly affiliated to the microsporophyll genus *Pteruchus* and the vegetative leaf genus *Dicroidium*. It is well represented from Argentina, Antarctica, Australia and South Africa where the Molteno Formation was by far the best sampled, yielding eight species and 503 specimens from 22 localities. The record of two specimens of *Umkomasia* from the Upper Permian of India is incorrect and to date there are no records of *Umkomasia* from the Triassic *Dicroidium* flora of India. A whorled fertile structure from Antarctica named *Umkomasia uniramia* is re-evaluated. The *Umkomasia* described from the Triassic of China is reclassified into a different genus. Other records of *Umkomasia* beyond Triassic strata are shown to be incorrect. The Lower Jurassic record from Germany is reclassified. The Lower Cretaceous record from Mongolia has been renamed by other researchers as *Doylea mongolica*. Records of *Umkomasia* sp. from the Rhaetic of Germany and the Jurassic of Libya that were based on limited material are corrected. A pictorial key to the accepted *Umkomasia* species has been constructed. By the removal of material previously incorrectly assigned to *Umkomasia*, a deeper understanding of this important genus can be ascertained and more constructive phylogenies may be formed.

O215

PLANT FOOD RESOURCES AND IMPLICATIONS ON THE DIET OF *HOMO ERECTUS* IN THE CAUCASUS

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The earliest hominid expansions from Africa into Eurasia date to about 1.8 Ma based on the Dmanisi record of *Homo erectus* in Georgia. Since then, humans were present in this region and required an energy- and nutrient rich diet.

As plants contribute to the amount and variety of obtainable food resources vegetation and vegetation diversity are important factors for human habitats. By evaluating the plant food potential of different vegetation units in the Southern Caucasus this study aims at exploring the resource space of early humans in the Early Pleistocene. The main research questions here are, which and how many edible plant parts can be found in different vegetation units and how is the availability distributed in the course of the year?

Vegetation units are chosen according to palaeobotanical reconstructions in the region, based on fossil records from plant macro fauna and pollen data. The units range from steppes to altimontane forests, comprising published taxa lists of dominant and most frequent species. The database *PlantBITES* hosts the relevant information compiled from the literature.

The results show that forest units provide the most edible plant parts, followed by open woodlands. The fewest ones are found in the steppes. Moreover, open woodlands and forests provided more species with high quality plant parts than the steppes. Especially fruits and nuts provide an energy- and nutrient rich diet. On the other hand, steppes provide a huge amount of grasses, which are considered good forage for grazing animals. Also, the availability of edible plant parts is more stable around the year in steppes compared to a strong seasonality in forests. However, the absolute numbers of edible plant parts are still higher in forests even during winter.

Based on the characteristics of the dentition, the stature and body proportions of *Homo erectus* it is widely assumed that they relied on a mixed diet of meat and plant food. However, it is not yet as-

sessed in detail which plants may have contributed to their diet and to what extend different vegetation types can deliver necessary nutrition. This study is a first attempt to quantify plant food resources and their availability for *H. erectus* showing the importance of access to edible plant parts from forests for a stable supply of an energy- and nutrient rich diet.

O216

VEGETATION CHANGE IN PRIMORY'E (FAR EAST OF RUSSIA) DURING THE PALEOGENE - A STUDY BASED ON DIVERSITY OF PLANT FUNCTIONAL TYPES

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Paleogene vegetation dynamic of Primory'e (Far East of Russia) is studied using the Plant Functional Type (PFT) Approach, for the first time applied on the large palaeobotanical records of this region. The palaeobotanical data for the reconstruction are based on the analysis of vast literature resources for 24 leaf floras and 30 palynofloras covering the early Paleocene (Danian) to late Oligocene (Chattian), i.e. a time-span of ca. 42 Ma, in total. The palaeobotanical records originate from continental deposits of 19 Cenozoic basins located on the territory of Primory'e. All paleofloras considered were carefully re-evaluated regarding the validity of taxonomic identifications and the Nearest Living Relatives (NLRs) of the fossil taxa. Based on the diversity of PFTs, changes in the structure of the vegetation can be investigated throughout the time-span regarded such as the proportion of aquatic plants, the ratio of herbal, shrubby and arboreal PFTs, as well the ratio of deciduous and evergreen angiosperm plants. Moreover, the PFT diversity spectra obtained from the palaeofloras are interpreted in terms of vegetation types. A map series is presented that shows the spatial distribution of these types for a total of seven stratigraphic level of the Paleogene of Primory'e.

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O217

PALAEOCLIMATE ANALYSIS OF THE FLORA OF THE LATEST EOCENE INSECT LIMESTONE OF THE ISLE OF WIGHT, SOUTHERN ENGLAND

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The latest Eocene flora from the Insect Limestone, Isle of Wight, is an important representative of British Paleogene vegetation providing information on terrestrial palaeoclimate at a time of major global change associated with the build-up of the first major ice sheets on Antarctica. Plant remains occur in concentrations of debris within an horizon of very fine micrite near the base of the Bembridge Marls Member, Bouldnor Formation, Solent Group. New collections, along with those in the Natural History Museum and the Dinosaur Isle Museum and material donated by local collector, Andy Yule, have been studied. Nearest living relatives of the most abundant fossils are wetland herbaceous plants, e.g. *Azolla*, *Sabrenia*, and most commonly, *Typha*. Less common trees and shrubs include representatives of the Juglandaceae, Lauraceae and other flowering plants, with some conifers. Despite fairly poor preservation, detailed drawings of angiosperm leaf characteristics combined with cluster analysis has enabled the recognition of distinct morphotypes. Palaeoclimate inferences are based on physiognomic features of the angiosperm leaves in combination with a nearest living relative approach. Angiosperm leaf taxa with toothed margins are comparatively rare, suggesting a warm climate. Small leaf size points to low rainfall. Plants such as *Acrostichum*, *Daphnogene*, *Neolitsea*, *Palaeocarya* and *Hooleya* are characteristic of warm temperate to subtropical mixed mesophytic vegetation today, whilst sclerophyllous elements (e.g. *Zizyphus*) suggest drier conditions.

O218

OLIGOCENE VEGETATION OF EUROPE AND WESTERN ASIA - DIVERSITY CHANGE AND CONTINENTAL PATTERNS REFLECTED BY PLANT FUNCTIONAL TYPES

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Spatial vegetation patterns potentially reflect coeval continental climate variations which are also impacted by palaeogeographic settings. Plant Functional Types (PFTs) and their distribution, frequently applied in ecological studies and biome modelling, serve as a tool for reconstructing palaeovegetation units and ultimately tracing palaeoecological/climate gradients. Earlier quantitative studies focusing on distribution patterns of PFTs and designed to put forward data–model comparisons were carried out on well-dated middle and late Miocene floras. Moreover, the PFT approach has been successfully applied to reconstruct Eocene vegetation patterns in several time slices at a global scale as well as in regional vegetation reconstructions throughout the Cenozoic.

In the current study the PFT approach is applied on Rupelian and Chattian fossil floras of Europe and western Asia to infer spatial vegetation differences across the study area. A comprehensive palaeobotanical record including ca. 100 macro- (leaves, fruits and seeds) and microfloras was compiled. The floristic components of these palaeofloras are translated to PFTs including herbaceous to arboreal classes. The PFTs are defined using traits and climatic thresholds of key taxa, and comprise species assigned by morphological and phenological features with respect to the related ecosystem. Diversity values of each PFT are calculated for the fossil floras and spatial gradients over Western Eurasia are investigated for the Rupelian and Chattian. PFT diversity maps and transects for both time slices reveal basic patterns of the vegetational structure at the continental scale. It is e.g. shown that in both time slices studied tropical and broadleaved evergreen PFTs were more diverse in the West and at lower latitudes. Consistently with the global climate evolution as known from marine archives and regional continental records their level was higher in the Rupelian compared to the Chattian. All over low diversities of xeric PFTs coincide with the previously assumed dominance of humid climate conditions in Western Eurasia throughout the Oligocene, however, the reconstructed spatial gradients suggest somewhat drier conditions to the Southeast.

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O219

VEGETATION AND CLIMATE SIGNAL OF THE MIDDLE MIOCENE PLANT RECORD IN EUROPE ASSESSED BY THE IPR VEGETATION ANALYSIS

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In the Middle Miocene, the Langhian/Serravalian (16-11.6 m.a.) is the period of most pronounced climate changes in Europe. The Mid Miocene Climatic Optimum (around 15 m.a.) is usually interpreted as a period of mild and humid climate. But various fossil assemblages (plants, herpetofauna, mammals) from the Middle Miocene showed quite controversal proxies regarding palaeoenvironment and climate, e.g., Böhme et al. (2007), Utescher et al. (2007). Climate signals range from very humid (Bruch et al. 2011) to much drier climate compared to the preceding and later periods with seasonal strong drought, e.g., Böhme et al. (2011), Böhme & Vasilyan (2014). We assume, that these interpretations followed quantitative methods in which sociological and ecological aspects were largely neglected. This contribution aims to reveal the fossil plant record applying the IPR vegetation analysis (Kovar-Eder et al. 2008, Teodoridis et al. 2011) and includes taxonomic, sociological and ecological aspects to assess vegetation changes and to interpret them in terms of climate.

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O220

ANATOMICALLY PRESERVED GLOSSOPTERID SEEDS PRIOR TO THE END-PERMIAN EXTINCTION FROM NORTHEASTERN AUSTRALIA

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Anatomically preserved seeds are common in permineralized peats within the Changhsingian (upper Permian) Fort Cooper Coal Measures near Homevale in the northern Bowen Basin, Queensland, Australia. At least two categories of seed are represented. One form is small (< 1 mm long), relatively thin walled, lacks clear evidence of bilateral symmetry or marginal wings, and appears to have been borne in large numbers on laminar reproductive organs attributable to *Homevaleia*/*Dictyopteridium*. A second form is 5–11 mm long, with well-developed wings and 180° rotational symmetry, and represents the largest permineralized seed type yet recorded from Permian deposits of Gondwana. These seeds have dimensions that could be accommodated on glossopterid reproductive structures of either Rigbyaceae or Lidgettoniaceae, which have been recorded elsewhere in the Sydney-Bowen basin complex. These seeds are characterized by a thin endotesta of longitudinally orientated cells, thick mesotesta incorporating an inner band of very thick walled sclereids and an outer layer of thin-walled parenchymatous cells, and an exotesta that comprises a well-developed epidermis and several layers of thick-walled hypodermal cells. Vascular supply to the base of the seed passes through the integument and bifurcates into the nucellar pad. Taeniate bisaccate pollen of *Protohaploxypinus*-type occurs in the pollen chamber of the seed. A comparison of the characters of this seed type with other permineralized forms from the Permian of Gondwana indicates that several of the characters used in previous phylogenetic analyses incorporating glossopterids are wrongly scored or ambiguous in their definition. Associated fossils in the permineralized peat include matted leaves of at least two forms of *Glossopteris*, woody axes, *Palaeosmunda* petioles, charcoalified plant organs, fungal hyphae, and dispersed pollen, microspores and megaspores. *Vertebraria* (glossopterid roots) are sparse. Impression assemblages in adjacent beds also include sphenophytes (*Paracalamites*, *Raniganjia* spp.), ferns (*Neomariopteris lobifolia*) and cordaitaleans (*Noeggerathiopsis* sp.).

O221

EXTINCT DIVERSITY NEAR THE BASE OF THE ANGIOSPERM TREE: EVIDENCE FROM CRETACEOUS MESOFOSSILS

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The study of Cretaceous mesofossil floras from Portugal and North America has disclosed an extraordinary diversity of early angiosperms related to lineages that are extremely species-poor today such as the Austrobaileyales, Nymphaeales and Chloranthaceae. Particular prominent among the Early Cretaceous mesofossils are a rich complex of exotestal seeds with features suggesting a phylogenetic position close to Austrobaileyales and Nymphaeales. The seeds are small, typically anatropous and characterized by their palisade-shape exotestal cells with strongly undulate anticlinal cell walls. Synchrotron based X-ray microtomography has revealed a wealth of details particularly in size and organization of the embryo and nutritive tissue, as well as cellular details of seed coat, especially in the micropylar-hilar region of the seeds. Some of the exotestal seeds are operculate and can be assigned to the Nymphaeales with high confidence. However, most of the exotestal seeds, including also an unusual group of seeds with hemianatropous-hemiorthotropous organization, show a combination of features that may be plesiomorphic for Austrobaileyales-Nymphaeales, and perhaps for angiosperms as a whole. The great variety seen among the seeds of Early Cretaceous angiosperms at this level of angiosperm evolution coupled with a marked decline in the Late Cretaceous provides evidence of extensive extinction among early diverging forms and emphasizes the systematically depauperate nature of extant angiosperms near the base of the angiosperm phylogenetic tree.

O222

A NEW SPECIES OF THE FRESHWATER FERN *AZOLLA* FROM THE UPPER CRETACEOUS OF PATAGONIA, ARGENTINA.

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The Upper Cretaceous (Campanian-Maastrichtian) La Colonia Formation crops out on the southeast slope of the Somuncurá Massif, Patagonia, Argentina. The flora of the La Colonia Formation is characterized by its freshwater component that includes several algae and aquatic ferns and flowering plants. In this contribution, we introduce a new species of *Azolla* (Salviniaceae) based on exquisitely preserved megaspore apparatuses and microspore massulae collected at the Cañadón del Irupé locality of the continental section of the La Colonia Formation. The excellent preservation of the fossils and frequent attachment of microspore massulae to megaspores indicate that they were fossilized *in situ* or after minimal transport. This new fossil heterosporous fern species produced megaspore apparatuses composed of the megaspore body and three tiers of floats covered by a dense filosum. The megaspore wall consisted of an exine and a two-layered perine, with a spongy endoperine and large, clavate, solid masses of exoperine. The microspore massulae were variable in size and shape and bore aseptate glochidia that had anchor-shaped tips. The new fossil species differs from extant *Azolla* megaspores and microspores in the number and arrangement of the floats and in the number of massulae per microsporangium. When compared to fossil species, there are consistent differences therefore it could not be placed within any previously described species; this warranties the erection of a new species. Definitely, this new species increases the record of Salviniaceae to the scarcely known fossil record of the family in Argentina and South America, and significantly extends our knowledge of the morphological variability of *Azolla*. Additionally, it also supports the hypotheses of the rapid geographic dispersal and diversification of *Azolla* during the Late Cretaceous.

O223

FOSSILS AND SEED CONE MORPHOLOGY IN THE RESOLUTION OF PHYLOGENETIC RELATIONSHIPS AMONG BASAL CUPRESSACEAE *S.L.*

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The Cupressaceae are the most genus-rich family of extant conifers and have an extensive fossil record going back as far as the Triassic, with extant genera present in the Early Cretaceous. The oldest fossil seed cone unequivocally assignable to Cupressaceae *s.l.* is the Early Jurassic *Austrohamia minuta*. Seed cone morphology provides diagnostic characters important for systematics. Seed cones are abundant in the fossil record and provide a wealth of characters that, if integrated into a phylogenetic framework, enhance our understanding of relationships. However, inclusion of Cupressaceae *s.l.* fossils has not improved phylogenetic resolution in the group. Basal lineages of the clade include cunninghamioids, taiwanioids, athrotaxoids, taxodioids and sequoioids. The relationships between these groups remain unresolved and phylogenetic studies of extant-only or extant + fossil Cupressaceae have produced conflicting topologies resulting in an unresolved polytomy between *Athrotaxis*, sequoioids, and a taxodioids + Cupressaceae *s.s.* clade. This lack of resolution is partly due to the fact that seed cone characters have not been sampled to their full potential in previous studies. To improve character sampling we are developing a dataset that emphasizes anatomical and morphological features of mature, often lignified seed cones. This is an area of plant morphology in which detailed anatomy has not been documented, even for the majority of extant taxa. Detailed anatomical characters allow for better integration of anatomically-preserved fossils, as the majority of fossil seed cones are preserved in mature stages. Exploratory tree searches using our character set that details mature seed cone anatomy, for living and fossil taxa, provide results relevant to the unresolved polytomy at the base of Cupressaceae and the phylogenetic positions of fossil species with conflicting placements. These suggest that cunninghamioids are paraphyletic at the base of a clade in which *Athrotaxis* is sister to the remaining ingroup taxa, in agreement with the results of most molecular phylogenetic analyses. Relationships between these remaining taxa are less resolved but show taxodioids in a clade that is sister to one of the sequoioids and can also include other sequoioids. The new data on the anatomy of mature ovulate cones in living Cupressaceae fills gaps in comparative morphology, allowing for denser sampling of morphological characters, and for broader taxon sampling by allowing the inclusion of fossil taxa. Comparisons between tree topologies obtained using morphological characters alone, molecular characters alone, and a combination of the two, will provide tests for the resolving power of fossils.

O224

EXTINCTION, EVOLUTION AND RECOVERY OF THE GONDWANAN FLORA THROUGH THE PERMIAN–TRIASSIC BIOTIC CRISIS IN SOUTHERN HIGH PALAEOLATITUDES, AUSTRALIA

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The Permian–Triassic biotic crisis, c. 251.9 million years ago, was the largest of the 'big five' mass-extinction events in Earth's history. Nearly 60% of families and 80% of genera were extinguished. Most previous studies of this crisis have focused on marine and Northern Hemisphere successions. We are undertaking the first detailed investigation of extinction and recovery patterns in the terrestrial flora at high (>65°) southern palaeolatitudes by extensive sampling of drill cores and outcrops in the Bowen and Sydney basins, Australia. Initial results indicate a dramatic termination of coal sedimentation at the end of the Permian, and a gradual increase in red–green iron-rich mudrocks through the Early Triassic. Forests of broad-leafed glossopterid gymnosperms dominated the latest Permian peat-forming communities and were the main casualties of the extinction event on land amongst plants. Several subsidiary gymnosperm (conifers and seed-ferns), fern and horsetail groups also became extinct at this time. These extinctions are reflected in both the leaf macrofossil record and pollen assemblages. Stepwise recovery and evolution of the Triassic vegetation is characterised by the appearance of small-leafed *Lepidopteris* (Peltaspermales) and *Voltziopsis* (conifer) trees, followed by successive spikes in abundance of lycophytes (club-mosses), then *Dicroidium* (Corystospermales). The spore-pollen record has facilitated the identification and correlation of six palynostratigraphic zones (one Permian, five Triassic) across multiple sections in the Sydney Basin, with no consistent evidence of a depositional hiatus across the P–T boundary. Quantitative palynology was employed to reveal the fine-scale changes across the P–T boundary. The stepwise recovery and replacement exhibited by the macroflora was also observed in the palynological record; several common Permian palynofloral elements persist in low abundances until the upper Lower Triassic, and several other spore-pollen groups show a protracted increase in abundance and diversity over the same interval. The end-Permian extinction was probably linked to the largest known continental flood basalt eruptions in Siberia, which affected the atmosphere and climate and led to intensification of the Pangaean monsoon system at that time.

O225

PERMO-CARBONIFEROUS BIODIVERSITY AND PHYTOGEOGRAPHIC DISTRIBUTION OF SPHENOPHYTES IN INDIA

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The present paper reviews and synthesizes Permo-Carboniferous sphenophyte diversity and evolution in India. Sphenophytes are less diversified in the southern Gondwana continents in comparison to their profuse diversity in northern hemisphere. In India, they are represented by orders Equisetales (19 genera, 43 species) and Sphenophyllales (3 genera, 15 species). The fossil record is mostly of leaf forms and axes, and a few fertile forms. Highest diversity is observed in the genus *Sphenophyllum* (with 11 species) followed by *Phyllotheca* (8); *Schizoneura* (5); *Lelstotheca*, *Raniganjia* and *Annularia* (4 species each); *Lobatannularia* and *Trizygia* (3 species each); *Giridia* and *Tatapania* (2 species each) and rest of the genera have one species.

During Carboniferous times, their diversity was meager, represented by three genera viz. *Archaeocalamites radiatus*, cf. *Annularia* sp. (Kashmir Himalayas), and *Asterophyllites* sp. (Spiti Himalaya). The Permian sphenophytes from Himalayas are represented by *Phyllotheca* sp., *Schizoneura gondwanensis*, *Sphenophyllum speciosum*, *S. thonii* var. *minor*, *S. thonii* var. *archangelskyii*, *S. thoniii*. var. *waltonii*, *Lobatannularia ensifolia*, *L. lingulata, L. sinensis* var. *curvifolia* and *Paracalamites* sp. (Kashmir); *Annularia* cf. *stellata*, *Phyllotheca* sp. and *Calamites* sp. (Kumaon Himalaya) and *Schizoneura gondwanensis* and *Phyllotheca* sp. (Northeastern Himalaya).

In comparison to the Himalayas, highly diverse assemblages of Sphenophytes have been recorded from the Permian sequences (Talchir, Karharbari, Barakar, Barren Measures, Raniganj and Kamthi formations) of Peninsular India. In the Talchir Formation, their diversity is extremely low (2 taxa) which enhances in the overlying Karharbari Formation, (9 taxa).

Their maximum diversity (22 taxa) is reached in the Barakar Formation represented by *Raniganjia* (2 species), *Lelstotheca, Phyllotheca* and *Sphenophyllum* (4 species each) and 1 species each of the genera *Benlightfootia*, *Trizygia*, *Barakaria*, *Paracalamites*, *Schizoneura*, *Sharmastachys*, *Rajmahaliastachys* and *Tulsidabaria*. Barren Measures Formation is devoid of sphenophytes. In the Raniganj Formation 10 sphenophyte taxa are represented: 2 species each of genera *Phyllotheca*, *Raniganjia*, *Schizoneura* and *Sphenophyllum* and one species each of *Lelstotheca* and *Bengalia*. Similar diversity (9 taxa) is observed in the Kamthi Formation (=Raniganj) and represented by 3 species of *Sphenophyllum*, 2 species of *Raniganjia* and one species each of *Lelstotheca*, *Phyllotheca*, *Schizoneura* and *Trizygia*.

The occurrence of some of the Euramerican and Cathaysian sphenophytes in India viz., *Annularia*, *Asterophyllites, Sphenophyllum thonii* var. *minor*, *Sphenophyllum hammakarelensis*, *Lobatannularia, Calamites, Archaeocalamites* and *Paracalamites* in the Indian Gondwana suggests intermixing of these elements in the Indian phytogeographic provinces due either to long distance migration of these spore-dispersed plants or to their independent development in restricted areas.

O226

DIVERSE FUNCTIONAL APPENDAGES IN THE EARLY PERMIAN WUDA TUFF FLORA

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The first tree forest appeared in the Middle Devonian and had significant impacts on terrestrial ecosystem. Compared with modern forest, it is yet unclear how an ancient forest community became self-adapted along with the increasing of plant diversity. The well-known Wuda Tuff Flora (also known as Chinese "vegetational Pompeii") is an early Permian swampy forest preserved in situ by a catastrophical ash-fall event. Previous investigation has revealed that the forest community is analogous to the Euramerican Pennsylvanian swampy forests in the case of using heterogeneous growth-form strategy to allocate the space and sunlight. In this study, enormous materials of diverse plant appendages such as trichome, spine, aphlebiae, tendril and aerial root have been recognized and sorted out from the whole collections of "vegetational Pompeii", allowing a more critical evaluation of the self-adaptation mechanism of this forest. It is surprising to see that more than half of the species in this forest have at least one type of additional appendages. These appendages differ in forms, sizes and growth positions, performing various functions such as protecting, defending, climbing, supporting and physiological accommodation. They certainly may have played an important role on the self-adaptation in both ancient and modern forest ecosystem. The early Permian forest had already been well physiologically and ecologically self-adapted as indicated by the highly diverse functional appendages.

O227

A MIXED HYGROMORPHIC-TO-XEROMORPHIC FLORA FROM ONE OF THE MOST BOTANICALLY RICH LOCALITIES IN WESTERN EQUATORIAL PANGEA, THE EARLY PERMIAN OF TEXAS, USA

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Permian floras of western equatorial Pangea, modern western North America, are often considered distinct from other floral realms of similar geological age due to the frequent presence of unique taxa. These distinct western equatorial floras began to appear during the later Pennsylvanian, seeming to exhibit marked differences in their overall community composition compared with floras from central parts of Pangea, and by the early Permian, xeromorphic plants dominated the seasonally dry western regions of the supercontinent. However, recent work in the early Permian of north-central Texas examining the ecology and diversity of this region suggests that the floras of western equatorial Pangea may, in fact, share more taxa with other floral realms and thus hold a greater global relationship than previously understood. One such study examines the Wolfcampian (Artinskian) age "Emily Irish" locality, a small oxbow lake deposit, which is believed to be one of the most extensively collected floras of this age from any place in the world, including ca. 6000 hand specimens housed at the US National Museum of Natural History. New evidence from this locality demonstrates apparent spatial floral linkages with contemporaneous European sections, most notably the Rotliegend, and temporal linkages with elements from both older deposits, the late Pennsylvanian of Kansas and New Mexico, and younger floras, middle and later Permian of Angara and Cathaysia. The Emily Irish flora is dominated by a mixture of xeromorphic elements, including conifers, taeniopterids, cordaitaleans, and noeggerathialeans, but with abundant mesomorphic-to-hygromorphic elements, including marattialean tree ferns and sphenopsids. This co-dominance of hygromorphic-to-xeromorphic elements is especially conspicuous as preservation of the macrofossils does not differ between the two groups suggesting strongly that they were inhabiting the same landscape local to the depositional environment and were likely only differentiated by microhabitat. Additionally, due its size the Emily Irish collection permits study of the dominance-diversity profile, particularly total diversity and the patterns of rarity. Specifically, this study examines the concept of rarity in the context of diversity of species novel to Emily Irish as well as abundance of Emily Irish taxa relative to their global occurrence. An increased understanding of these concepts of ecology and diversity in combination with the global perspective can contribute to a more comprehensive picture of the late Paleozoic ecosystem.

O228

SECONDARY TEMPERATE FOREST SUCCESSIONS REVEALED BY HIGH-RESOLUTION PALYNOLOGICAL ANALYSES FOR THE NEOLITHIC PERIOD IN THE LAKE MONDSEE REGION, AUSTRIA

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The resolution of standard palynological analyses is often around 100–150 years for Holocene studies. More recently, palaeoenvironmental studies emphasised higher resolution, of about 40–50 years. These studies suggested that potentially high-frequency signals were to be recorded in palynological data sets from Central European temperate forests, resulting from vegetation successions, and eventually sustained by direct prehistoric forest management impact. However, only high-resolution analyses can recover such a signal, due to the pioneer character and flowering capacities of the tree taxa involved. Here we present vegetation successions recorded in the Lake Mondsee area (Upper Austria) using continuous, high-resolution palynological analyses of lake marl and gyttja sediments (on a depth resolution of every centimetre) for the time period 4000–2500 cal. BCE. The chronological resolution for this time period varies from 12 to 13.5 years. Short-term impacts seem to occur on the arboreal components of the pollen assemblages: charcoal particle peaks are regularly followed by recurring sequences of higher pollen proportion of *Corylus avellana*, *Betula sect. alba*, *Fraxinus excelsior*, and *Fagus sylvatica*, altogether lasting 200–250 years. At the same time, oscillating values of pollen indicators typical for agro-pastoral activities, as well as spores of coprophilous fungi occurred. We therefore postulate that the local prehistoric Neolithic human population of the so-called *Mondsee Culture* had a strong impact on the flora and vegetation surrounding Lake Mondsee, resulting and triggering several cycles of vegetation successions. We will compare these results to similar studies from pre-alpine lake sites in Switzerland and Germany, and which were also analysed at continuous high chronological resolution.

O229

PROVIDING THE PALAEOENVIRONMENTAL CONTEXT TO BRONZE AGE SOCIETAL COLLAPSE IN THE EASTERN MEDITERRANEAN.

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During the Early Bronze Age (EBA) and Late Bronze Age (LBA) eastern Mediterranean societies experienced two intervals of political-economic decline. While the role of climate during the EBA collapse is largely agreed, the extent to which climate influenced the LBA collapse is widely debated. For the LBA, a lack of robustly dated regional records is one aspect that prevents the identification of a significant climate trigger. To rectify this, we present a standardised recalibration and analysis of the highest resolution palaeoenvironmental proxy records from the eastern Mediterranean Bronze Age. A review of 234 publications identified 12 records which satisfied PAGES 2K selection criteria, and a further 11 that were of sufficient resolution to allow analysis at fifty year intervals. We focus on pollen and stable isotope records from lake sediments, marine cores and speleothems, using principle component analysis to decouple climatic and anthropogenic controls on local pollen assemblages, and stable isotope data to provide a regional climate consensus.

We identify three intervals of increased aridity during the Bronze Age: 4.3 – 4.15 ka BP (EBA), 3.7 – 3.5 ka BP and 3.4 – 3.0 ka BP (LBA). The oldest intervals featured increasing aridity throughout the central Mediterranean and Levant, while the Anatolian region remained humid. The final interval featured the first occurrence of increased aridity throughout the entire eastern Mediterranean, beginning in Anatolia and Greece (ca. 3.4 ka BP) before spreading to the Levant (3.2 – 3.0 ka BP). Therefore, the LBA coincided with region-wide aridity that may have been the result of changes in the Siberian High and/or the African-Arabian Monsoon and placed societies under increased pressure.

We also present the first palynological and diatom results from a new study of the Akrotiri Salt Lake, southern Cyprus, aimed at investigating the role of climate on Bronze Age societies. As Cyprus lies central within the eastern Mediterranean, it forms an ideal site to seek evidence for intervals of aridity that may correlate with those previously identified. This would further understanding of potential links between climate change and Bronze Age Cypriot societies.

O230

HOLOCENE FOREST-GRASSLAND DYNAMICS AND THE EXPANSION OF THE ARAUCARIA FOREST IN SOUTHERN BRAZIL

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Woodland - grassland boundaries are generally mediated by fire and understanding the dynamics of such limits requires a long-time perspective at high resolution. In the mosaic between *Araucaria* forest and grassland (Campos) in southern Brazil, the forest cover increased during the Holocene, often in a stepwise manner. While the general increase in forest may be due to a raise in summer precipitation the dynamics of it may have been controlled by fire. To investigate this Late-Holocene spread of *Araucaria* forest, we choose to study a site with a high sedimentation rate during the Holocene. The small lake "Lagoa Dourada" (815 m asl) in Vila Velha State Park (Paraná State, southern Brazil), is located near an *Araucaria* forest covering a low hill and adjacent remnants of natural grasslands. Thus, the site meets all requirements for this investigation. We obtained a 14,5 m sediment core, which contains mainly Holocene deposits allowing high resolution analysis. The preliminary results show the dominance of grassland vegetation during the last 12000 cal yr BP and the expansion of *Araucaria* forest around 3000 cal yr BP. We are presenting insights from the Holocene vegetation history at a centennial resolution and the expansion of the *Araucaria* forest at a decadal resolution.

Keywords: Araucaria, Atlantic forest, Climate change, Grassland, Holocene, Lagoa Dourada, Palynology.

O232

TRIASSIC PALYNOSTRATIGRAPHY OF TULONG, SOUTHERN XIZANG (TIBET), CHINA

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Triassic palynoflora is poorly known in southern Xizang (Tibet), China. In this study, thermally altered but relatively well-preserved pollen and spores from Tulong, southern Xizang were recovered and identified. Triassic palynological zonation of this area was erected based on stratigraphical markers and compositional changes. Six formal and one informal zones from Lower to Upper Triassic were recognized in ascending order: the *Endosporites*δ*Densoisporites* Assemblage Zone (lower Olenekian), the Bisaccatesδ*Aratrisporites* Assemblage Zone (upper Olenekian), the *Triplexisporites* Interval Zone (Anisian), the *Staurosaccites quadrifidus* Taxonδrange Zone (upper Anisian to lower Norian), the *Striatella* Interval Zone (lower Norian), the *Craterisporites rotundus* Taxonδrange Zone (middle to upper Norian) and the informal '*Dictyophyllidites harrisii* zone' (Rhaetian).

This palynological sequence has been correlated with the typical Australian zonation of Gondwana. The *Endosporites*δ*Densoisporites* Assemblage Zone is correlated with the *Protohaploxypinus samoilovichii* Oppel Zone on the occurrence of *Aratrisporites* at the base and major compositional changes. The Bisaccatesδ*Aratrisporites* Assemblage Zone and the *Triplexisporites* Interval Zone are correlated with the lower and upper parts of the *Triplexisporites playfordii* Oppel Zone according to the abundance changes of *Aratrisporites* and the first occurrence data of *Staurosaccites quadrifidus*. The *Staurosaccites quadrifidus* Taxonδrange Zone is correlated with the *Staurosaccites quadrifidus* Oppel Zone at the base, but the correlation on the top was hampered by the rarity of *Ephedripites macistriatus* at Tulong. Furthermore, correlations of the Upper Triassic *Striatella* Interval Zone and the '*Dictyophyllidites harrisii* zone' are difficult because the stratigraphical markers of these time intervals (e.g., *Polycingulatisporites crenulatus* and *Zebrasporites*) are all lacking at Tulong. Well correlation between Upper Triassic *Craterisporites rotundus* Taxon-range Zone and Eastern Australian *C. rotundus* biozone emphasizes the stratigraphical significance of taxon *C. rotundus*. The updated radiometric dating of the Australian *C. rotundus* biozone is in accordance with the age assignment of *C. rotundus* Taxon-range Zone at Tulong, demonstrating that the biozones (including pollen and spores, conodont and ammonoid) at Tulong are solid and crucial for stratigraphical correlation across Gondwana.

O233

PALYNOLOGY AND PALYNOFACIES ASSOCIATIONS OF LATE TRIASSIC ASSEMBLAGES FROM THE MUNGAROO FORMATION IN THE GREATER GORGON AREA, NORTHERN CARNARVON BASIN, WESTERN AUSTRALIA

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The Northern Carnarvon Basin (NCB), Australia's premier hydrocarbon province, has witnessed several major gas developments during recent decades including Chevron's A$53 billion Gorgon LNG project. Drilling in the Gorgon area has resulted in the acquisition of several very long continuous conventional cores in the gas-bearing Mungaroo Formation, a thick, laterally extensive fluvio-deltaic unit ranging in age from Ladinian to Rhaetian. These cores provide an exceptional opportunity to thoroughly examine the palynology and palynofacies associations of the wide range of depositional environments ("depofacies") and lithofacies found in the Mungaroo Formation.

Based on sedimentological studies and wireline log analysis, various facies associations were recognized in the Mungaroo Formation cores in fluvial channel, floodplain, crevasse splay, distributary channel and tidal zone paleoenvironments. Sediments as varied as laminated mudstones, massive siltstones, immature soils showing pedogenic alteration, coals and cross-bedded fine to coarse-grained sandstones are represented in the cores.

This paper outlines the results of a scoping study in which 20 samples representing 12 depofacies and 10 lithofacies were collected from the upper *Samaropollenites speciosus* and lower *Minutosaccus crenulatus* Zones from two wells, GOR-1D and West Tryal Rocks-4A, and processed using standard palynological techniques. The palynological and palynofacies assemblages found in these samples are correlated with their depofacies and lithofacies in order to enhance understanding of the complex Mungaroo Formation.

Although *Falcisporites australis* dominated most palynofloras, in some cases contributing over 90% of the assemblage, there was a greater diversity of spores than pollen in most associations. Several types of assemblages could be distinguished according to taxonomic composition and abundance of spores. These results suggest that a mosaic of diverse and distinctive plant associations characterized the vegetation of the Middle to Late Triassic deltaic environments of south-eastern Gondwana as has been documented in north-western Europe. The study also demonstrates that detailed palynological analysis of economically significant intervals adds valuable insights into reservoir and source rock characterization.

Ongoing work is aimed at strengthening and expanding these initial results by increasing the number of samples examined and broadening the range of depofacies and lithofacies examined, improving the taxonomy of the Carnian-Norian in the NCB and improving the biostratigraphic zonation of this key interval.

O234

MEANING AND VALIDITY OF THE THÜRINGIAN CONCEPT IN PALYNOSTRATIGRAPHY IN THE IBERIAN PENINSULA AND BALEARIC ISLANDS

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This paper focuses on the diversity and biostratigraphical sense of the "Thüringian" palynological assemblages in the middle-upper Permian of the Iberian Peninsula (Ramos & Doubinger, 1979, 1989; Virgili et al., 1979, Virgili 2008). In this region, it has been used the Permian classic division of Autunian and Thüringian to refer to the lower and middle-upper Permian respectively. However, the concepts of Autunian and Thüringian are used in the wrong way as chronostratigraphic references of the early-middle Permian (Autunian s.l.) and late Permian (Thuringian s.l.) omitting that these terms were initially used for floristic associations paleoecological meaning that could be linked to two different climatic environments. In addition, although in Iberia there are some absolute ages from the lower Permian related with the presence of Autunian floras, the age dating of the Thüringian is, to date, relative. Therefore, a revision of these terms and their adjustment to the international chronostratigraphic scheme is necessary.

With this aim, we use the compilation of previously published palynological assemblages and unpublished data such as the study of Alcotas Fm located near Talayuelas and Landete (Castilian Branch of Iberian Ranges, Cuenca Province, Spain) and the re-study of Boniches Fm in Garaballa site (Castilian Branch of Iberian Ranges, Cuenca Province, Spain) and Sa Pedra de S'Ase Fm in "Raco de S'Algar - Sa Pedra de S 'Ase section" (West Tramuntana Range, Majorca, Balearic Islands, Spain).

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O235

SYNTHESIS OF THE PALYNOLOGICAL CONTENT OF THE LOWER CRETACEOUS CONTINENTAL DEPOSITS IN FRANCE: STRATIGRAPHIC IMPLICATIONS

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A first attempt at a biostratigraphic and palaeoenvironmental synthesis of the palynological content of French Lower Cretaceous continental deposits is the subject of this paper. Palynomorphs listed in previous studies on Berriasian–Albian non-marine palynology have been taken into account, gathering 360 species of pollen grains and spores altogether. In addition, 70 samples have been recovered from outcrops of argillaceous rocks, mostly corresponding to the Purbeck and Wealden facies of southern England. The samples concerned are from the departments of Charente-Maritime, Charente, Savoie (Berriasian, Valanginian, Albian), Oise, Seine-Maritime, Pas-de-Calais (Hauterivian–Barremian), and Isère (Aptian). Early Cretaceous miospores are commonly long-ranging; hence, it is necessary to consider fluctuations in their abundance within palynological assemblages if they are to have any biostratigraphic value. Lower Berriasian assemblages are often dominated by gymnosperm pollen grains, associated with anemiaceous spores such as *Cicatricosisporites australiensis* and *C. hughesii*. These taxa are also found in younger strata, but upper Berriasian–Valanginian assemblages are characterized by containing more abundant lygodiaceous verrucate spores associated with the appearance of gleicheniaceous *Clavifera triplex* from the Valanginian onwards. Many genera have been erected to accommodate Mesozoic verrucate spores. The considerable overlap between diagnoses diminishes the stratigraphic significance of the constituent species. Only the genera *Concavissimisporites* and *Trilobosporites* are considered useful here. Hauterivian–Barremian assemblages are similar to those of the Valanginian, but differ in the reduction in numbers of verrucate spores and a commensurate increase in abundance of *Cicatricosisporites* and *Appendicisporites* associated with the first occurrences of monoaperturate angiosperm pollen grains, such as *Clavatipollenites hughesii,* within Barremian deposits of northern France. Considered to be more typical of Albian assemblages, *Clavatipollenites rotundus* has been recovered from lower Aptian deposits in south-eastern France. Aptian palynofloras are also characterized by the appearance of other monoaperturate pollen forms, such as *Retimonocolpites*. Very little information is available on French Albian assemblages. They are defined by the diversification of dicotyledonous tri– and polyaperturate pollen grains associated with the virtual disappearance of lygodiaceous verrucate spores.

O236

ARE THE CLIMATIC RANGES OF PLANT SPECIES IMPACTED BY ATMOSPHERIC CO_2? AN ATTEMPT OF QUANTIFICATION WITH A DYNAMIC VEGETATION MODEL

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The observed present-day climatic ranges of plant species are frequently used by palaeobotanists and palynologists to reconstruct the climate evolution in the past. This is, for instance, the case of the widely used "Coexistence Approach" method, which has provided a wealth of palaeoclimatic data on many periods of the Neogene. Such vegetation-based palaeoclimate reconstruction methods rest on the uniformitarian assumption that the climatic tolerances of plant species, or the way their establishment and growth respond to climate parameters, have not changed markedly over time. This hypothesis can be questioned, because climatic tolerances and growth of plant species may depend on many factors likely to change over time. A first example is that other abiotic and biotic factors allowing the plant presence have probably changed in the course of time. Another example is genetic evolution that may affect climate resistance and end up to some adaptation of the populations as climate is changing.

Atmospheric CO_2 may also modify the plant response. It is not accounted for in the vegetation-based palaeoclimatic reconstruction methods, but may alter the tolerance of plant species to aridity through stomatal closure or stomatal density changes. Moreover, a rise of atmospheric CO_2 stimulates photosynthesis through the well-known CO_2 fertilisation effect. How far this effect impacts plant growth and how long it can persist is still much debated in the scientific community. It likely depends on the nutrient abundance in the soils. However, if CO_2 stimulates growth, it will also facilitate the colonisation of extreme environments by plant species. Indeed, their growth rate between two successive extreme climatic events will be enhanced and, so, the accumulated biomass will be larger and the likelihood to find their signature in the palaeovegetation records will increase.

In this contribution, we attempt to quantify this impact of CO_2 on the climatic ranges of plant species by using the CARAIB dynamic vegetation model. This dynamic vegetation model can be run at the species level. We use a set of tree species from various climatic zones over different continents, for which the model has proved a good ability to simulate the present-day distribution. The model is run for different levels of atmospheric CO_2, but with exactly the same climatic inputs. The simulated tree species distributions versus different climate variables (mean annual temperature, coldest month temperature, mean annual precipitation, precipitation of the driest month, etc) are then analysed and compared among the different CO_2 configurations.

O237

EXPLORING THE NEOTROPICAL DIVERSITY OF MIOCENE PANAMA: MORPHOLOGY AND X-RAY COMPUTED TOMOGRAPHY OF EXTINCT AND EXTANT *HELICONIA* (HELICONIACEAE, ZINGIBERALES) SEEDS

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Morphology and anatomy are critical data for elucidating relationships between fossil and extant organisms. *Heliconia*, commonly known as the 'lobster-claws,' comprises neotropical herbaceous plants of the monogeneric Heliconiaceae (order Zingiberales). Heliconiaceae have no published, reliable fossil record to date, but morphological characterization of extant *Heliconia* will help recognize potential fossil plant material. The goal of our study here is the description and phylogenetic placement of a new fossil taxon represented by abundant, anatomically preserved seeds from the Cucaracha Formation of Panama, early Miocene (~19 Ma), hypothesized to belong to Heliconiaceae. Comparative data on *Heliconia* "seeds" (botanically, pyrenes) was also collected. There are 201 species of *Heliconia* in five subgenera currently recognized, and representatives of each clade were assessed, with 72 extant species included in our dataset. Specimens were studied using X-ray micro-computed tomography (microCT) at the University of Michigan, or by synchrotron-based X-ray tomographic microscopy (SRXTM) at the Swiss Light Source, Advanced Photon Source, or the Advanced Light Source. Three-dimensional datasets were analyzed with the program Avizo for overall morphology, including embryo orientation and location, operculum shape, size, and location, and overall pyrene shape, as well as quantitative measurements of tissue layer thicknesses and pyrene size. In addition, high-resolution macrophotographs were taken of extant species and measured in the program ImageJ to quantify the degree of surface undulation and pyrene length-to-width ratios. These morphological characters were used to examine trait distribution within extant *Heliconia* in the context of a recent molecular phylogeny. These results inform the phylogenetic placement of the Panamanian fossil taxon and confirm its affinities to Heliconiaceae. This study highlights the utility of microCT for studying morphological diversity in plants. Placing the Cucaracha fossils confidently in the family Heliconiaceae demonstrates the presence of the lobster-claws in Central America at least since the early Miocene, before the closing of the Central American Seaway, and adds to our understanding of past diversity in the Neotropics.

O238

WORLDWIDE TEMPERATE FORESTS OF THE NEOGENE: NEVER MORE DIVERSE?

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Temperate forests had covered large areas of the Earth's continents before the dramatic increase of the human population in the past two millenia. However, their floristic diversity seems to have decreased consistently, already brought about long time before the human expansion. Using new perspectives, we will reanalyze Neogene plant diversity and post-Neogene loss of diversity in the light of the increased availability of palaeobotanical data in several key temperate regions. The European fossil plant assemblages show, more apparently than elsewhere in the world, a higher floristic diversity in the Neogene compared to the present one, suggesting massive local extirpations of woody taxa. Such difference in past and modern diversity is less apparently shown by North and South American fossil floras. However, palaeobotanical data indicate that the temperate forests of South America decreased consistently after the late Miocene, and the dominant woody plants were conserved only in the westernmost regions. The floristic impoverishment in the same time interval is consistent in New Zealand, but not clearly documented in Australia, where only much higher diversity of conifers in the Oligocene-Miocene is apparent. Eastern Eurasia may be the Earth's relict area where plant extirpation has been more limited. The high Neogene plant diversity can be explained by several reasons. First of all, there was an apparent phylogenetic diversification in the Cretaceous and Paleogene; the new plant lineages could easily disperse between North America and Eurasia, and migrations occurred also across other continents. Furthermore, since the Eocene/Oligocene transition, some members of tropical/subtropical lineages acquired an adaptation to cooler conditions and entered the warmer temperate forests. In the Neogene the climate at the middle latitudes was slightly warmer than at present, with abundant precipitation in large areas. Such equable climatic condition provided a suitable habitat for moisture-requiring woody plants. The temperate forests were more extended and formed by a large diversity of plant taxa, higher than the present in several areas. Since 6 Ma several cold and/or dry pulses have reduced the habitat of the most thermophilous elements, finally causing a large mass extinction of thermophilous plants in western Eurasia.

O239

SIMULATING PAST AND PRESENT DISTRIBUTIONS OF PODOCARPUS SPECIES IN MOUNTAIN AREAS OF AFRICA AND SOUTH AMERICA WITH THE CARAIB DYNAMIC VEGETATION MODEL.

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It is today established that climate change alters biodiversity, since the migration of many species, especially plants, is presumably too slow to follow climate change. Tropical mountain floras are particularly vulnerable to the climatic threat. Species in mountain areas tend to shift their range through upslope rise when climate warms. These altitudinal migrations are possible when the migration speed is large enough to follow climate change. Otherwise, species tend to survive in isolated mountain refugia - microrefugia - where local climate may remain more stable and suitable than in the surrounding landscape. In the past, microrefugia have played a major role in the persistence of mountain species.

In the framework of the international VULPES project (VULnerability of Populations under Extreme Scenario, https://vulpesproject.wixsite.com/vulpes), we use the CARAIB dynamic vegetation model (Dury et al., iForest - Biogeosciences and Forestry, 4:82-99, 2011) to simulate the evolution in the past (Last Glacial Maximum (LGM) and Holocene) and understand the current distribution of *Podocarpus* species in Africa and South America. *Podocarpus* species (*Podocarpus latifolius/milanjianus* in Western and South Africa; *Podocarpus lambertii* and *sellowii* in Brazil) have today a very fragmented distribution, persisting in relict patches of montane forests, and are classified as vulnerable or threatened of extinction

according to the International Union for Conservation of Nature and Natural Resources (IUCN) red list (http://www.iucnredlist.org/).

The CARAIB model is run at high spatial resolution over several focal areas in Cameroon and Southern Brazil, using climatic inputs derived from the ERA-Interim climate dataset combined with WorldClim climatology at 30 arc seconds (~1 km) to simulate the current distribution of *Podocarpus* species. Past distributions are reproduced using interpolated climatic fields of the HadCM3 model from LGM (21,000 BP) to present time with a temporal resolution of 1 kyr. Climatic tolerances and morphological traits of *Podocarpus* species are adapted in the model simulations, in function of material collected in the field completed with data from online databases, such as TRY. CARAIB results are discussed in terms of biomass and net primary productivity (NPP). Past distributions are compared to available pollen records.

O240

THE EVOLUTIONARY ORIGIN OF THE PLANT SPORE IN RELATION TO THE ANTITHETIC ORIGIN OF THE PLANT SPOROPHYTE

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The origin of lands plants was not a singularity in geologic time, but rather occurred gradually as major evolutionary novelties became established during a period of adaptive selection in subaerial habitats during early Paleozoic time. One can envision that acquisition of novel structures as the outcome of a more basic evolution of plant development within an evolving charophyte lineage. Here we focus on just one component of becoming an embryophyte - the fossil record of land plant spore development. Bower's antithetic (interpolational) hypothesis for the origin of the plant sporophyte from algal ancestors called for the evolution of the embryophytic spore in advance of the vegetative sporophyte. Intriguingly, the fossil record of cryptospores from lower Paleozoic strata directly supports such a "spores before sporophytes" paradigm. Some late Cambrian and Early Ordovician cryptospores sometimes occur in geometrically-regular, planar sheets; these were effectively predicted by Bower, who thought that mitotic divisions in fully-sporogenous tissue would have preceded the origin of vegetative sporophytic tissue. Cryptospores show marked changes between pre- and post- Darriwilian time. These include shifts from smaller to larger spore diameters, topological changes from irregular to isometric spore-body attachment configurations, the loss of synoecosporal walls and the *de novo* origin of homogeneous sporoderm. These changes in spore morphology and topology appear to reflect the canalization of meiosis in the evolving sporocyte, as karyokinesis and cytokinesis became tightly coupled and meiosis resulted in only four (meio)spores. Indirect evidence of embryophytic sporangia is first found in Darriwilian rocks in the form of homogeneous sporoderm, which is considered to be tapetal in origin. Thus, the fossil record appears to support the progressive acquisition of evolving sporophyte characters with respect to spore formation. If embryophytic sporogenesis first evolved during the Darriwilian, the antithetic hypothesis also predicts that the full suite of vegetative characters that defined the first sporophyte must have evolved later. This scenario is consistent with the Homerian origin of land plants as seen in the (mega) fossil record, but it also leads to a prediction that morphological traits that distinguish embryophytes from charophytes might be found in the intervening fossil record.

O241

CARBONIFEROUS WILDFIRE REVISITED.

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The nature and occurrence of fossil charcoal (often called fusain) in sediments and coals (often given as inertinite/fusinite/semi-fusinite) is the main way that the history of Carboniferous fire has been studied. Fires have been shown to have been common in many Carboniferous ecosystems worldwide yet we still have little understanding of the detail of what, where and how such fires occur or indeed upon their effects both of the local ecosystem as well as the Earth System as a whole. Recent studies have indicated that detailed scanning electron microscope studies of charcoal residues can provide data on the plants that have been burned by wildfires and the reflectance of the particles may provide information on the charring temperature and nature of the fire itself. Information on the amount of charcoal in coal appears to relate to atmospheric oxygen composition and this shows that throughout the Carboniferous oxygen levels were as high or higher than those of the present day. Interpreting the frequency of fires in different ecosystems remains fraught with difficulty and calculations within peat (coal) systems are at an early stage. The impact of fire on vegetational change as well as the relationship between fire and climate in the Carboniferous remains little studied. New data on some charcoal deposits from the British Isles is integrated into previous studies to provide an indication of our current understanding of the role of fire on land and also provide strategies for obtaining new information in the future.

O242

CONSERVATION PALEOBOTANY: PUTTING OUR DEAD TO WORK FOR THE LIVING

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Conservation paleobiology is a discipline focusing on how geohistorical research can be integrated with ecological and systematic data to model biotic response to environmental stressors. This emerging field has developed largely within the invertebrate paleontology community, generating insights essential for evaluating the nature of biotic change and the vulnerability and resilience of modern ecological communities. A major goal of conservation paleobiology is to provide tools for managers and policymakers. Paleobotanists already have contributed data vital for addressing climate change and continue to provide insights needed to develop responses to vegetation changes. Likewise, archeological studies have used plant remains to reconstruct vegetational history of sites prior to and during the development of human colonization. However, the conservation community has needs for which paleobotanical data could be useful. The process of addressing those needs starts with a dialogue where conservationists articulate what questions they are working to resolve, and paleontologists think about what types of data they can provide that will be helpful.

A fundamental skill in paleobotany is the ability to identify fragmentary plant remains, altered by taphonomic processes. The ability to identify plant structures taxonomically from small fragments is also an essential tool in wildlife conservation, in particular, the identification of plant debris from feces. For example, determining feeding ranges requires many hours of observation in the field that cannot be obtained from unhabituated herbivore populations.

Volcanoes National Park (VNP), Rwanda, consists of highland tropical forest which has been exposed to large herbivores. The flora within the Park contains plants (e.g. *Rubus*) capable of responding to heavy pressure from high levels of perturbation by large mammalian herbivores including the African elephant (*Loxondonta africana*) and buffalo (*Syncerus caffer*) (Plumptre, 1993). Three species of stinging nettles occur within the Virunga Mountains, as well as the one mammal capable of consuming them as a major portion of their diet, the mountain gorilla (*Gorilla beringei beringei*). To date, we have identified quantifiable features of nettle trichomes and *Rubus* prickle shape and density induced by herbivory. These morphological "fingerprints" can be used to document modern feeding ranges, identify mammalian herbivory in the fossil record, and serve as a way of comparing the past with the present.

O243

TRANSFORMATIVE PALEOBOTANY: PAPERS TO COMMEMORATE THE LIFE AND LEGACY OF THOMAS N. TAYLOR – BOOK PRESENTATION

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Paleobotany today is a vibrant and innovative science that promotes new approaches and avenues of inquiry in biology and geology. Thomas N. (Tom) Taylor, who's scholarship, insightful contributions, and scientific impact this symposium celebrates, was the initiator and strong advocate of many of these innovations. Of perhaps even greater significance than the voluminous research personally developed and conducted by Tom, are the colleagues he has influenced and students he has inspired to elevate our understanding of the evolution of life, and chart the forthcoming directions of paleobotanical research for the 21st century. Although it is impossible to distill a lifetime of scientific contributions into a single volume, a team of authors from a wide variety of disciplines has taken on the challenge to assemble a commemorative volume designed to celebrate the life and legacy of Tom Taylor, and to exemplify the influence he has asserted onto the continuing enrichment of the discipline. The volume is divided into five sections to emphasize the most promising avenues of investigation that Tom Taylor has opened, and to highlight the fruitful contributions that his influence has engendered, including (1) early land plants: innovations and adaptations; (2) late Paleozoic and Mesozoic plants and floras; (3) paleobiogeography, biology, and phylogenetic relationships of plants; (4) fossil microorganisms, and (5) Antarctic paleobotany. As we realize that research areas such as geochemistry, molecular biology, microbiology, biomechanics, phylogeny etc. are transforming our approaches to, and perception of, the analysis of fossil plants and ecosystems, many of these once so remote research areas are becoming increasingly important for, and integral parts of, paleobotanical research. This volume exemplifies the benefits and continuing potential of utilizing interdisciplinary research in the advancement of paleobotanical inquiry that we anticipate will focus the progress of our ever expanding discipline well into the new millennium.

O244

TERATOLOGY OF SPORES AND POLLEN ACROSS THE TRIASSIC–JURASSIC BOUNDARY: IMPLICATIONS FOR THE END-TRIASSIC MASS EXTINCTION

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A disturbed spore/pollen production can result in increased amounts of abnormal spores or pollen. Usually, this is linked to naturally occurring environmental stress in the mother plant due to sudden changes related to weather, e.g. draught, water logging, temperature changes, in which case the environmental stress is seasonal and may only affect parts of a population. Disturbed spore/pollen formation can also occur due to anthropogenic pollution, leading not only to prematurely aborted spores, retained tetrads, or naturally occurring polyploids, but also to mutagenic changes in the mother plants and the reproductive cells. Normal sporogenesis follows a path where the spore mother cell (2n), through double meiosis, forms a spore/pollen tetrad in which each spore/pollen is haploid (n). This process results in 96 % normal, viable spores and 4 % aberrant, non-viable spores, which is more or less in accordance with studies on both fossil and extant bisaccate pollen from pollen sacs, where ca 3–4 % of the pollen within the pollen sac are abnormal grains (Foster and Afonin, 2005; Wilson, 1963; Lindström et al 1997). A few previous studies have noted increased abundances of aberrant spores and pollen during extinction events linked to large volcanic provinces. The teratology has been attributed to mutagenic effects of a thinned ozone layer has been suggested as a cause (Visscher et al., 2004; Foster and Afonin, 2005; Filipiak and Racki, 2010; Kürschner et al. 2015), and in one case volcanic pollution (Hochuli et al. 2017). Here, we explore and discuss examples of spore/pollen teratology from several Triassic–Jurassic boundary successions in Europe. We further discuss their link to volcanism the Central Atlantic Magmatic Province, and the implications on the causality of the end-Triassic event.

O245

DETAILED INSIGHTS INTO THE END-TRIASSIC BIOTIC CRISIS WITH RESPECT TO ITS IMPACT ON PALYNOFLORAL ASSEMBLAGES

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The end-Triassic mass-extinction (ca. 201 Ma) is often linked to the activity of the Central Atlantic Magmatic Province as the trigger of environmental and climate change. While the faunal realm depicts a drastic turnover, plant and especially palynomorph assemblages, do not show such a caesura. Nevertheless, studying changes occurring in assemblage composition and observing changing morphological features can give insight into the subtler impact on the floral realm and its vegetation history.

Here, we present data from 64 samples taken from a new outcrop 'Bonenburg' in North Rhine-Westphalia (Germany) from the Exter Formation in the Germanic Basin, comprising the Triassic–Jurassic transition. Our study provides high-resolution data, giving the first detailed palynological insight into the transition from the middle to the late Rhaetian.

Based on terrestrial and marine palynological analysis, we show that the studied section can be divided into five informal assemblage zones that mostly correlate well with existing palynological zonations for the North Germanic Basin. We will discuss the vegetation history as attested for in Bonenburg comparing pre-extinction phase (middle-Rhaetian Contorta-Beds), extinction phase (Triletes-Beds) and post-extinction phase (Hettangian) as indicated in the faunal turnover.

Additionally, we document intraspecific palynomorph variability, indicating an increased number of aberrant spore, pollen and tetrad formation in the middle Rhaetian, the lowermost upper Rhaetian and the lowest Hettangian. We thus provide the first quantitative record of aberrant palynomorphs (tetrads) over the end-Triassic extinction from the German Triassic.

These findings might indicate a prolonged period of increased mutagenesis. Often 'environmental stress' is invoked to explain such aberrant forms. Further investigations are needed to disentangle the mechanisms causing the end-Triassic mutations. This case illustrates the need for more high-resolution spore- and pollen-morphological studies, to identify those stratigraphic intervals that hold an increased number of aberrant palynomorphs and to better understand the mechanisms and triggers that might have led to their formation.

O246

PALYNOFLORAL AND ECOSYSTEM VARIATIONS ACROSS THE TRIASSIC-JURASSIC TRANSITION IN THE SICHUAN BASIN, CHINA

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The end-Triassic mass extinction is considered as one of the five largest Phanerozoic extinction events, but the terrestrial records of floral turnover across the Triassic-Jurassic boundary are relatively scarce in East Asia. The Late Triassic-Early Jurassic deposits of the Sichuan Basin, southwestern China are significant for hosting abundant and diverse fossil assemblages including plants (containing spores and pollen), bivalves and insects. However, Late Triassic-Early Jurassic palaeoecological variations are still poorly documented in this region. Here we present results from detailed palynological studies of the Upper Triassic Xujiahe Formation and the Lower Jurassic Zhenzhuchong Formation in Xuanhan and Hechuan regions of the Sichuan Basin, China, to reconstruct the palaeoecosystem variations.

The palynological analysis revealed a well-preserved terrestrial palynoflora of high diversity, comprising 184 species in 75 genera of spores and pollen in Hechuan region, and 148 species of 67 genera in Xuanhan region. Palynological successions reflect significant changes in the terrestrial vegetation from the Late Triassic to the Early Jurassic. Palaeovegetation reconstruction shows a predominance of fern floras, followed by gymnosperms represented by conifers during the Late Triassic; at the latest Late Triassic, cycads/bennettites/ginkgophytes and conifers show an increasing trend, whereas ferns decreased; at the earliest Early Jurassic, ferns were the most abundant, conifers were less abundant, the Cheirolepidiaceae began to develop; during the Early Jurassic, conifers became thriving, represented by the Cheirolepidiaceae.

We applied the Spore-pollen Morphological Group (SMG) method and Sporomorph EcoGroup (SEG) model to interpret the palaeoclimate features. The results reveal that the lower part of the Xujiahe Formation was deposited under relatively warm and humid conditions with an overall cooling and drying trend from latest Norian to Rhaetian time, accompanied by a general decrease of ferns and simultaneous increase of gymnosperms, and a decline in diversity of miospores. At the beginning the Early Jurassic, it became warm and humid; later during the Early Jurassic, it has a cooling and drying trend upward.

This study presents data on variations within the terrestrial ecosystem across the Triassic/Jurassic boundary in the Sichuan Basin, and therefore provides important information for understanding the changes in the vegetation across the Triassic/Jurassic transition.

Keywords: Triassic-Jurassic, palynology, palaeovegetation, palaeoclimate

O247

PALYNOLOGICAL EVIDENCE OF THE CARNIAN PLUVIAL EPISODE (CPE) IN THE WESTERN TETHYS FROM MARINE SUCCESSIONS IN THE TRANSDANUBIAN RANGE (TR), WESTERN HUNGARY

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The Carnian Pluvial Episode (CPE) represents a shift to more humid climate associated with increased continental runoff, multiple clastic pulses in the generally carbonate-dominated depositional setting of the western Tethys during the late Julian-early Tuvalian accompanied by hygrophyte floral elements. Here, palynological assemblages have been studied from three boreholes, from the Transdanubian Range to reveal climate variations. The palynological record has been compared to clay mineralogy and weathering indices (α^{Al}_{Ba}, α^{Al}_{K} and α^{Al}_{Na}) to detect episodes with hygrophyte vegetation and enhanced continental hydrolysis. Palynostratigraphy has been applied to correlate the clastic pulses known from elsewhere in the western Tethys.

A total of 55 samples were counted for palynology, 93 terrestrial taxa and 14 different types of aquatic palynomorphs are identified and three local palynomorph assemblages are distinguished in the Julian 2: the lowermost *singhii-acutus-vigens*, the *acutus-vigens-maljawkinae* and the uppermost *Aratrisporites-astigmosus-densus* in the upper part of the late Julian.

The quantitative palynological analysis indicates a shift towards hygrophyte elements in the Julian 2, and return to xerophyte associations in the Tuvalian. The increase in the hygrophyte vegetation elements is coincident with elevated kaolinite and partially with higher weathering rates in the early Julian 2 indicating enhanced continental hydrolysis and more humid climate. In the late Julian 2, in a second clastic pulse the high amount of hygrophytes would point to a second humid episode but the clay mineral profile and the weathering indices indicate stronger seasonality and diminished continental weathering. The increase in the spores and pollen which are usually associated with hygrophyte affinity can be also linked to a change in source vegetation due to the northward migration of the TR during the Julian 2, or a sea level lowstand, when the TR shifted to a more proximal position to the coastal areas.

Although, the clastic pulses in the western Tethys were related primarily to more humid climate, the comparison to clay mineralogy and weathering proxies suggest a more complicated scenario in the TR. The enhanced continental weathering related to a more humid climate is only suggested for the early stages of the CPE, in the early Julian 2. The clay mineral and palynological records are clearly influenced also by other environmental parameters e.g., sea level changes, current or basin topography.

O248

MEDIEVAL CLIMATE ANOMALY AND LITTLE ICE AGE AS REVEALED FROM A NEW HIGH-RESOLUTION POLLEN RECORD FROM THE GULF OF GAETA (CENTRAL MEDITERRANEAN)

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The history of the last thousand years in Europe was characterized by several climate oscillations, the most important being the so-called Medieval Climate Anomaly (MCA) and the Little Ice Age (LIA). Despite their names, evoking a warmer and colder anomaly, respectively, the actual nature of these climate fluctuations and their effects on vegetation are far to be understood yet. Here, we present a new high-resolution pollen record from a marine core collected in the Gulf of Gaeta (central Mediterranean), showing in the last thousand years clear vegetation fluctuations corresponding to the MCA and LIA. This is one of the most detailed pollen records in the central Mediterranean spanning the last thousand years, having a mean time-resolution of ca. 20 years. Here, the medieval period shows a remarkable forest decline between 800 and 1150 AD, affecting mostly natural broadleaved trees along with *Castanea* and *Olea*. A strong increase in Cichorioideae indicates the establishment of extensive open areas, disturbed by agro-pastoral activities. The local $\delta^{18}O$ $G._{ruber}$ signal and the planktonic foraminifera indicate temperature decrease. Between 1150 and 1550 AD, the forest vegetation partly recovered, showing a maximum expansion around 1250 AD. A marked change in the oxygen isotopes, associated with a strong rise in *Globigerinoides*, point to the warmest interval of the MCA. Montane taxa like *Fagus* and *Abies* appear reduced, while mediterranean elements like evergreen *Quercus*, *Myrtus*, and *Phillyrea* increase. Excluding a modest increase in cereal pollen, no clear change in land use is documented. Between 1400-1850 AD, corresponding to the LIA, there was a new forest decline mainly affecting evergreen vegetation, showing a drop during the Maunder minimum (1645-1715 AD). Both the foraminifera and oxygen isotope records indicate colder climate conditions. At the same time, olive, chestnut and cereal cultivation appear strongly diminished, probably also for the demographic effect of the plague that afflicted the Kingdom of Naples in 1656. The record ends with a new general forest increase, related to both cultivated trees and natural evergreen trees and shrubs, favoured by the modern temperature increase. The forest fluctuations observed in the Gaeta record correspond to changes in the North Atlantic Oscillation index, with forest declines associated to negative NAO index and vice versa. However, also other climate factors may have concurred in determining these vegetation dynamics, such as a complex interplay of NAO with East Atlantic pattern, solar activity, and local cyclogenesis.

O249

ECOLOGICAL IMPACTS OF THE INDUSTRIAL REVOLUTION IN A LOWLAND RAISED PEATBOG NEAR MANCHESTER, NW ENGLAND.

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Throughout history, formerly widespread peatlands in the UK have been heavily impacted by industrial activities, land management and peat extraction, prompting dramatic loss of peatland ecosystems. Holcroft Moss is a rare example of an intact ombrotrophic lowland bog that was not disturbed by cutting for peat. This wetland reserve is located in the heartland of the Industrial Revolution in NW England, within 16 km of the urban areas of Manchester and Liverpool, the first industrial cities of the modern world. Unlike many developing areas of the world, the decline of industrial activity since the mid 20th century in NW England provides a valuable test bed for understanding the potential for recovery of natural systems. Holcroft Moss therefore offers the opportunity to assess the ecological impacts before and after the Industrial Revolution. Using palaeoecological tools including pollen, non-pollen palynomorphs (NPPs), microcharcoal, peat composition (organic content, ash-free bulk density) and heavy metal content (ICP-OES), we can assess the environmental responses of the vegetation to past climate and anthropic pressure. Our aim is to perform a high resolution (decadal-scale) reconstruction of Holcroft Moss to understand the nature of environmental changes during the historical era and evaluate the role of local to regional anthropogenic impacts, especially atmospheric deposition of pollutants (heavy metals, ash). In this way, we seek to determine thresholds for local and regional vegetation changes and post-Industrial recovery. Here, we studied a 50 cm peat core recovered in 2015 with a contiguous sampling of 1 cm slices. The chronological framework was based on three radiocarbon dates with a timespan of 700 years. The record reveals fluctuations in peat composition and local vegetation composition (shifts between Cyperaceae, *Sphagnum, Calluna*, Ericaceae). Prior to 1900 AD these fluctuations appear to reflect primarily climatic influence on bog surface wetness. From 1900 AD, intensification of anthropogenic activity associated with the rapid industrialisation of Manchester corresponded with the near extinction of *Sphagnum* and decline in regional tree cover. Recent changes in the 20th century and drier climate reflect the development of Poaceae dominated vegetation and increase in trees associated with reduced anthropogenic pressure and physical encroachment of fields and roads into the area of Holcroft Moss. Although the direct impacts of the Industrial Revolution have decreased strongly, we do not observe a return to previous or pre-Industrial conditions. Therefore, restoration actions are required to prompt *Sphagnum* recovery, supporting the current conservation activities underway at the study site.

O250

USING ANNUAL RESOLUTION POLLEN ANALYSIS TO SYNCHRONIZE VARVE AND TREE RING RECORDS

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Tree rings and varved lake sediments are valuable archives that at the same time allow studies with (sub)annual resolution and provide a chronology through layer counting. In reality, building chronologies from a single record is susceptible to error because single rings/varves may be invisible or missing. In lakes, non-varved periods may occur. For tree rings, single records can easily be synchronized over broader regions on the basis of the ring width pattern, which allows to remove errors and to build long regional time series. For varved lake sediments, such approach is not possible because varve thickness does not show similar variations between sites. We here explore whether annual pollen analysis is suitable to synchronize varve records. Particularly taxa that flower irregularly in a masting pattern may be suited for that task. Masting is known for a number of tree taxa, including *Fagus* and *Quercus*. For *Fagus*, years with strong flowering are known to be synchronous across regions and beyond

We sampled four short sediment cores from two large lakes in NE-Germany, 110 km apart. Annual samples were taken in the varved section, which includes ~90 years in Lake Tiefer See and 30 years in Lake Arendsee. Pollen percentages and pollen accumulation rates of *Fagus* and *Quercus* were compared with each other and with masting data from forest monitoring, tree ring data and weather observations.

Pollen accumulation of *Fagus* is closely correlated between all cores; all masting years are indicated by high pollen accumulation. Apparently, annual variations in the pollen production of *Fagus* are indeed preserved and recognisable in varved sediments. For *Quercus*, correlation between the two sites is instead low, obviously flowering is less synchronous across the region. Pollen accumulation of *Fagus* also shows close correlation with weather observations; years with high flowering and hence high pollen accumulation follow a sequence of years with a cool, wet spring in the first year and a warm summer in the second year. Finally, for *Fagus* also a link between pollen accumulation and tree ring width is observed; all years with high pollen accumulation correspond to narrow tree rings. In masting years tree resources are allocated to pollen and seed production rather than to wood production. Overall, in NE-Germany pollen accumulation of *Fagus* is well suited to annually synchronize varved sediment records over a region and possibly allows to link varve chronologies with tree ring records.

O251

ALL YOU NEED IS POLLEN – INSIGHTS ON CRYOPALYNOLOGY

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Ice cores from the mid latitude glaciers are capable of retaining information on past climate, environment and human activities on seasonal/annual time resolution. However, for a correct interpretation of these records a good chronological control is essential. Annual-layers counting of seasonal variations in chemical species and oxygen isotope ratios ($\delta^{18}O$) is a powerful tool, but cannot always be successfully applied to alpine glaciers because of inhomogeneous snow accumulation. Absolute time markers such as ^{3}H peaks and Sahara dust horizons, together with radiometric methods as ^{210}Pb, radiocarbon from carbonaceous aerosol particles and AMS-dating are commonly used to obtain the age depth model of ice cores. Recent advance in pollen analyses from ice cores has shown the high potential of pollen as a chronological tool for ice core dating. In this contribution, we present an algorithm developed to build a high-resolution pollen based timescale and we substantiate examples of its successful application to Alpine glaciers (Adamello and Mt. Ortles, Italy). Finally, we use pollen data from the glaciers to infer variations in past snow accumulation and climate for the last century.

O252

PALAEOBOTANY, PALYNOLOGY AND ISOTOPIC AGE EVALUATION OF THE "COUCHE DE MUSE", AUTUN BASIN (FRANCE)

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The intracratonic equatorial basins of central Euramerica are characterized by an alternation of sandstones and shales intercalated with either carbonates or bituminous shales. The bituminous shales, often comprising plant fossil remains, fish and tetrapods represent lakes. Palaeofloral recurrences within these basins have been considered as indicative of a glacial/interglacial cyclicity of orbital origin suggesting that cyclicities from paralic basins are also recovered in limnic basins.

The Autun basin represents such an intracratonic equatorial basin where the lower Permian (Asselian) Muse Formation is characterized by two bituminous shales within generally more arenitic deposits. The upper bituminous shales, the "Couche de Muse", were the object of systematic sampling leading to the collection of approximately 450 plant fossils distributed over circa three meters of sediment. It also was sampled systematically for palynologic purposes. The "Couche de Muse" is punctuated by eight ash bands of which the first and seventh were selected for isotopic age determination. These ash bands indicated an early Asselian age, a duration of approximately 0.5 Ma years for the interval between the two and approximately 1 Ma for the whole section.

Palaeobotanic fossil distribution along the section indicates the presence of Lycophyta, Sphenophyta (Calamitaceae), Marattiales (Asterothecaceae), Medullosales, Peltaspermales, ?Cycadales, Cordaitanthales, Pinales. The taxa distribution indicates a general decline in lycophytes and sphenophytes, an increase in marattialeans, peltasperms and to an extent cordaites and more or less constant but low abundance of conifers and cycadophytes. A preliminary study of the palynology indicates a rather constant spectrum of fern and lycophyte spores, and monosaccate pollen, and diverse palynomorphs, albeit with some alternation between monosaccates and ferns, a light increase in bisaccates at the top of the section and a general decrease in biodiversity. The vertical palaeobotanic and palynologic distributions of taxa are compared to each other and to various potential cyclicities for which tectonic, orbital and sedimentary processes are considered.

O253

GINKGOPHYTE SEEDS AND OVULATE STRUCTURES FROM THE MIDDLE OXFORDIAN STAGE OF KUTCH, INDIA

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The present investigation records the occurrence of petrified remains of seeds and ovules from the ferruginous ammonite band of Middle Oxfordian stage of Kutch (India). The detached seeds, five in number are permineralised, oval–elliptical in shape, apex pointed, base rounded, bilaterally symmetrical, light brown in colour, with scattered patches of ill preserved carbonised matter; outer parenchymatous sarcotesta not preserved; sclerotesta is hard, forming the shell, which is slightly flattened laterally and each with two longitudinal prominent ribs facing each other, which represents the sutures. Surface of the seeds have longitudinal striations. The size ranges from 25 to 35 mm in length and 16 to 24 mm in breadth. In one of the seeds there is the presence of a basal attachment scar. Anatomically the sclerotesta shows scattered remnants of sclerotic cells. The seeds bear structural similarity to the morphographic features of the extant *Ginkgo biloba* seeds. Dispersed ovules, four in number, are top shaped, with broad base (15 to 16 mm), slightly flattened, apex pointed, mucronate. Basal portion has a broad rounded scar, which is darker than the remaining part of the seed. All the ovules are almost equal in size, ranging in length from 15 to 16 mm and breadth 14 to 16 mm. The characteristic features of these dispersed ovules are the presence of basal cupule-like structure enclosing the ovule. Based on its position and function, it can be suggested that it is homologous with the collar of extant *Ginkgo*. The dispersed ovules have close similarity with the genus *Nehvejdeyella*. The finding indicates the presence of *Ginkgo* and its associates in the Upper Jurassic forests of India.

O254

PALYNOLOGICAL DATA ON THE JURASSIC-CRETACEOUS TRANSITION OF THE WESTERN SECTOR OF THE CAMEROS BASIN (TERRAZAS SECTION, N IBERIAN PENINSULA)

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A new palynological assemblage has been studied in the Terrazas-2 section (Sacristán-Horcajada et al., 2015) close to the village of Terrazas (Cameros Basin, N Iberian Peninsula). This outcrop presents stratigraphic levels of the Nuestra Señora de Brezales, Boleras and Jaramillo de la Fuente Formations which have been assigned to the Tithonian–Berriasian? according to the stratigraphy (Sacristán-Horcajada et al., 2015). The aim of this work is to determine their stratigraphic relationships on the basis of their palynological content for clarifying their lateral facies changes. It corresponds to the first palynostratigraphical data of the Jaramillo de la Fuente Fm., as it lacks of guide levels (Martín-Closas and Alonso, 1998), and information about the palaeoclimatology and the palaeoenvironment is provided, as well as the age.

The Cameros Basin (N Iberian Peninsula) is an extensional intraplate continental basin related to the Mesozoic Iberian Rift System. Eight Depositional Sequences have been described in this basin, where the studied deposits correspond to the first and second one (DS1 and DS2). The studied sequences were the result of several alluvial-lacustrine sedimentary cycles (Mas et al., 2011).

Twenty-four samples were collected from the top of the Nuestra Señora de Brezales Fm. to the top of the Jaramillo de la Fuente Fm. Only eight samples from the base and the middle part of the Jaramillo de la Fuente Fm. yielded palynomorphs. The palynological assemblage is represented, among others, by *Leptolepidites major*, *Baculatisporites comaumensis*, *Biretisporites potoniaei*, besides algae, which confirms an Early Cretaceous age in agreement of the sedimentological data.

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O255

ECOSYSTEM CHANGES DURING THE EARLY JURASSIC TOARCIAN GLOBAL WARMING EPISODE

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The Early Jurassic Toarcian Ocean Anoxic Event (T-OAE; ~183 million years ago) is characterised by a period of rapid global warming (in the region of ~6.5˚C), marine mass extinction and ocean oxygen deficiency, reflected in the widespread deposition of organic-rich black shales. The event is also associated with a major negative carbon isotope excursion (CIE), signifying a massive release of isotopically light carbon into the atmosphere. Proposed causal mechanisms include elevated CO_2 flux driven by emplacement of the Karoo-Ferrar large volcanic province in the Southern Hemisphere, and the release of thermogenic and/or biogenic methane. Efforts to understand the biological consequences of this event have hitherto primarily focussed on marine ecosystems, and responses include the temporary and/or complete disappearance of marine plankton groups (e.g. dinoflagellates), and widespread extinction among higher trophic groups of marine invertebrates. Comparatively few studies have addressed the impacts on terrestrial ecosystems. Here we examine the palynological record across the T-OAE succession of Yorkshire, UK to track how this episode impacted terrestrial and marine environments and test links between continental and marine ecosystem changes. We record abrupt changes in assemblage composition across the event and reveal how shifts in floral and marine communities are intimately linked with climatic changes.

O257

INTERRELATIONSHIPS BETWEEN FOSSIL LEAF ANATOMY, LEAF CARBON ECONOMY AND LEAF TEMPERATURE: POTENTIAL FOR PALAEO-CLIMATE AND PALAEO-ECOLOGY ANALYSIS

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In this contribution, a model is proposed that combines leaf energy balance, that is, components of radiation interacting with a leaf, latent heat transported by transpiration and the contributions of heat conduction and convection, with leaf gas exchange and photosynthesis. The model represents a hybrid ecological/physiological approach described by systems of equations based on quasi-instantaneous leaf-gas exchange theories, fossil stomatal data and atmospheric CO_2. The model allows to distinguish between air temperature and leaf temperature and thus to explore the dependence of leaf cooling or heating on environmental conditions (e.g. wind velocity, atmospheric humidity, atmospheric CO_2-level), anatomic leaf properties (e.g. leaf size) and physiologic quantities (e.g. assimilation rate, transpiration rate).

The usage of the model is illustrated by applying it to isotopic and anatomical measurements from extant species.

It is furthermore shown that the model can also be used to derive palaeotemperature from leaf anatomy, provided atmospheric CO_2 is known from other sources, such as ice core data.

O258

EARLY PLEISTOCENE CLIMATE AND REGIONAL ENVIRONMENTS IN BAZA BASIN, SOUTHERN SPAIN

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The Early Pleistocene of Baza's intramontane basin (Granada, SE Spain) contains a long and continuous sedimentary record depicting a lacustrine and saline environment that spans from the late Miocene to Middle Pleistocene. Baza basin has provided numerous vertebrate fossil sites, including some of the oldest *Homo* findings of Western Europe in the locality of Orce (1.3-1.4 Ma) in the form of fossil teeth and lithic industry. The present work presents the pollen analysis of the Early Pleistocene lacustrine facies of Baza, sampled by a 107 m long drill core and with ages between 1.6 to 1.1 Ma. Paleoclimatic parameters for temperature and precipitation are obtained by applying the Coexistence Approach method. The biome succession for the Early Pleistocene is reconstructed by assigning Plant Functional Types (PFTs) to each taxa and using the Biomization technique for biome assignment. The resulting pollen profile shows high taxa diversity, typical for that time in the Iberian Peninsula, but dominated by a few pollen groups. The paleoclimatic parameters picture an overall wetter climate when compared with modern values without much difference in temperature. The biome succession is dominated by steppe with temperate or cool forest biomes appearing during the wet stages. It's concluded that the Early Pleistocene environments in SE Spain were heavily controlled by humidity. The dry stages would see the development of steppe with xeric elements while the wet stages allowed for the formation of a *mosaic* landscape with open environments and patches of forested areas. These environments with more humid climatic conditions and access to a variety of plant resources would be favorable for the development of hominin communities.

O259

SIMULATING LAST GLACIAL AND POSTGLACIAL DISTRIBUTIONS OF AFRICAN TROPICAL TREES WITH A DYNAMIC VEGETATION MODEL

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Climate change and human pressure threaten species richness of African tropical forests. Understanding how the past climate changes have shaped the current distribution and composition of African rainforests can certainly help to the ecosystem conservation in the future. This topic is addressed in the framework of the multi-disciplinary AFRIFORD project (Genetic and palaeoecological signatures of African rainforest dynamics: pre-adapted to change?, http://www.ulb.ac.be/facs/sciences/afriford/). In parallel to genetic and palynological analyses, the CARAIB dynamic vegetation model is applied at the level of African tropical plant spe-

cies to simulate change in their distributions from the Last Glacial Maximum (21,000 years BP) to the present in sub-Saharan Africa. We prepared a set of about a hundred species, mostly composed of tropical tree species (evergreen/deciduous, cool/warm taxa) for which we compiled observed occurrence data (e.g.., RAINBIO database), determined climatic requirements and gathered some specific traits (e.g., TRY database).

From LGM to present time, the vegetation model is forced with the 1-kyr snapshot outputs of the HadCM3 climate model. Statistically downscaled at a spatial resolution of 0.5°, we only kept modelled past anomalies that we added to the GSWP3 (20 CR) climate data chosen as the reference for the historical period. Sub-Saharan simulations are performed with CARAIB forced by these climatic projections to simulate the net primary productivity of the species over time and space. We analyse the modelled changes in tropical forest composition and extension as well as in the distribution of individual species whose glacial refugia and postglacial dynamics remain poorly known.

O260

ANGIOSPERM WOOD EVOLUTION REVISITED. CHANGES IN FUNCTIONAL TRAITS THROUGH TIME.

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Bailey & Tupper's classical paper (1918*) on size variation in tracheary cells of vascular plants has given rise to the establishment of the so-called Baileyan trends in xylem evolution, based mainly on correlated character syndromes in basal and derived woody angiosperms. In an earlier study (1991**) we analysed the fossil record of dicotyledonous wood and found general support for these Baileyan trends as well as evidence that ecological factors such as temperature and seasonality has driven parallel and convergent xylem evolution throughout the evolutionary history. Here we present an updated analysis of the fossil record based on the InsideWood database, which now has more robustly dated records, especially from the Cretaceous and early Paleogene of the Northern Hemisphere. It appears that the evolution of hydraulic efficiency from scalariformly perforated vessel elements to simply perforated ones remains strongly supported by the fossil record, and that at tropical paleolatitudes these transformations already resulted in "modern" incidences of simple perforations by the K-Pg boundary. Other Baileyan trends for axial parenchyma distribution and cellular ray composition are also supported. Thanks to vastly increased knowledge of angiosperm phylogeny and our understanding of wood anatomical character states as functional traits, it is apparent that wood anatomical diversity has evolved along Baileyan lines in multiple parallel or convergent transformations, and that reversals, though present, were much less frequent.

*Bailey IW & Tupper WW. 1918. Size variation in tracheary elements. I. Acomparison between the secondary xylems of vascular cryptogams, gymnosperms, and angiosperms. Proc. Amer. Acad. Arts. Sci. 54: 149-204.

**Wheeler EA & Baas P. 1991. A survey of the fossil record for dicotyledonous wood and its significance for evolutionary and ecological wood anatomy. IAWA Bull. N.s. 272-332.

O261

HOW MANY TIMES DID WOOD SPLINTER? CLOSING IN ON THE ORIGINS OF SECONDARY GROWTH IN EUPHYLLOPHYTES

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Secondary vascular tissues produced by a vascular cambium are encountered in the extant flora only in seed plants and isoetalean lycophytes. In contrast, the fossil record shows significantly higher diversity of lineages with secondary vascular tissues. These are recognized primarily by the presence of secondary xylem (with secondary phloem sometimes associated but often difficult to ascertain) and are recorded in several euphyllophyte and lycophyte groups, by the Carboniferous (350 Ma). Looking deeper in the fossil record, within the euphyllophytes, species exhibiting secondary growth can be traced to the Middle-Late Devonian (390-360 Ma) and are placed in well-circumscribed taxonomic groups: cladoxylopsids, sphenophytes, rhacophytaleans, progymnosperms (aneurophytes and archaeopterids), stenokolealeans, and seed plants. Traditional hypotheses on the evolution of secondary growth have assumed independent origins in different lineages, based on the late appearance of the feature, relative to the older age of euphyllophytes (at least as old as the late Lochkovian, ca. 414 Ma). Recently, secondary growth was documented in older, Early Devonian plants, whose age and anatomical simplicity indicate basal positions among euphyllophytes. These plants include *Armoricaphyton* (408 Ma), *Franhueberia* (395 Ma), and a third, unnamed plant (395 Ma). Our ongoing investigations of the same strata in Canada that yielded *Franhueberia*, have revealed up to five other plant types exhibiting secondary xylem. The early age and expected basal position of these new fossils challenge the traditional hypothesis of independent origins of secondary growth and raise the possibility that this developmental feature or, at least, major pathways responsible for its regulation, may have a single origin in an ancestral euphyllophyte lineage. One difficulty derives from the fact that we currently don't know how Early and Middle Devonian euphyllophytes with secondary growth are related. The shared mechanisms of secondary growth regulation

by polar auxin transport demonstrated in sphenophytes, progymnosperms, and seed plants, could be an example of a regulatory pathway that became part of the euphyllophyte developmental toolkit early in the evolution of the clade. Exploring the hypothesis of a single common origin of secondary growth, to shed light on the evolution of euphyllophytes entails (1) understanding the developmental controls of secondary growth and how they affect anatomical features; (2) assembling an anatomical framework to compare secondary growth, from a developmental standpoint, between Early Devonian species, younger Devonian-Carboniferous species, and living plants; and (3) applying the results of such comparisons to resolve the phylogenetic relationships of early euphyllophytes with secondary growth.

O262

CRETACEOUS ANGIOSPERM TREES ARE COMMON IN MID-LOW LATITUDES OF NORTH AMERICA

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Over the past twenty years, work on wood assemblages from New Mexico, Texas, and Mexico has countered the generalization that Late Cretaceous angiosperms were small statured and demonstrates that angiosperm trees dominated some environments by the Campanian. *In situ* stump fields in the Late Campanian Aguja Formation (Texas) and McRae Formation (New Mexico) have angiosperm stumps of >1 m in diameter, which occur in assemblages that exclude conifers and other gymnosperms. The largest, a *Paraphyllanthoxylon* from McRae Formation's "Forest of Giant Angiosperms", has a stem ~2 m in diameter with buttress roots that span 3.7 m. This record Cretaceous angiosperm tree occurs with other angiosperm stumps and logs >0.5 m diameter in an assemblage that comprises ≥3 taxa. Spacing in the Big Bend stump field suggests an open canopy. In addition to *in situ* stumps, logs of >30 cm diameter are common in both these formations. Angiosperm trees also occur in the Albian Edwards Formation (Texas), the Cenomanian Dakota Formation (Arizona), the Turonian Moreno Hill Formation (New Mexico), the lower Campanian Ash Canyon Member of the Crevasse Canyon Formation (New Mexico), and the upper Campanian/lower Maastrichtian Olmos Formation (Mexico) and Kirtland Shale (New Mexico), either as *in situ* stumps or logs. The McRae Formation contains the most diverse assemblage of mature angiosperm woods, with Lauraceae, *Paraphyllanthoxylon*, *Platanus*-like woods and a variety of other eudicots. Shared elements between the Olmos Formation (Mexico), the McRae, Crevasse Canyon, Kirtland Shale, and Moreno Hill formations (New Mexico), and the Aguja and Javelina formations (Texas), attest to floral similarities between different depositional basins of the southern Western Interior, and imply distinct latitudinal differences in flora and vegetation between the south and the north. While the ordinal, familial, and generic affinities of many of these woods has not yet been determined, work to date indicates that by the end of the Cretaceous the tree habit was well established in the eumagnoliids (Lauraceae), basal eudicots (e.g., Platanaceae), rosids (e.g., Malvales, Malpighiales), asterids (e.g., Ericales), and other clades. The hydraulic traits of Olmos Formation woods suggest high theoretical conductivity and low resistance to embolism. Further exploration of lower latitude Cretaceous beds for woods is important for broadening our understanding of the ecology and diversification of angiosperm trees during the Cretaceous and determining latitudinal variation in the rise to dominance of angiosperms.

O263

DECONSTRUCTING SECONDARY GROWTH AS DEVELOPMENTAL POTENTIAL: A PERSPECTIVE ON THE EVO-DEVO OF WOOD

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The number of Early Devonian plants showing evidence of wood (secondary xylem) has increased dramatically in past years – from none pre-2011 to at least seven, currently. Aside from these, secondary xylem is known from a broad array of lineages, including lycophytes and many euphyllophytes (cladoxylopsids, sphenopsids, rhacophytaleans, zygopterids, stenokolealeans, archeopteridalean and aneurophytalean progymnosperms), several of which are present in the Middle and Late Devonian. These early occurrences of wood in multiple groups, along with evidence for regulatory mechanisms of secondary growth shared between lineages as distant phylogenetically as the lycophytes, sphenophytes, and lignophytes, raise questions about how much, or which aspects, of secondary growth present in the various groups reflect homoplasy and how much is due to common ancestry. Such questions fall under the evo-devo umbrella, wherein evolutionary inference derives from comparative assessment of developmental processes (and their regulation) within a phylogenetic framework. However, except for seed plants and isoetalean lycophytes, all known instances of secondary growth are reported exclusively from fossil lineages, in which developmental processes are only recorded as wood anatomy patterns. To integrate these fossils in questions addressing the evolution of secondary growth, we need to bridge the gap between pattern and process, by understanding the processes that produce anatomical patterns. Complex developmental processes tend to be systems of modular component processes. Evidence that secondary growth is a modular system comes from observations of living and extinct plants that show: de-synchronization of cambial divisions (e.g., cambial variants); unifacial

cambia; pressure-controlled radial cell patterning; cambial growth lacking multiplicative divisions; rayless wood and "woodless rays". We deconstruct secondary growth into component modular processes and we assess for each of these processes (1) requirements and constraints (pre-conditions) imposed by anatomical organizations of primary tissues, and (2) known regulatory mechanisms, and (3) we relate them to anatomical patterns (fingerprints) they generate in secondary xylem. The developmental potential of each component process can then be (1) circumscribed for diverse lineages, based on whether pre-conditions are met and on presence of known regulators (or their homologs) in nearest close relatives; and (2) verified by identifying its fingerprints in preserved anatomical patterns. Together, these provide a framework for characterizing secondary growth in each lineage based on parameters that can be subsequently used to integrate all available fossil evidence within an evo-devo perspective, to address questions on the origin and phylogeny of secondary growth.

O264

SECONDARY XYLEM CHARACTER SUITES IN CRETACEOUS WOODS

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The fossil record of wood formation in angiosperms documents secondary growth in some early lineages during the Cretaceous. Cambrial growth is controlled by sets of genes relatively conserved across vascular plant lineages, and cambium activity has been gained and lost in different flowering plant lineages through time. In those plants with wood formation, the character traits seen in secondary xylem are under complex selective pressures involving trade-offs related to function. Furthermore, during the evolution of angiosperms, the activity of the vascular cambium in some lineages increased along with divergence of cell types and was likely related to a combination of eco-evolutionary dynamics in the early history of the group.

In order to assess our current knowledge of wood characters and assemblages in early Cretaceous environments, angiosperm wood from over 100 Cretaceous sites globally was surveyed for specimen features and site data. Data analyses focused on anatomical features with relation to their overall location, co-occurrence, type of environmental setting, and stem diameter, if known. Character traits included perforation type, vessel density and arrangement, vessel diameter, type of pitting, and ray composition, among others. Predictions emphasizing function include increasing complexity of cell types within wood through time, by overall size, latitude, assemblage, and type of setting.

Results from the dataset support an increase in taxa and the co-occurrence of angiosperms obtaining tree stature through time and varies with latitude and along environmental gradients. Trends in character suites within lineages include larger vessels sizes and greater diversity in traits and will be discussed in the context of co-occurrence site data.

Cretaceous wood was not yet as specialized and efficient as compared with Cenozoic woods but may have nevertheless provided some advantage to certain lineages at key times and environments. By focusing on the settings and assemblages that lead to, or supported, more extensive cambrial growth activity in angiosperms, we can better evaluate their role in the radiation of angiosperm populations into different environmental niches.

O266

THE EXTINCT SEED FERN *LEPIDOPTERIS OTTONIS* AS A PROXY FOR PALAEO-*P*CO_2: PROGRESS AND NEW INSIGHTS

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The latest Triassic, leading up to the Triassic/Jurassic boundary (ca. 200 million years ago), is characterised by dramatic climate changes associated with a massive perturbation of the carbon cycle, which culminated in the end-Triassic mass extinction. The associated fluctuations of *p*CO2 concentrations can be reconstructed utilizing the inverse relationship between the stomatal densities of fossil plants and paleo-*p*CO2. A large fossil leaf database of the species *Lepidopteris ottonis* (Goeppert) Schimper from Scania (Skåne) in southern Sweden, housed at the Swedish Museum of Natural History, enables high-resolution estimations of Late Triassic *p*CO2. So far, only one published *p*CO2 record (from Germany (Bonis et al., 2010)) is known using this species, reporting highly elevated *p*CO2 in the latest Triassic. Here we test the methods and results of this previous study with our higher resolution database. Our results confirm *L. ottonis* as a proxy for *p*CO2, and suggest that this species is an ideal proxy taxon for the Triassic because of its wide geographic and long stratigraphic range during this period. However, new caveats in using *L. ottonis* as a *p*CO2 proxy were noted, including that abaxial and adaxial cuticles are sometimes difficult to distinguish, potentially leading to overestimations of palaeo-*p*CO2. In particular since adaxial cuticles are often thicker and thus have a higher preservation potential. In addition, subsidiary cells are difficult to differentiate from epidermal cells on some specimens, introducing another source of potential errors. We suggest a statistical method to distinguish between stomatal densities of abaxial *vs* adaxial cuticles, thus enabling the analysis of leaf fragment databases where the two leaf cuticle surfaces cannot be distinguished using morphological features alone. Finally, a method is suggested to standardize stomatal density databases, regardless of whether subsidiary cells were in- or excluded in the analysis.

O267

VEGETATION DYNAMICS IN THE EEMIAN LAKELAND IN THE GARWOLIN PLAIN (CENTRAL POLAND): A HABITAT APPROACH

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During the cartographic work performed for the needs of the Detailed Geological Map of Poland, Garwolin sheet (scale 1 : 50 000) more than 20 new profiles of biogenic sediments proved to be of the Eemian interglacial age. Thus the Garwolin Plain occurred to be a part of the Eemian fossil great lakeland of Central Poland (Żarski et al. 2005). In terms of the number of the palaeobasins found, the area is unique and a very important within the European Plains. The investigated sites are located in two geomorphological positions: in depressions without outflow and within the valleys of small contemporary watercourses. The thickness of the sediments filling the palaeolakes ranges from 1.5 m to about 12 m, and their diameter differs significantly due to the origin. The preliminary results of palynological investigations revealed an important influence of the habitat conditions in the region on the vegetation composition during the Eemian interglacial. The differences are connected with the permafrost melting and the proximity of the Vistula river valley, which was a wide (a dozen or so kilometers), deeply incised river valley very active during the Eemian interglacial. The proximity of the big river not only affected the climate of the fossil lakeland, but could have had a significant impact on the hydrological conditions in the Eemian lakes. Moreover, the results of palynological analyses proved to be extremely interesting for tracing the expansion of thermophilous trees after ice-melting of the Warta (=Saalian) glaciation (Kupryjanowicz et al. 2017).

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O268

PATTERNS OF MODERN POLLEN AND PLANT DIVERSITY ACROSS NORTHERN EUROPE

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Sedimentary pollen data provides potentially a valuable source of information about past vegetation diversity. However, diversity is seldom considered in palaeo-vegetation studies, mainly because the relationships between plant diversity and sedimentary proxy-based diversity are poorly understood. Present study aims to improve the methods for assessing and interpreting plant diversity from sedimentary pollen. We compare measures reflecting diversity in modern sediment pollen data with equivalent measures in vegetation data and study the associations of pollen and plant diversity with different climatic and landscape variables.

The stuy area covers northern Europe and western Siberia (52-80 ° N; 5-65 ° E). The pollen sample dataset consists of 511 pollen surface samples from small and medium-sized lakes (24 ha on average). Plant data for the lake locations comes from pan-European plant distribution atlas with 50 × 50 km resolution. WorldClim climate data and datasets with global land cover, elevation, clobal forest cover and human population density are used to provide background environmental data for diversity estimates. Linear Mixed Effects models and variation partitioning are used to study the associations between the diversity estimates and environmental variables.

Species richness and pollen richness are significantly positively correlated ($r=0.53$, $p<0.001$). However, the best predictor of total plant richness appears to be the pollen richness of trees and shrubs ($r=0.78$, $p<0.001$). Minimum temperature of the coldest month is the strongest predictor of both pollen and plant richness with more taxa at higher temperatures. The results of variation partitioning analysis indicated that the environment influences pollen diversity indirectly (through the influence on plant diversity) but that the climate and landscape variables have also direct effects on pollen diversity most probably via the influence on pollen production and dispersal. Maximum temperature of the warmest month has a significant interaction with pollen-plant diversity relationship – the association between pollen and plant richness is much weaker in lower maximum temperature values and the pollen-plant richness association can even be negative at the very high latitudes.

Our results strongly suggest that the richness of trees and shrubs is the best pollen diversity estimate for reconstructing the trends in plant richness in large-scale studies using pollen data from different sources and with relatively low sampling effort. The diversity estimates are less reliable at low temperature conditions where the local pollen production is low and long-distance pollen transport is strongly influencing the pollen diversity.

O269

IDENTIFYING PLANT DIVERSITY FROM THE POLLEN RECORD; LIMITATIONS AND CONSIDERATIONS

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We rely primarily on pollen and macrofossil evidence to reconstruct post-glacial vegetation. However, results from surface pollen studies suggest that the diversity of pollen assemblages is rarely a faithful representation of the diversity of the local vegetation (Cleal et al. in prep). Reasons for this discrepancy are examined, including pollen production, dispersal and preservation.

The paper draws on examples of surface pollen deposition from alpine communities in Jotunheimen, Norway and temperate woodland in Snowdonia, Wales to compare the representation of contrasting plant communities. On Storbreen glacier foreland, for example, the diversity of small, insect-pollinated plants growing locally is poorly represented in the pollen assemblage which is dominated by long-distance arboreal pollen. Here the small proportion of grains of indicator taxa provides a more effective means of characterising local vegetation (Pardoe 2001). In contrast, in Welsh woodland the range of plants growing locally is better represented in the pollen assemblage but even in this community, where 90% of pollen has a potential source within 10 metres of the sampling point, several dominant taxa are still under-represented. The effect of sampling medium on the representation of individual taxa is also examined (Pardoe et al. 2010).

This paper considers how the methodology might be improved to increase resolution. For example, producing long records of surface pollen deposition will help better understand temporal variation in deposition and adapting the pollen sum may better reflect local vegetation. Issues surrounding the pollen-vegetation relationship are assessed, together with the resulting implications for the reconstruction of past vegetation, during the Quaternary and on the longer time-scale.

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O270

DEEP TIME, A VISUAL, MUSICAL, ARTISTIC AND SCIENTIFIC EXPERIENCE OF LIFE THIRTY MILLION YEARS AGO.

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This presentation is based on the PhD thesis, *Epistêmê, technê and poiesis: visualisations of evolution and extinction in Queensland Flora* written by Dr AK Milroy.

See back through geological time using incredible scanning technology. This unique animated short film and presentation show the imagery of ancient fossil seeds and fruit, their internal mophologies revealed after being scanned at the Australian Synchrotron. Using high energy radiation, one million times brighter thatn the sun, the synchrotron has allowed researchers to examine the structure and function of 30 million year old fruits and seeds in unprecedented detail and unrivalled accuracy.

These studies allow researchers to determine the relationship of these fossil seeds and fruits to the modern Australian flora and provide insights into the evolution of the rainforests.

O272

RELATIVE POLLEN PRODUCTIVITY ESTIMATES AND QUANTITATIVE POLLEN-BASED RECONSTRUCTION OF PLANT COVER IN TEMPERATE CHINA

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Quantification of the effects of human-induced vegetation-cover change on past (presentand future) climate is still a subject of debate. Our understanding of these effects greatly depends on the availability of empirical reconstructions of past anthropogenic vegetation cover. Until recently quantitative reconstructions of plant cover based on pollen data was a challenge due to the non-linear relationship between pollen percentages and vegetation abundances. The Landscape Reconstruction Algorithm (LRA, Sugita, 2007a and b) is a modelling strategy that corrects biases due to factors involved in pollen dispersal and deposition such as intertaxonomic differences in pollen productivity and pollen dispersal properties and between-site differences in size and type of accumulation basin (lake or bog). The LRA uses in a first step the REVEALS model and pollen records from one to a few large lakes or from multiple small sites (lakes and bogs) to estimate regional vegetation cover. In a second step it uses the LOVE model and pollen records from small sites to estimate local vegetation cover.

Relative pollen productivity (RPP) of plant taxa is a key parameter required for the application of the REVEALS and LOVE models. RPP can be estimated from data sets of surface pollen assemblages (in e.g. moss posters) and related vegetation cover. Some RPPs are available for herbs and trees from earlier studies in steppes and meadows of northern China, and forests of temperate NE China. We complemented those earlier studies by estimating RPPs for herbs and trees characteristic of traditional agricultural landscapes in the low mountain ranges of the Shandong province located in central-eastern China. These RPPs were estimated using a dataset of 36 sites with pollen assemblages from moss pollsters and related vegetation data within 1500m radius of the pollen sample site. The same dataset and a sophisticated scheme of model runs were used to evaluate the RPPs of nine taxa. The results show that the LRA-based estimates of vegetation cover are closer to the actual surveyed vegetation than pollen percentages for all nine taxa, especially for *Artemisia*, Poaceae, *Pinus*, and *Quercus*. All available RPPs in China were then assessed, and selected RPPs were combined into a synthesized RPP data set. The latter was used with pollen records from lakes and bogs in REVEALS-based reconstruction of Holocene regional vegetation cover in temperate China.

References: Sugita S., 2007. The Holocene 17 (2), 229–241; Sugita S., 2007. The Holocene 17 (2), 243–257.

O273

QUANTIFYING PAST ARBOREAL COVER BASED ON MODERN AND FOSSIL POLLEN DATA: A STATISTICAL APPROACH

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Reconstructing and quantifying past vegetation changes is needed to fully understand long-term influence of anthropogenic land cover changes on the global climate, ecosystems and geomorphic processes. Nevertheless, quantifying past human impact is not straightforward. Recently, multivariate statistical analyses of fossil pollen records are applied to reconstruct vegetation changes and to get insights in past human impact. However, these methods cannot be used as an absolute quantification of past human impact. To overcome this shortcoming, in this study fossil pollen records were included in a multivariate statistical analysis (cluster analysis and non-metric multidimensional scaling (NMDS)) together with modern pollen data and modern vegetation data. The information on the modern pollen and modern vegetation dataset can be used to get a better interpretation of the representativeness of the fossil pollen records. Moreover, the integrated approach results in a full quantification of past vegetation changes including error estimates. This methodology was applied in two contrasting environments: SW Turkey and Central Spain. For each region, fossil pollen data from different study sites were integrated, together with an extensive modern pollen dataset and information on modern vegetation. In this way, arboreal cover, grazing pressure and agricultural activities in the past were reconstructed and quantified. The data from SW Turkey provides new integrated information on changing human impact through time in the Sagalassos territory, and shows that human impact was most intense during the Hellenistic and Roman Period (ca. 2200-1750 cal a BP) and decreased and changed in nature afterwards. The data from Central Spain shows that the evolution of the arboreal cover through time differs along an altitudinal gradient, with a decrease in arboreal cover during the Roman and Visigoth periods (2000 – 1240 cal BP) at low altitudes and only during the Christian/Feudal period (850 – 500 cal BP) at high altitudes. Overall, the presented examples from two contrasting environments shows how cluster analysis and NMDS of modern and fossil pollen data can provide quantitative insights in anthropogenic land cover changes. Our study extensively discusses and illustrates the possibilities and limitations of statistical analysis of pollen data to quantify human induced land use changes.

O274

POLLEN-BASED RECONSTRUCTION OF LANDSCAPE OPENNESS IN MOUNTAIN REGIONS: EVALUATION OF THE LANDSCAPE RECONSTRUCTION ALGORITHM AT THE VICDESSOS VALLEY, FRENCH PYRÉNÉES

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Land use and climate are the major drivers of European vegetation change during the Holocene. Over the last decade, objective regional estimates of forested and non-forested areas have become feasible by using pollen records and the REVEALS model. At the local/landscape scale, however, the use of the Landscape Reconstruction Algorithm (LRA=REVEALS + LOVE models) is still a challenge particularly in mountainous regions. This study evaluates the extent to which LRA is effective to quantify the landscape-scale vegetation cover in the French Pyrénées.

Pollen records from 8 small sites in the Vicdessos valley and adjacent mountain tops were used in this study; lakes and peatlands, being all located above the current tree line. In a first stage, the regional vegetation within 50-100 km around the Vicdessos valley was estimated using i) CORINE vegetation data and ii) pollen records and the REVEALS model. These regional estimates of vegetation are fed into the second step of the LRA, i.e. the LOVE model to reconstruct the local vegetation cover around each site. The effect of two different dispersal-models - the Lagrangian Stochastic Model (LSM) and Gaussian Plume Model (GPM) - on the LRA results was evaluated. For evaluation of the LRA results, we used the regional and local percentage cover of coniferous trees, broadleaved trees and non-forested areas extracted from available land-cover maps for three time windows (i.e. 1960-1970, 1990-2000 and 2000-2013).

Major findings include: (1) The LRA results in a 2-km radius are closer to the local observed vegetation cover when the regional estimates of vegetation used as inputs for the LOVE model are based on the CORINE data rather than the REVEALS model. Accordingly, the systematic selection of sites above the tree line may affect the accuracy of the LRA results at both regional and local scales. (2) Differences in dispersal models do not affect significantly the LRA-based estimates at both regional and local scales; however, error estimates tend to be larger with the LSM option than with the GPM. (3) The LRA approach significantly improves pollen-based local vegetation reconstruction compared to pollen percentages alone. Although further empirical and simulation studies are necessary, our results emphasize the importance of site selection for the LRA-based reconstruction of vegetation in mountainous regions.

This study is part of the ANR research projects TRAM and MODE RESPYR, the PEPS CNRS POPEYE, the LAbex DRIIHM OHM Pyrénées Haut VIcdessos and the PAGES LANDCOVER6K working group.

O275

POLLEN-BASED RECONSTRUCTION OF PLANT COVER IN EUROPE FOR STUDIES OF LAND-USE CHANGE AS AN ANTHROPOGENIC CLIMATE FORCING IN THE PAST: LANDCLIM II

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There is a need for in-depth knowledge on climate forcings from anthropogenic land-cover/vegetation changes if land-use policies are to be successful in mitigating climate change. Afforestation is largely promoted today as a way to mitigate climate warming, relying on the assumption that the biogeochemical forcing of an increase in tree cover will override its biogeophysical forcing and imply a carbon sink. However, many climate modelling studies using global climate models have shown that the biogeophysical forcing may offset or override climate gains from the increased carbon sequestration in forests. Nonetheless, many of the socio-economic factors and assumptions controlling future land-use policies take indirect biogeochemical processes into consideration while neglecting direct biogeophysical processes. The main purpose of the LandClim II project is to quantify the effects of the biogeophysical forcings induced by human-induced deforestation (i.e. the "land-use" forcing, see IPCC5) on the regional climate of Europe at 2500

and 1000 calendar years before present (henceforth abbreviated 2.5k and 1k BP), two periods of major anthropogenic land-cover change. The magnitude and sign, and the seasonal and geographical differences, in the effects will be estimated. To put these forcings into context, we will also quantify the contributions of European deforestation to (global) biogeochemical forcing, i.e. the net land-atmosphere CO_2 exchange translated into radiative units, W/m^2. The emphasis will be on the biogeophysical forcings, as these have an effect on climate mainly at the regional scale. Biogeochemical forcing (primarily changes in the land-atmosphere carbon balance) caused by land-use change, although induced locally, imposes a low, globally averaged, shift in radiative forcing over the whole globe due to rapid dilution of carbon in the atmosphere.

In an earlier project, LandClim I, the effects of anthropogenic land-cover change in Europe between 6k and 0.2 k on biogeophysical forcings were studied using a regional climate model. In that project, the first generation of pollen-based REVEALS reconstructions of vegetation cover for the purpose of climate modelling were achieved for five time windows of the Holocene over most of Europe (excluding the Mediterranean area and the easternmost regions). In this presentation we will i) briefly present the results of LandClim I project, ii) explain the research strategy of LandClim II, and iii) present the second generation of pollen-based REVEALS reconstructions of vegetation cover over the whole of Europe and the entire Holocene produced for the purpose of LandClim II. These reconstructions are a contribution to PAGES LandCover6k.

O276

POLLEN PRODUCTIVITY ESTIMATES FOR THE RECONSTRUCTION OF LAND-COVER CHANGES IN THE FOREST-STEPPE ZONE FROM SE ROMANIA (SE EUROPE)

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The lowlands in south-eastern Romania are located at the convergence of several ecoregions (continental, steppic and maritime) and represent one of the oldest areas of human impacts on the environment and vegetation in Europe. Due to its dry character, this region is already confronted with prolonged droughts and water shortage for plant growth. This trend is predicted to become accentuated in the future under increased anthropogenic pressure on the natural landscape. However, little is known about the past vegetation dynamics of this landscape and when significant shifts of the forest cover occurred due to human impact, although several archaeozoological studies from the area have suggested larger areas of forested habitats up until the first half of the 2nd millennium AD.

Thus, an accurate and comprehensive quantification of past human-environment interaction is necessary to fully grasp the extent to which humans have impacted land-cover through deforestation and biomass burning and to explore the feedback mechanisms on the climate and between environmental change and societal development.

Pollen productivity estimates (PPE) are key parameters for the quantitative estimation of past vegetation cover. In this study, we use modern pollen assemblages and present vegetation data from 26 sites in order to estimate relative pollen productivity of 12 major tree and herb taxa characterizing the forest steppe landscape around Lake Oltina (SE Romania). We will apply the obtained estimates to the fossil pollen record to quantitatively reconstruct the late Holocene (last 6000 years) vegetation cover and to explore the magnitude of landscape alteration across cultural phases and land-use changes.

O277

ELEMENTAL AND PALYNOLOGICAL ANALYSIS OF HONEY FROM AZAD JAMMU AND KASHMIR PAKISTAN

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Mellisopalynological, heavy metal and macronutrient studies of wild and farm honey was carried out. Fifty six pollen type from thirty three families was extracted from total nineteen honey samples. Asteraceae was the common family with highest occurrence frequency along with Rosaceae, Lamiaceae, Poaceae and Malvaceae families. Pollen richness varied from 360 -10160 grains per 10g of honey. Elemental analysis indicate Potassium (K)as the most abundant macro-nutrient. Lead (Pb) being the most abundant among other heavy metals. Macro-nutrient concentration trend in mg/kg K > Ca> Na > Mg while the trend followed by heavy metals was Pb > Cr > Ni >Cd> As> Hg.

Present studies proved helpful in declaring authentication of domesticated produced origin of honey to meet the international standards and beeflora of the selected region. It is concluded that macronutrient and heavy metals participate little in the composition of honey but their role in determining honey quality can't be ignored.

O278

THE FOSSIL ATMOSPHERES EXPERIMENT: IMPROVING ESTIMATES OF DEEP-TIME ATMOSPHERIC CO_2 CONCENTRATIONS FROM *GINKGO* LEAVES

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During the Late Cretaceous and Paleogene, Earth's climate was much warmer than today. The background warmth is often attributed to increased atmospheric CO_2 concentration (pCO_2), yet paleo-pCO_2 proxy estimates for these intervals disagree widely. Consequently, we have an inadequate understanding of what generated past warm climates. Herbarium collections of *Ginkgo biloba* demonstrate that the stomatal index proxy for paleo-pCO_2 is strongly correlated with pCO_2 over the range of 290-400 ppm. However, despite wide application of the *Ginkgo* paleo-pCO_2 barometer, our understanding of pCO_2 in the fossil record has been hindered because the morphological and physiological changes in *G. biloba* stomata under pCO_2 above 400 ppm have been poorly constrained.

To address this problem, we are conducting an elevated CO_2 experiment to quantify the effect of elevated pCO_2 and other environmental variables on stomatal properties of living and historic *G. biloba* trees, an experiment we call 'Fossil Atmospheres'. We are growing 15 *G. biloba* trees in open-topped chambers under natural field conditions. Three outdoor controls grow under ambient (400 ppm), and 12 trees grow in chambers under atmospheres of 400, 600, 800, and 1,000 ppm of CO_2. Each tree is regularly monitored for changes in stomatal frequency and rates of photosynthesis and transpiration to constrain parameters used in gas exchange models of paleo-pCO_2. This approach allows the tree to function normally . They are growing under the natural daily and seasonal fluctuations of the environment, providing a more appropriate comparison to the fossil material. The experiment commenced in August of 2016. The 2018 leaf flush represents the first crop from plants that grew under a full year of elevated pCO_2 conditions. We will be able to compare leaves from pre-experimental conditions (2015-2016) with the leaves produced under elevated conditions (2017-2018). We expect the plant response to elevated pCO_2 to be fully manifest after 3-5 growing seasons.

To collect the stomatal index measurements, we have enlisted citizen scientists using the online Zooniverse platform, utilizing the interaction to educate citizens about modern climate change from the less-menacing viewpoint of deep-time climate change events. Preliminary results suggest that the aggregate answer from images repeatedly counted by citizens produces a similar result to 'expert' counts. Our results can then be used to infer paleo-pCO_2 from stomatal features of Late Cretaceous-Paleogene fossils of *G. adiantoides,* allowing for paleo-pCO_2 estimates from these terrestrial record to be compared with the pCO_2 and temperature estimates from the marine realm.

O279

ASSESSING *GINKGO* LEAF TRAITS AS A CLIMATE PROXY FOR THE FOSSIL RECORD

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Ginkgo biloba has a long evolutionary history, with leaves of a strikingly similar morphology to those of the modern plant found in sediments over 100 million years old and well-preserved representatives of the family identified in the Early Triassic. This makes the sole survivor of this once diverse clade of significant interest to palaeobotany and palaeoecology. *G. biloba* is known for its fan-shaped leaves and noted for the variety of shapes that these leave can produce. A survey of *G. biloba* trees growing in 15 cities in Great Britain and Ireland was conducted to sample leaf shape and leaf trait variation along a relatively mild climate gradient. Twenty leaves were collected from each tree and between one and three trees were sampled at each location, with one to three locations per city. Analysis of these leaves has shown a strong leaf shape variation with temperature – leaves growing in the warmer, southern locations (e.g. Exeter, London) had significantly ($p < 0.5$) rounder and larger leaves than those growing in more northern locations (e.g. Aberdeen). An addtional 12 cities spanning North America, Europe, Asia, and Africa were samples to test the relationship identified in UK and Irish leaves. A tempeture controlled experiment was also conducted on *Ginkgo* plants to determine if the leaf shape change and other trait variation could be clearly linked to temperature variation. The obseved leaf morphology changes were also applied to a collection of ~40 Gingkoites fossils from the Mesozoic and Cenozoic to determine if leaf shape related to known palaeoclimate data. Overall, the analysis suggests that leaf shape in *G. biloba* is correlated to mean annual temperature and may provide a useful palaeo-temperature proxy.

O280

REVISITING EARLY PERMIAN CO_2 VIA IMPROVED INPUT PARAMETERS AND MODELS.

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The late Paleozoic Ice Age (LPIA; 340–290 Ma) archives repeated major climate changes within an icehouse and is the only record of a permanent turnover from icehouse to fully greenhouse conditions since the evolution of metazoans and vascular plants. In addition, the LPIA has long been compared to the Pleistocene glacial state given that both were characterized by very low atmospheric pCO_2, eccentricity-scale glacial-interglacial cycles, and extensive, long-lived continental ice sheets. Existing mid-Pennsylvanian to earliest Permian paleo-atmospheric CO_2 estimates, based on paleosol carbonates and fossil plant proxy methods, show a linkage between shifts in pCO_2, ice volume, and climate that are indicative of greenhouse gas-forcing. Here, focusing on the demise of the LPIA, we reevaluate published latest Pennsylvanian through middle Permian CO_2 estimates (Montañez et al. 2007) by applying paleosol carbonate data and an improved organic matter data set to the PBUQ model (Breecker, 2013), which fully propagates the uncertainty associated with all input parameters. The updated CO_2 estimates are directly compared to plant-based early Permian CO_2 values obtained using a mechanistic CO_2 model and fossil cuticles collected from some of the same stratigraphic successions as the pedogenic carbonates. Reformulated early Permian CO_2 results indicate absolute pCO_2 estimates less than half those previously published (Montañez et al. 2007) and delineate a stepped CO_2 rise from a Late Pennsylvanian-earliest Permian nadir to a mid-Permian maximum of ~1400 ppm. In addition, there is good agreement between latest Pennsylvanian through middle Permian paleosol-based and stomata-based mechanistic CO_2 estimates. Furthermore, we integrate the pCO_2 estimates from this study with a recently published eccentricity-scale pCO_2 reconstruction for the mid- to late Pennsylvanian (Montañez et al. 2016) in order to build a consensus CO_2 curve through ~30 Myr of the LPIA and its turnover to a permanent greenhouse state. The consensus pCO_2 curve is compared to independently constrained records of the timing of glaciation/deglaciation and evidence of volcanism. The improved data set further confirms a robust linkage between shifts in pCO_2, ice volume, and climate, with implications for our current glacial state.

O281

SINGLE SPECIES OR PLANT ASSEMBLAGE APPROACH? A COMPARISON OF PLANT-BASED PALEOATMOSPHERIC CO_2 PROXIES

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Reconstructing Phanerozoic paleoclimate is dependent upon well-developed proxy methods and in recent years new plant-based models that can estimate paleoatmospheric CO_2 have emerged. One of these is an empirical model, termed the C3 plant proxy, developed from the hyperbolic relationship observed between plant carbon isotope discrimination (angiosperm species *R. sativus* and *A. thaliana*) and pCO_2. Another model of interest is a mechanistic model based on established equations for leaf gas exchange and photosynthesis that utilises stomatal anatomy measurements and plant carbon isotope composition. Despite the potential benefits of using these models for deep time paleo-pCO_2 reconstruction there has been relatively little testing on their robustness and accuracy to predict pCO_2. This presentation will compare these two models using 10 plant species representing the four major vascular plant groups (lycophytes, monilophytes, gymnosperms and angiosperms) grown in environmentally-controlled plant growth chambers. Examining model performance for all vascular plant groups is important considering the emergence and turnover of dominant plant groups throughout the Phanerozoic. Plants were also exposed to a range of O_2:CO_2 ratios to simultaneously address two main questions: 1) are the models phylogenetically independent regardless of CO_2 concentration, and 2) does atmospheric O_2 concentration, which has fluctuated with CO_2 in the geological past, influence model CO_2 estimates? The answer to these questions determines whether a plant assemblage or a single species approach is appropriate for these models.

O282

LEAF EVAPOTRANSPIRATION AND PALEOPHYSIOLOGY OF EARLY EOCENE NEOTROPICAL RAINFORESTS

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The Paleocene-Eocene boundary and the early Eocene recorded the warmest temperatures of the last 60 million years. Global estimates of sea surface temperatures and many climate models have suggested a collapse of the Neotropical forests under high tropical temperatures during the early Eocene, however, the pollen record available indicates that tropical rainforests were able to persist under the increasing temperatures. Here, we test whether increased leaf evapotranspiration and consequent thermal cooling may have provided a mechanism for tropical plants to cope with increasing temperatures and avoid thermal damage to the photosynthetic machinery. We compare leaf anatomical and geochemical data from tropical plants grown under high CO_2 – high temperatures at the Smithsonian Tropical Dome Project to determine whether changes in leaf evapotranspiration can be potentially observed in fossilized leaves. Results from these experiments are then compared with late Paleocene (Cerrejón Fm., 58-60 Ma) and recently discovered early Eocene (Bogotá Fm.) leaf cuticles from Colombia, as a means to assess relative changes in leaf evapotranspiration in Neotropical rainforests during the global warming events of the early Eocene.

O283

IMPROVING THE USE OF MOLECULAR FOSSILS TO IDENTIFY FLORISTIC COMPONENTS IN PALEOENVIRONMENTS

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There is growing use of biogeochemical markers to understand floristics components of paleofloras. Unfortunately, there are gaps in understanding the similarity of molecules from living systems and fossil biomarkers after diagenesis. Collaborative work, including the use of hydrous pyrolysis to artificially mature specimens, provides some preliminary results that will aid our reconstruction of paleoenvironments. First, the triterpenoid des-A-oleanane may be a better biomarker for angiosperms than oleanane. Second, high concentrations of the diterpenes fichtelite and beyerane correlated well with mega- and micro-fossil concentrations of conifers. Third, fernane is not a reliable biomarker for ferns and no universal fern biomarker is known. Fourth, the concentration of terpenoid compounds from living herbaceous plants vary, as do the concentrations in different organs, but not in a consistent way. Fifth, there may be consistent difference between concentrations of alkanes and bulk triterpenoids in herbs and woody plants. Finally, caution is need when comparing frequencies of conifers and angiosperms as it appears that at higher temperatures, triterpenoids (angiosperm biomarkers) appear to preferentially disappear compared to diterpenes (conifer biomarkers). Molecular fossils have the potential to increase our understanding of angiosperm evolution and paleoecology.

O288

THE INBETWEEN: LANDSCAPE IMAGE AND LANDSCAPE OBJECTS

Rachel Lillie

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There is a space that lies between walking and making, between observing and drawing, between lived experience and reflected experience, between being witness and being interpreter, and between landscape image and landscape object. Process, content, form, symbolism and materiality are all at play here.

This presentation considers Illustration as an explorative and poetic practice and seeks to engage the audience to meditate on these spaces within and beyond the boundaries of illustration, reaching to archaeology, engineering, conservation and craftsmanship.

Through a series of case studies and examples of ongoing creative field work methodologies, I ruminate on my expanded approach to Illustration practice and consider my role as researcher and storyteller. Throughout I will highlight the unique role of the craft object and the illustrated image in documenting place, revealing the unseen and engaging with audiences.

The first (Case study 1) seeks to explore to the history of Epping Forest, Essex, using drawing to interpret the seen (present) and the object to reveal the unseen (past). Experience of landscape through walking provides content here. The work explores narratives that are recorded in the land, shaped by man, but often overlooked. Pictorial representations of significant locations are exhibited alongside cod-historical wooden artefacts, hand carved from fallen wood in Epping Forest. Collectively it invites the audience to explore the space between the past and the present, knowing and unknowing and between image and artefact.

The second (Case study 2) considers the narrative of Wallasea Is-

land, on the coast of Essex, currently in the process a landmark conservation and engineering project. Here 4.5 Million tonnes of earth removed from London's Crossrail has been relocated to recreate ancient wetlands and mud flats, to help combat the threats of climate change and coastal flooding. My role as illustrator looks towards understanding a past and communicating the future of a place very much in transition and whose history is displaced and reformed. I will discuss my experiences at the site, the potential for drawing to record the progress of a changing landscape, and for the object to intervene and inhabit the landscape to create spontaneous encounters and experience for the audience.

Rachel Lillie MA *(Royal College of Art),* Senior Lecturer *(Kingston University)*

O289

BURNT AREA EXPLORING THE EFFECTS AND ECOLOGY OF FIRE THROUGH ART-SCIENCE FUSION

Charlotte McDonald, Claire M. Belcher

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Over the last 4 years we have sought to explore the relationship between the ecology of fire over landscapes and time. Burnt Area has been funded through the European Union and relates to a grant entitled "ECOFLAM – The impact of plant evolution on fire behaviour". Throughout this period both our disciplines have acted as a catalyst to bring out new and uncharted explorations, where having the opportunity to use the research from the wildFIRE Lab at the University of Exeter has opened up untapped avenues from an artistic side. Using data, figures, tangible materials, imagery, and video footage of fires has acted as a vehicle to aid the creative artwork practice. Enabling a new way of working that has allowed a deeper connection with landscape, the environment and evolutionary time to emerge in Burnt Area. This presentation will outline the new avenues that have appeared by working closely with scientists via their data and novel material collections. Exposure to tangible materials from scientific studies in the field such as soil, ash, leaves, charcoals and fossil charcoals has broken down creative restrictions allowing new expression to be formed by working in 2D through to 3D and with a variety of creative materials. Here we aim to highlight that art and science are disciplines that work well hand in hand. The artistic approach has likewise returned a whole new view of scientific approach that feeds back into scientific practice. We hope that this pairing allows us to create a new message to the viewer with Burnt Area enabling the influences of wildfire events to cross-cut societal and disciplinary bounds.

O290

A NEW CLUE FOR THE ORIGIN OF CONIFERS FROM THE BEEMAN FORMATION (KASIMOVIAN, NEW MEXICO)

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A new fossil plant assemblage from south-central New Mexico contains peculiar plant remains consisting of foliated branches that have a morphology characteristic of walchian-type conifers but bear ovuliferous compound strobili like those known from Cordaitales (cf. *Cordaianthus*). The morphology of these remains may seem to affirm the long-standing hypothesis that conifers originated from within the Cordaitales, which would entail a major change in shoot structure. These new remains strongly suggest that such shoot structure shifts occurred, in either one direction or the other. The fossil flora is preserved in the Beeman Formation, exposed in the Sacramento Mountains. This formation is an approximately 200 m thick unit of terrigenous clastics and marine carbonates. Fusulinid and conodont biostratigraphy indicates that it is of Missourian-Virgilian (Late Pennsylvanian) age. The gymnosperm-rich flora discussed here is from the lower part of the formation, and thus of early/middle Missourian (i.e. early Kasimovian) age. This flora is of the "mixed" type, consisting of both typical Missourian-age wetland elements, principally pteridosperms and ferns, and xeromorphic taxa often associated with climatic indicators of seasonal drought, such as conifers. These plants are intimately associated, indicating that they grew in close proximity, suggesting local landscape heterogeneity. The Missourian (Kasimovian) was the time of onset of more seasonally dry conditions across much of Euramerican Pangaea, thus improving the chances that long-existing, more drought-tolerant taxa entered areas of higher preservation potential. Since the new finds are younger than the oldest described conifers, the question arises whether they represent descendants of an early-diverging cordaitalean lineage that gave rise to a single conifer clade; evidence of multiple changes to a conifer-like shoot structure that occurred within the Cordaitales, but did not lead to any of the known conifer lineages; or a persisting line from a common ancestor of Cordaitales and conifers that had conifer-like vegetative morphology, indicating that cordaitalean shoot organization is derived.

O291

A WHOLE PLANT SPECIES *PARATINGIA* SP. NOV. AND ITS IMPLICATION ON THE SYSTEMATICS OF NOEGGERATHIALES

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Noeggerathiales are an enigmatic group of spore plants that flourished during the late Palaeozoic. The systematic position of this group remains uncertain, mainly because of unknown whole plant morphology and anatomic feature. Groups proposed as close relatives include leptosporangiate ferns, sphenopsids, progymnosperms, or the extant eusporangiate fern *Tmesipteris*. Previously identified noeggerathialeans lacked anatomical preservation, limiting taxonomic comparisons to their external morphology and spore structure. We here present from the Permian of China newly discovered, a whole plant new species of *Paratingia* Zhang for the first time reveals the morphology and anatomy and unambiguously resolves the group's controversial systematic affinity. It is a small tree producing an apical crown of pinnate, compound leaves and pseudo-strobili that are homologues; It combines features of hetersporous pteridophytic reproduction with production of 'gymnospermous' secondary wood; It appears to represent a stratigraphically young member of a clade that previously played an important role in the origin of seed plants but continued to have a high diversity as seed plants underwent their Palaeozoic primary radiation. Our new preliminary cladistic analysis reveals Noeggerathiales comprise a clade of advanced eusporangiate ferns that, together with the Carboniferous progymnosperm *Protopitys*, are immediate sister to seed plants, and it is therefore recommended future studies concentrating on the origin of seed plants should focus on *Protopitys* with define structure apart from archaeopteridalean or aneurophytalean progymnosperms.

O292

NEW INSIGHTS INTO A PECULIAR MIXED FLORA FROM THE UPPER PERMIAN OF JORDAN

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The Late Permian Umm Irna Formation is an up to 85-m-thick succession of continental deposits exposed along the shore of the Dead Sea, Jordan. It has yielded spectacularly well-preserved plant compression fossils with cuticles that seem to have undergone hardly any alteration. Most recent studies so far focused either on palynology and biostratigraphy (Abu-Hamad, 2004; Stephenson & Powell, 2013; Powell, et al., 2016; Bandel & Abu-Hamad, 2013) or on the unusual occurrence of the typical Triassic seed-fern foliage *Dicroidium* (Kerp et al. 2006; Abu-Hamad et al., 2008; Abu-Hamad et al., 2017) in this formation. During recent fieldwork in 2017 and 2018, however, rich and diverse assemblages of additional plant taxa have been recovered, including typical Cathaysian floral elements (e.g. *Lobatannularia*, Gigantopterids and putative ginkgophytes such as *Rhipidopsis*), possibly Gondwanan taxa (e.g., glossopterid leaves), and more cosmopolitan taxa (e.g., *Saportaea*, Noeggerathiales, and various conifer remains). Our finds demonstrate that these peculiar mixed floras of the palaeo-tropics are much more diverse than previously thought. We are confident that continuing work on these remarkable floral assemblages will yield deeper insights into Late Permian vegetation communities and their palaeogeographic significance.

O293

THE DIVERSITY OF LAND PLANTS ACROSS THE PERMIAN–TRIASSIC BOUNDARY: COMPARING MACRO- AND MICROFOSSIL RECORDS

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The Lopingian (upper Permian) to Lower Triassic interval is marked globally by important changes in faunas and floras, including the famous Permian–Triassic extinction and subsequent recovery. In Lopingian successions, macrofossils of land plants are common, contrasted by comparatively rare and mostly impoverished floras dominated by pleuromeiacean lycopsids in Lower Triassic sediments. Despite the reduced abundance of preserved macrofossils, there is no shortage of spores and pollen grains from

the latter interval suggesting that there might be a considerable taphonomic bias for the macroremains during this period. In order to gain a more coherent picture of land plant macroevolution, global sporomorph and plant macrofossil occurrence records from the Lopingian to the Middle Triassic have been compiled into a comprehensive digital database, which was then used to calculate taxonomic diversity (or richness), extinction and origination patterns of land plants. The taxonomic diversity of land plant macrofossil species exhibits a drastic decline through the Lopingian, culminating in the apparent loss of more than half of the species across the PTB and followed by a prolonged recovery phase starting in the Olenekian. This is essentially the expected pattern that has been observed in previous studies. However, on the level of genera, the Changhsingian appears as a time of net diversity increase, rather than a time of catastrophe. On the level of families, the observed trends depend heavily on the way in which taxa are partitioned into families, which is not incontestable. Compared to the Lopingian, macrofossils from the Early Triassic are also 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. While macro- and microfossil diversities differ, and while both have limitations, they do both individually and in their sum provide arguments against a mass extinction in plants as previously conceived. Our analysis does not negate the clearly dramatic ecological disturbances in floras during the studied interval, which however do not translate to a proper mass extinction, and in large parts are not coeval with the mass extinction in animals, but succeeding it.

O294

THE PERMIAN TRIASSIC BOUNDARY FROM KAP STOSCH, EAST GREENLAND

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The Permian-Triassic boundary is marked by a major faunal turnover in numerous successions. In the microfloral record, however, the boundary seems to be indistinct with respect to extinctions and originations of taxa at least in some records, such as the Kap Stosch record in East Greenland. There, in a succession marked by high sedimentation rates, range charts seem to be insufficient to delineate the Permian-Triassic boundary. However, relative abundance data of taxa and plant groups show distinct changes. These changes reflect the ecological aspect carried in palynological datasets. Thus environmental changes can be drivers for extinctions and originations but they also influence the relative abundances of individual taxa or plant groups in spore-pollen assemblages. The carbon isotope curve from Kap Stosch is marked by very distinct changes. The major changes are high-amplitude perturbations, which are also documented in other regions illustrating profound changes in global carbon cycling and thus environmental changes. In Greenland changes in spore-pollen assemblage composition often coincide with changes in the carbon isotope record. Additionally oxygen isotope data of conodont apatite from comparable latitudes on the southern hemisphere indicate sea surface temperature changes during the Early Triassic. The resilience of some taxa might have been overstressed by the environmental upheaval indicated by proxy data and they disappeared gradually during the earliest Triassic (e.g. *Vittatina* spp.)

O295

PALYNOLOGY OF THE PERMIAN–TRIASSIC BOUNDARY IN THE NORWEGIAN ARCTIC: PALAEOCLIMATIC AND PALAEOECOLOGICAL IMPLICATIONS

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The Permian–Triassic (P–T) mass extinction event is widely recognised as the most severe biotic crisis witnessed during the Phanerozoic. However, the impact of the event on terrestrial floras is debatable; the plant macrofossil record indicates major losses of taxa, while palynological studies suggest a more gradual floral transition. To contribute to this discussion, we present the results of an interdisciplinary study of a recently drilled core from the southern Barents Sea, Arctic Norway. The core spans the boundary between the spiculitic packstones of the Upper Permian Røye Formation and the mud-dominated deposits of Lower Triassic Havert Formation, and provides a rare opportunity to study the P–T boundary in the area.

Fifty-two samples were collected over a 10 m interval across the boundary, and were analysed for bulk C-isotopes, palynology and palynofacies. The core records an abrupt negative excursion in $\delta^{13}C_{org}$ values of 6‰ through basal the Havert Formation. This corresponds with a transition to pyritic laminated mudrocks and an AOM dominated palynofacies, which are consistent with records of marine anoxia at the boundary interval elsewhere. Following the convention of previous workers, and in the absence of independent biostratigraphic age control, we tentatively place the P–T boundary at this first isotopic minimum. This negative shift persists over a further 2 m before rebounding and stabilising at values of approximately -28.5‰ for the remainder of the core.

Palynological assemblages from below the P–T boundary are characterised by a dominance of taeniate bisaccate pollen, including *Lunatisporites* and *Protohaploxypinus*. However, above the boundary there is slight influx in monosulcate pollen, such as *Cycadopites follicularis*, and polyplicate pollen of the *Ephedripites* group. Following the stabilisation of the $\delta^{13}C_{org}$ values, there is a steady increase in diversity, with the gradual increased abundance of cavate lycopsid spores, including *Densoisporites*, *Lundbladispora* and occasional specimens of *Aratrisporites*. Our preliminary results indicate gradual change in floral composition across the P–T Boundary, and are comparable to the recently published data from East Greenland (Schneebeli-Hermann et al. 2017). Intriguingly, the

boundary 'spore spike' was not observed despite the high sampling density; however, lycopsid spore tetrads and fungal palynomorphs, both features of P–T boundary assemblages elsewhere, were recorded in relatively low abundance throughout the studied interval.

Schneebeli-Hermann E, Hochuli PA, Bucher H. 2017. Palynofloral associations before and after the Permian–Triassic mass extinction, Kap Stosch, East Greenland. Global and Planetary Change 155, 178-195.

O296

LEAVES AND INFLORESCENCES OF ARACEAE AND OTHER MONOCOTS IN THE LATEST ALBIAN (MID-CRETACEOUS) OF SPAIN: IMPLICATIONS FOR EARLY MONOCOT EVOLUTION

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Molecular phylogenetic analyses imply that monocots began to diversify early in the angiosperm radiation, but they are less common than other major clades in the Early Cretaceous fossil record. The best-established Early Cretaceous monocot group is Araceae, in the near-basal order Alismatales, known from leaves, inflorescences, and pollen from the Aptian and Albian of Brazil and Portugal. Here we report an unusually well-preserved araceous leaf, diverse monocot leaves with parallel venation, and araceous inflorescences from two localities in the Boundary Marls Unit (latest Albian) of Teruel Province, Spain. The araceous leaf shows an unthickened multistranded midrib, several orders of low-angle primary lateral veins, two orders of transverse veins, and variable paracytic-oblique stomata. This suite of characters (but with anomocytic as well as paracytic stomata) is diagnostic today for Orontium in the near-basal subfamily Orontioideae, and similar leaf architecture is seen in later Cretaceous and Cenozoic leaves assigned to Orontium and Orontiophyllum. However, our phylogenetic analyses, using a morphological data set and molecular tree of Cusimano et al., indicate that this character combination may be ancestral for Araceae, and the fossil could be either sister to Orontium, sister to Araceae as a whole, or nested at other points in a basal grade of the family, below the True Araceae clade. Nine other leaf types from the same locality have diverse patterns of parallel venation but similar paracytic-oblique stomata, as do linear leaves reported from the Cenomanian of Portugal, consistent with the hypothesis that such stomata are ancestral in monocots. The inflorescences, from the second locality, are spadices of closely packed, sessile flowers with four tepals, the predominant condition in perigoniate Araceae, and a long basal stipe, in contrast to True Araceae, in which the spathe is attached just below the fertile portion of the spadix. Similar inflorescences occur today in Gymnostachys and Orontioideae. Phylogenetic analyses confirm that the inflorescences are related to Araceae, either sister to the family or nested in the same basal grade as the leaf from the first locality. The lacustrine sedimentary environment of the Boundary Marls is consistent with phylogenetic inferences that both Araceae and monocots as a whole were originally aquatic (helophytic). Our results reaffirm that Araceae were one of the first recognizable monocot lines in the Cretaceous, alongside unexpectedly diverse monocots of uncertain affinities.

O297

MESOZOIC FERN ONTOGENY IN ACTION: LEAF GROWTH PATTERN OF *WEICHSELIA RETICULATA*

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Weichselia reticulata (C. Stokes et Webb) Fontaine has been reported from the Bathonian to the Cenomanian worldwide. Several whole-plant reconstructions have been proposed with differences in the frond architecture, but there is no detailed quantitative study of its frond; and so far, its growth pattern is unknown.

The studied material was collected from the upper Barremian La Huérguina Formation of the fossil locality Las Hoyas, Cuenca, Spain. Twenty six specimens including the hand specimen MCCM-LH 17327 showing a petiole head with 9 radiating pinnae, and 25 specimens of more or less complete primary pinnae bearing secondary pinnae, were photographed with a Nikon D5100 digital camera and measured with ImageJ 1.49. In order to study the variation of the secondary pinnae along the primary pinna, the latter was divided into three parts (basal, middle and apical), and each into zones of an equal number of secondary pinnae, resulting in seven zones in total. These were called B1, B2, M1, M2, A1, A2, and A3. The following metric variables were studied: DBP, distance between two successive secondary pinnae; FSL, length of the first segment of the secondary pinnae; IA, insertion angle of the secondary pinnae; RW, the rachis width at the insertion of each secondary pinna; TL, total length of each secondary pinna. The variation of every metric variable was explored throughout the seven zones, and correlations were studied using a Principal Component Analysis (PCA).

The metric values of all pinnae are similar and show that the primary pinnae have an elliptic shape with a sinuous rachis that tapers apically. Compared to mature specimens, MCCM-LH 17327 probably corresponds to a juvenile frond based on differences in

the variation of DBP and RW along the primary pinnae. On the juvenile, DBP is shorter from zones M2/A1 to the apex, and RW diminishes with a steeper curve than expected, which suggests that the primary pinnae had an acroplastic (from base to apex) growth. Furthermore, each primary pinna of MCCM-LH 17327 corresponds to a different growth stage, in which the most axial primary pinna is more mature than the more lateral pinnae. This condition suggests a basioplastic (from apex to base) growth on the petiole head, which resembles the growth pattern observed in the living fern *Matonia pectinata* R.Br.

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O298

EARLY CRETACEOUS ANATOMICALLY-PRESERVED MARSILEACEAE FROM CALIFORNIA (USA) AND THE EVOLUTION OF SPOROCARP MORPHOLOGY

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The Marsileaceae are a heterosporous, leptosporangiate lineage of ferns with specialized reproductive mechanisms. Sporangia are grouped in indusiate sori contained inside structures called sporocarps, hypothesized to be homologous to fused modified pinnules. Fossils of marsileaceous affinity can be traced to the base of the Cretaceous and a few – represented by spores – cross into the Late Jurassic. Fossil marsileaceous sporocarp records are sparse and known only from the Late Cretaceous onwards, with the exception of Regnellites, reported from deposits of uncertain age (Late Jurassic–Early Cretaceous) in Japan. Anatomically preserved sporocarps are known only in two pre-Cenozoic taxa, Regnellidium and Rodeites, both of Late Cretaceous age. Recently, the Early Cretaceous Budden Canyon Formation of northern California has yielded marsileaceous sporocarps from layers dated to the Barremian-Aptian boundary (ca. 125 Ma) based on invertebrate and radiolarian biostratigraphy. These marsileaceous fossils are some of the best preserved permineralized sporocarps and are part of allochthonous assemblages exposed near the town of Ono, preserved in marginally-marine deposits that contain a rich flora that also includes other pteridophytes, gymnosperms, as well as bryophytes and fungi. The Ono fossils represent the second sporocarp occurrence that pre-dates the Late Cretaceous and the oldest to yield anatomical preservation. The Ono sporocarps are thick-walled, reniform, ca. 3 x 1 mm, and can be paired on common stalks. The sporocarp wall consists of a 1-cell thick outer sclerenchymatous palisade layer and a parenchymatous, 2-3 cells thick inner layer. The sporocarps show evidence of a longitudinal slit suggesting bi-valvate dehiscence, similar to that of extant Marsileaceae and extinct Rodeites. Thin bifurcated partitions preserved inside the sporocarps represent indusia, protruding from the sporocarp wall toward the center. The proximal end of the sporocarps features a conical protrusion where the wall is much thicker and is traversed by a vascular bundle of scalariform tracheids surrounded by parenchymatous tissue. Numerous microspores with bi-layered walls are preserved inside the sporocarps; megaspores could not be identified. A morphology-based phylogenetic analysis using parsimony as the optimality criterion, including extant Marsileaceae and extinct forms featuring well-characterized reproductive structures, with Hydropteris as outgroup, recovers the Ono sporocarp as a stem-group member of the Marsileaceae. This provides insights into ancestral character states within the family, critical to understanding the evolution of morphological features such as sporocarp symmetry and dehiscence mechanisms.

O299

NEW FINDINGS OF THE MIDDLE ALBIAN ANGIOSPERMS IN PRIMORYE, RUSSIA

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Unique locality with middle Albian angiosperms was discovered near town of Bolshoy Kamen in Primorye, Far East of Russia. It is situated in southern Primorye, on the shore of Ussuriysk Bay. Fossils come from the Early Cretaceous deposits of the Partisansk coal basin. The rich Lower Cretaceous flora of this basin was studied mostly by Krassilov. Fossil plants are associated with the alluvial and lagoon deposits of the Frentsevo Formation. In the lower part of the Frentsevo Formation there are marine Trigonia beds, representing a short marine ingression and containing the middle Albian invertebrate assemblage.

Angiosperm remains come from one layer about 15 cm thick, containing greenish gray psammitic tuffites. The plant remains are folded or obliquely imbedded in the tuffaceous matrix. It is likely that this fossiliferous layer was formed during one flood event, and plants at the locality are practically autochthonous.

This site is dominated by 6 species of herbaceous angiosperms: Achaenocarpites capitellatus, Ternaricarpites floribundus, Asiatifolium elegans, Jixia pinnatipartita and two undescribed species. The preservation of fossils is rather good. Sometimes it is possible to recognize almost whole plants, with roots, branching stems, leaves and fruits. Angiosperms are accompanied by abundant fern remains, represented by Onychiopsis psilotoides. Sometimes also whole plants with roots were found. Other fossils are represented by occasional scale-leaved conifer shoots and rare fragmented remains of other ferns.

Therefore, this site contains numerous remains of diverse herbaceous angiosperms mixed with the fern Onychiopsis psilotoides. Preservation of fossils indicates that they were deposited not far from their growing place. It is likely that these plants formed open pioneer communities colonizing fresh sediments of coastal plain in periodically flooded areas. In other early-middle Albian

localities of Northeastern Russia ferns, cycadophytes, czekanowskialeans, ginkgoaleans and conifers predominate. Angiosperm remains occur rarely and irregularly.

The locality at Bolshoy Kamen is of importance not only for ecology of early angiosperms, but also for stratigraphy. Two species (Jixia pinnatipartita and Asiatifolium elegans) are in common with the famous angiosperm assemblage from the Chengzihe Formation in eastern Heilongjiang. The Chengzihe Formation is exposed near the city Jixi in Northeast China near the boundary with Russia and not far from the Bolshoy Kamen locality. The angiosperms from the Chengzihe Formation were considered to be Hauterivian-early Barremian in age. Analysis of stratigraphic position of these two assemblages and distribution of other Albian angiosperms suggest a younger age for the Chengzihe flora.

O300

PALAEOVEGETATION AND PALAEOENVIRONMENT OF THE LATE CRETACEOUS OF CENTRAL EUROPE

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Fossil record of Late Cretaceous floras of Central Europe and its interpretation is based on four key floras: 1) Peruc Flora from the Cenomanian of the Bohemian Cretaceous Basin, 2) Klikov Flora from the Santonian-Coniacian of the South Bohemian Basins, 3) Idzików Flora from the Coniacian of the Sudetic Basin, 4) Grünbach Flora from the Campanian of the Gosau Group. Major vegetational associations are characterised: aquatic fresh water habitat dominated by monocot Pandanites, Sabalites; salt-marsh habitat dominated by conifer Frenelopsis and ginkgophyte Nehvizdyella;, back swamp habitat dominated by cupressoid conifers Cunninghamites and Elatocladus), flood plain habitat dominated by platanoids (Ettingshausenia) and lauroids (Myrtoidea, Mauldinia), upland vegetation was dominated by xerophytic ferns and conifers.

Palaeoenvironmental interpretations are based mainly on CLAMP analysis, but also on Carbon stable isotopes and fossil wood. Central European Late Cretaceous floras show quite similar palaeoclimatic values. This fact is a result of their quite similar latitude and relatively stable palaeogeography, but also caused by sampling possibilities. In terms of mean annual temperature (MAT), the highest temperatures are calculated for Coniacian Idzików Flora (17.1°C), while the coldest MAT 13.2°C is calculated for the Campanian Grünbach Flora. The highest values for the warmest month mean temperature (WMMT) come from the Cenomanian Peruc Flora (28.12°C), while the lowest values of WMMT were calculated for the Grünbach Flora (25.2°C). The highest values of the coldest month mean temperature (CMMT) were obtained for Idzików Flora, which experienced milder temperature extremes over the course of the year. The lowest values of CMMT calculated for the Grünbach Flora were 2.3°C, which does not preclude the possibility of some days when the temperature dropped below 0°C. The longest growing season was reconstructed for the Peruc Flora (9.7 month), the shortest growing season is suggested for Grünbach Flora (7.6 months).

Fossil woods studied in the Peruc Flora indicate false growth rings. CLAMP analysis showed that that ratio of average precipitation of three driest (3-DRY) and three wettest (3-WET) months are very close to a ratio of 1:5 and precipitation of 3-WET is close to equal to or higher than 55% of the total annual precipitation. The combination of these independent observations indicates that climate in Central Europe was under monsoonal influence.

O301

CHALLENGING THE CONVENTIONAL INDICATORS: ANTHROPOGENIC ACTIVITIES INFERRED FROM ALGAE RATHER THAN POLLEN AND COPROPHILOUS FUNGI

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Introduced by Karl-Ernst Behre (Lower Saxony Institute for Historical Coastal Research Wilhelmshaven, Germany) in 1981, the definition of pollen indicators for human activities (i.e. agro-pastoralism) was an important step forward for palaeoecological studies, offering new approaches to the interpretation of pollen data. In the last decades, the systematic identification of non-pollen palynomorphs (NPP), initiated by Bas van Geel (University of Amsterdam, The Netherlands) in 1978, resulted in a new leap forward to better understand local ecological processes in all types of landscapes worldwide. Some of the most valuable NPP taxa are spores from coprophilous fungi, which are often used as indirect indicators of pastoral activities. Here we present the results from a continuous high-resolution record from Lake Mondsee (Austria), where archaeological evidences acknowledge human presence and agricultural activities during the so-called Neolithic *Mondsee Culture*, between 4000 and 2500 cal. BCE. Despite an important sampling effort (i.e. high pollen sum), typical indicators of anthropogenic activities such as pollen grains of cereals and spores of coprophilous fungi are scarce in the lacustrine sediments from this more than 60 m deep lake. However, some algal groups are highly represented such as *Botryococcus*, *Tetraedron*, and Volvocaceae. We address their potential value as indicators of eutrophication by comparing them with other palynological and palaeoecological proxies, as well as archaeological evidence related to prehistoric pile-dwelling and upland societies living around the lake.

O302

COMBINING PRESENCE WITH THE PAST – AN ATTEMPT OF USING MODERN NON-POLLEN PALYNOMORPH SURFACE SAMPLES IN THE PALAEORECORDS - AN EXAMPLE FROM POLISH RAISED BOGS

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Raised bogs are commonly used to infer past environmental changes by applying different proxies. In our research, we focused on three peat cores from raised bogs located in northern Poland, in the W-E gradient of increasing continentality (Bagno Kusowo, Gązwa and Mechacz Wielki, respectively). Previously obtained results of pollen, testate amoebae, and plant macrofossil analyses were supplemented with analysis of non-pollen palynomorphs (NPPs) and additional AMS radiocarbon datings. To facilitate the interpretation of results and discussion about bogs' development, and their hydrological and vegetation changes, we incorporated data obtained from 90 modern surface samples, collected from the same bogs as previously studied cores. The samples represent different microhabitats such as hummocks, hollows, pools, moss carpets, *Sphagnum* patches in forests, and overgrowing drainage ditches. Moreover, we measured environmental variables such as pH, hydrochemistry, and water level, and described vegetation (within the frame 50 x 50 cm). The main aim of the research was to untangle the relationships between NPPs and environmental conditions, both in modern and fossil samples. The results of analysis of modern NPP dataset revealed the relationship between the habitat openness and NPP spectra, i.e the open area (0-25 % of tree cover) samples were similar to samples from half-open area (25-50 % of tree cover), but varied from samples collected in half-forested and forested areas (50-75 % and 75-100 % of tree cover, respectively). For the peat profiles, we combined the results of NPP analysis with available quantitative and qualitative reconstructions. Our results show that HdV-10 and HdV-90 seem to be related to dry phases or water level fluctuations, whereas HdV-13, HdV-30 and HdV-37 were present mostly during wet shifts. Higher pH values seemed to be preferred by HdV-29, HdV-77A and HdV-96A, whereas lower by HdV-35. The occurrence of HdV-10 is connected with the presence of macroscopic remains of Ericaceae (mostly *Calluna vulgaris*), similarly, HdV-77A (*Geoglossum sphagnophilum*) occurred in spectra where macroscopic remains of *Sphagnum magellanicum* were identified. The increases of HdV-90 appear to be related to intensified *Sphagnum* sporulation.

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O303

FUNGI FRAGMENTS IN DEEP SEA QUATERNARY SEDIMENT ON THE AMAZON FAN RIVER, AMAZON BASIN, BRAZIL

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The vast forest present in the Amazon basin involves countries such as Brazil, Peru, Bolivia, Colombia, Ecuador and Venezuela and its evolution strongly influenced the basin of Foz do Amazonas, on the north of the Brazilian equatorial margin with 268 thousand of km^2 into the well-known fan of Foz do Amazonas. The fan has about 45% of its area in deep water zone, containing more than 50% of the sediment from the Andes, occurring at least 20 million years ago. Tectonic and climatic episodes resulted in a landscape dominated by lowland lands with tributaries of the Amazon River forming drainage systems with shape and size constantly altered during the Cenozoic. All this sediment that goes to the bottom of the sea brings nutritive content capable of feeding a diversity of microorganisms present in the sediment in the bottom of these waters. In an analysis of material collected from three thousand meters of water depth in the marine subsurface, it was possible to find remains of fungal material through the presence of spores and hyphae of this group. These fragments may be related to a community living under special pressure and temperature conditions, thus characterizing them as extremophile organisms, or are part of the sediment thus far entrained by the stream of mud poured daily into that área. Here are presented a fungal components found in the area of the Amazon Fan River, which are analyzed in an attempt to understand the elements that make up the microbiota present in this environment. According to some studies the occurrence of fungi in the deep-sea subsurface has been more common than expected, characterizing their survival capacity under high pressure and very low temperatures. The marine micota may be associated with the decomposition of benthic algae from intermarine zones or from the remains of mangrove plants connected to the sea.

O304

INSIGHTS INTO PREHISTORIC HUMAN IMPACT AROUND LAKE ATTERSEE, AUSTRIA, BY MEANS OF NON-POLLEN PALYNOMORPHS

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Archaeological settlements at pre-alpine lakes in Austria bare large potential for interdisciplinary research. They offer outstanding preservation conditions for organic matters and are therefore key sites for the understanding of past socio-economic and ecological changes. This study presents results of a multi-proxy investigation applied for the first time in such an archaeological context. Sediment cores were obtained at the Late Neolithic-Chalcolithic site of Weyregg II (Lake Attersee, Upper Austria, ca. 3900-3500 BC) and analysed by means of palynological, palaeoethnobotanical, archaeological, and sedimentological approaches. Special emphasis was given to the determination of new non-pollen palynomorphs (NPP). A wide range of well-known and 222 so far unidentified NPP-types was documented contributing to the reconstruction of past environmental conditions on a local scale. The broad set of methods applied on the on-site deposits contributed significantly to our understanding of anthropogenic activities, site formation processes as well as climatic changes (e.g. lake level fluctuations). High frequencies of spores from coprophilous fungi imply the important local presence of livestock. The occurrence of intestinal parasitic eggs of whipworms (*Trichuris*) gives direct evidence for disease, health, and quality of life of prehistoric people. Furthermore, sedimentation patterns represent different stages of depositional and erosive processes (traced by e.g. *Glomus* fungal spore finds). Finally, focus is given on the comparison with adjacent palaeoenvironmental records in order to track similarities and differences for short- and long-term transformation processes of prehistorical cultural landscapes.

O307

HOW DO PATTERNS OF SUBSISTENCE, NON-SUBSISTENCE PRODUCTION AND PALAEODEMOGRAPHIC CHANGE RELATE TO REGIONAL VEGETATION COVER IN BRITAIN AND IRELAND?

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Quantification of regional vegetation can greatly enhance the understanding of how past cultures have transformed and shaped their surroundings. Much attention is paid to the role of food procurement, and in particular the emergence and intensification of agriculture. By the later Bronze Age spatially-extensive field systems characterised at least some areas of western Europe (e.g. southern Britain) and later prehistoric farming has been shown to have a major impact on regional vegetation cover (e.g. Fyfe et al 2015). The impact of early agriculture, and temporal change within early agricultural practice (e.g. the balance of crop cultivation, pastoral land use and gathering of wild resources) has been less fully explored, although Woodbridge et al (2014) describe relationships between demographic change and land cover. Less attention has been paid to non-agrarian land use, and in particular extractive practices such as mining. In this paper we explore the inter-relationships between land cover, palaeodemographic change, subsistence and extraction, particularly focussing on earlier prehistory and the emergence of agriculture within Great Britain and Ireland. Regional vegetation cover is estimated from open-access pollen datasets, transformed using the REVEALS model (Sugita 2007). Palaeodemographic change is reconstructed using a radiocarbon dates-as-data approach (Bevan et al. 2017). Non-subsistence production focusses on a new evaluation of the timing of flint and stone mining for axe production, particularly at the start of the Neolithic. The results show clear relationships between REVEALS-based vegetation cover, radiocarbon-derived palaeodemographic and mining from at least 6000 cal BP. Relationships between the subsistence base and land cover are clear during the first emergence of agriculture in Great Britain and Ireland, but become less clear in later prehistory, possibly as land cover was already substantially transformed by this time.

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O309

MEDITERRANEAN VEGETATION CHANGE, LANDSCAPE DYNAMICS AND HUMAN POPULATION TRENDS THROUGH THE HOLOCENE

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The Mediterranean landscape has undergone significant changes throughout the Holocene. This research utilises large databases of modern pollen (Davis *et al.,* 2013) and fossil pollen from sediment cores (Leydet *et al.*, 2007-2017) as a proxy for vegetation change. Radiocarbon-led archaeological population proxies (Shennan & Edinborough, 2007) and settlement surveys are used to compare vegetation change with demographic trends. Cluster analysis and phytosociological classification of pollen datasets have revealed numerous closed forest/wooded vegetation types (e.g. evergreen and deciduous oak woods) and several open or scrub vegetation types (e.g. sclerophyllous scrub, steppe, grassland, parkland) (Fyfe *et al*., 2018; Woodbridge et al., *in review*). Pollen-inferred landscape change indicates both short and long-term variability, which reflects temporal variations in climate, human land use and ecological dynamics. The results indicate that the Mediterranean has been a dynamic landscape throughout the Holocene with frequent changes in land-cover and persistence of disturbance and drought-adapted plant assemblages within an extensively human-modified environment. The pollen-inferred vegetation patterns and archaeological-inferred demographic trends are compared with palaeo-fire and palaeoclimate datasets in order to explore the drivers of disturbance in time and space within Mediterranean ecosystems.

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O310

UTILIZATION OF MOUNTAINOUS AREAS IN THE IRON AGE – THE POTENTIAL OF LAND-COVER RECONSTRUCTIONS

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People have used mountains in all time periods, but their impact on vegetation was probably minor until different transhumance practices came into use, in Norway especially from the Iron Age (the last ca. 2000 years). Livestock grazing, iron production, fodder and wood collection, have all had an effect on the local vegetation and formed characteristic cultural landscapes in these areas. Pollen analysis may reveal the history of this exploitation of outfield resources. At the same time mountainous landscapes are often open and suffer from long distance pollen transport combined with low local pollen production. The vegetation in mountain areas is also more exposed to climate changes than in lowland landscapes. This may result in difficulties in separating between climate change and human impact as cause of vegetation changes. We have studied the development in two different mountainous areas in south Norway reflecting different landscape types: one in the fjord landscape of western Norway, the other in a broad mountain valley in eastern Norway. Both areas have been used for summer farming by lowland farms in historic time periods. Based on several bog pollen diagrams, land-cover reconstructions for the last 3000 years using the Landscape Reconstruction Algorithm (Sugita 2007a, b) are presented. The estimated vegetation cover in the two study areas is compared and connected to archaeological data achieved through surveys and excavations of house remains, hunting traps and iron production sites. The potential of quantitative reconstructions using the Landscape Reconstruction Algorithm on data from such areas is presented and methodological questions related to the reconstructions discussed.

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O312

BENEFITS OF APPLYING X-RAY MICRO-COMPUTED TOMOGRAPHY TO PALEOBOTANICAL STUDIES

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Fossils provide critical data for understanding broad patterns of biodiversity, biogeography, ecology, and evolution over geological time scales. Challenges remain in being able to compare between localities, overcoming sampling issues due to various preservation states, accessibility, and accurately interpreting morphology in 2D or 3D. Experiments using synchrotron-based or industrial X-ray micro-computed tomography (microCT) is a particularly useful tool for studying fossil plant material because it is non-destructive, rapid, and provides both 2D and 3D morphoanatomical data. The resulting data can be used to produce models. In addition, this technique is enhancing collections by creating a lasting record of specimen data in case of compromised integrity, and enabling remote, virtual sharing and examination of material. MicroCT has been used on variety of paleobotanical materials including charcoalifications, permineralizations in carbonates and cherts, and compression fossils. Virtual dissections of fossils, and the creation of virtual fossils, generate hypotheses of expected morphologies from either extant or extinct taxa, revealing cryptic morphologies, which provide "search images" so that we may recognize fossils and correctly place them in a taxonomic and phylogenetic framework. Additionally, it can be used for acquiring comparative morphological data within extant taxa, and the non-destructive nature of the technique allows for rare, modern collections to be studied too. While microCT is becoming more widely used in paleobotany, here, examples from the Cretaceous-Paleogene Deccan Intertrappean Beds of India demonstrate how microCT is helping to understand the paleobiodiversity at these localities. Studies of specific groups, like the Arecales (palms) and Zingiberales (gingers, bananas, and relatives), illustrate the power of microCT in assembling large comparative datasets to place critical fossils in a phylogenetic context. Although access to microCT machines is a potential barrier, industrial microCT is becoming more common in part due to their multidisciplinary applications (e.g. engineering, materials science, earth science, anthropology, biology), and the resulting datasets, in addition to providing a record of the internal and external morphology of a specimen, can be made available to anyone. MicroCT is an invaluable tool for paleobotanical studies, enhancing our ability to study museum specimens and build comparative datasets to elucidate broader patterns of diversity and evolution gleaned from the fossil record.

O313

THE EARLIEST WOOD DOCUMENTED BY SYNCHROTRON ANALYSES

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The evolution of wood was fundamental to the early diversification of vascular plants, giving rise to progymnosperm trees by the end of the Devonian (ca 370 Ma), however wood first evolved in plants of small stature during the early Devonian (407–397 Ma). Here we develop an approach based on nondestructive synchrotron analyses to investigate the wall structure and chemical composition of the tracheids in the earliest fossil wood with the aims of characterizing their nature and the potential remaining chemical signature of their lignin component.

Axes of *Armoricaphyton chateaupannense* (ca 407 Ma) from the Armorican Massif, western France) were preserved as both thin coalified compressions and 3D permineralizations. Permineralized axes were imaged using propagation phase contrast X-ray synchrotron microtomography (PPC-SRμCT). Visualizations were obtained by digital three-dimensional reconstruction of the tomographic data. Chemical analyses were performed on both types of axes using focused ion beam (FIB) ultrathin sections extracted from freshly fractured specimens. Synchrotron-based scanning transmission X-ray microscopy (STXM), coupled with X-ray absorption near edge structure (XANES) spectroscopy was used to document the chemical nature of the tracheids.

Tomography enables digital visualizations of the cell wall and pit structures in unprecedented details (voxel-resolution of <1μm). The tracheids have a P-type cell wall structure. They possess scalariform bordered pits, which is a characteristic feature of P-type tracheids. The perforations have a highly variable shape and they are distributed in a reticulum. These results reveal structures similar to those observed in extant lignified cells.

Spectrometry shows that organic carbon from both samples has a similar spectrum and does not exhibit molecular biosignatures characteristic of modern lignin. They exhibit a broad absorption feature at ~285 eV indicating the presence of aromatic or olefinic carbons, a peak at 286.2 eV that can be attributed to carbons bonded to oxygen or sulfur, and a peak at ~ 288.5 eV likely corresponding to the presence of ester or carboxylic groups. The C-XANES spectrum of the organic compounds composing the specimens preserved in 3D exhibits an additional slight absorption feature at 287.3eV that can be attributed to the presence of phenols or ketones. The findings indicate that the preserved organic matter has been altered and is not original. The synchrotron-based microscopy, coupled with spectroscopy, shows that permineralization does not preferentially conserve elements of original cell wall chemistry and that both compressed and 3D-preserved fossils can be used in terms of chemical analyses.

O314

HYDRAULIC CONDUCTIVITY AND CONSTRAINTS AMONG PALEOZOIC PLANTS

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Plants are unique among multicellular organisms because much of their physiology is biophysical, rather than behavioral, and the anatomy that defines these biophysical capabilities is preserved in the fossil record. Mathematical models, when applied to fossilized plant organs—particularly leaves and stems—can provide quantitative insight into the physiology and ecology of plants that have been extinct for hundreds of millions of years. Comparing the physiology of extinct plants with strategies that are currently employed by living plants sheds light on ecophysiological trajectories in plant evolutionary history and the history of plant-environment coevolution.

Mathematical models of xylem structure can be applied to macerated or thin-sectioned permineralized xylem. Key parameters, including conduit diameter, pit dimensions, and pit frequency, are measured directly from individual cells from specimens. This presentation will focus on key plants from the Euramerican Carboniferous tropical forests, including *Medullosa*, a morphologically diverse genus of Carboniferous plants that evolved fronds and stems capable of high rates of transpiration, *Psaronius*, a stem group marattialean tree fern with divergent hydraulic strategies in its stem xylem and root mantle xylem, and two sphenopsid genera with distinct hydraulic capacities and constraints, *Arthropitys* and *Sphenophyllum*. Each of these plants contains anatomical features that result in novel physiologies, and together they represent the early evolution of hydraulic complexity—and the capability to influence regional climates and biogeochemical cycles—in terrestrial ecosystems.

O315

REFINING PHYTOLITH ANALYSIS IN DEEP-TIME PALEOECOLOGY THROUGH MODERN ANALOGUE STUDIES

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Phytolith analysis has been used in Archaeobotany and Quaternary paleoecology for over 40 years, but it is only in the last 15 years that the plant silica record has emerged as a source of data also for deep-time paleoecological studies. As the use of phytoliths in Quaternary paleoecology grows, it is crucial to refine this tool by establishing more rigorous, precise, and reliable protocols allowing application and comparisons among diverse studies. Modern analogue studies are a necessary step in this direction but they have only recently been undertaken. In addition, existing studies suffer from several methodological shortcomings that limit their use both geographically (mainly North America and Africa) and temporally (Quaternary). At the heart of these limitations are several assumptions about phytolith taphonomy, which might vary depending on the habitat (open vs. closed), the time studied (Quaternary vs. pre-Quaternary), as well as the spatial scale considered (local vs. regional).

In this study, we focus on two main methodological issues that need to be solved in order to appropriately apply modern analogue studies to the deep-time fossil record. By comparing phytolith assemblages from upper versus lower soil A-horizons, and composites (made of several subsamples taken from a small area) versus single phytolith assemblages, we aim to determine: 1) whether phytoliths from the lower portion of the A-horizon (as the upper A-horizon is often truncated by erosion) adequately reflect the current vegetation; and 2) whether a composite (i.e., spatially averaged) soil sample more accurately captures standing vegetation than a single sample. In addition, 3) in order to define the spatial resolution of phytolith analysis, we compare modern soil phytolith assemblages collected along vegetation transects to each other and to the modern, local vegetation (species composition) and canopy openness (LAI). We present data from two Neotropical habitat types from Costa Rica: a dry forest and a rainforest. Data from the rainforest site indicate that the phytolith assemblage in the lower A-horizon does not differ significantly from that of the upper A horizon; in addition, no major compositional differences are found between the single vs. the composite samples. These results suggest that the typical field approach in deep-time paleoecology of sampling single paleosol samples from the lower A-horizon is likely to produce reliable results, at least in rainforest soils. We aim to include additional vegetation type in our future work.

O319

A SEM AND TEM STUDY OF TWO FOSSIL MALVACEAE FROM NORTHERN SOUTH AMERICA PROVIDES NEW INSIGHTS INTO PAST FOREST COMPOSITION

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The palynological record of the northern South American lowlands is very rich in sporomorphs yet their botanical affinities are poorly resolved. In this study we focus on *Rhopities guianensis* and *Malvacipolloides maristellae*, two characteristic taxa of the early Neogene, which decline from the middle Miocene onwards. We applied LM, SEM and TEM to resolve their botanical affinities and found that *Rhoipites guianensis* closely resembles Grewioideae such as *Vasivaea* and *Trichospermum,* while *Malvacipolloides maristellae* resembles Abutilinae such as *Abutilon*, *Bakeridesia, Callianthe* and *Herissantia.* Nowadays, both taxa are common in the Andes and Central America, with the Abutilinae also being characteristic in the dryer vegetation types of the South American lowlands. Integration with the molecular phylogeny of these taxa further shows that *Rhopities guianensis* is of South American ancestry whereas *Malvacipolloides maristellae* seems to be an immigrant from the northern hemisphere. Collectively, our integrated study sheds new light on the phytogeography of the Malvaceae, with implications for our understanding of plant evolution in the context of Neogene climate change and Andean tectonics.

O320

LM VS. SEM BASED ANALYSES OF THE EARLY MIOCENE SALDANHA BAY PALYNOFLORA, WESTERN CAPE, SOUTH AFRICA

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Since the birth of paleopalynology fossil pollen have mostly been studied using light microscopy (LM) despite that already 60 years ago scanning electron microscopy (SEM) was shown to be superior regarding diagnostic surface features observed in recent pollen. The conventional LM procedure including counting of 300-600 grains per slide is considered fast and reliable and is used by palynologists all over the world to identify and segregate pollen types and to document subtle or major vegetation and climate changes. Many refrain from using SEM and argue that it is too time-consuming and that it does not add much compared to the effort. Here we present preliminary results of an ongoing combined LM/SEM investigation of the early Miocene Saldanha Bay palynoflora and compare our results to a previous account of the same flora using conventional LM. The previous LM study worked 22 samples from the same drill-core. For our SEM based analyses we used a single sample that was processed without sieving. The residue in glycerol was stored in test tubes and studied on open slides and grains were movable. We looked at thousands of pollen grains under LM and picked out representatives of all pollen types for SEM. The conventional LM study reported 130 angiosperm pollen types from the 22 samples. Two out of the 130 (1.5%) were considered unknown angiosperms. From our single sample we have identified 140 angiosperm pollen types. Fifty out of the 140 (36%) are currently assigned as unknown angiosperms. There are other profound differences between the two studies. The conventional LM study documents several taxa including Castaneoideae, *Ilex*, Juglandaceae, Malvaceae, *Quercus* and *Tsuga*, that we did not find in our sample. We also found many taxa, especially small and/or rare pollen types including Loranthaceae, not reported in the previous LM study. Comparing the two methods we conclude that combined LM/SEM analyses exceed conventional LM studies regarding morphological data. Correct affiliation to modern taxa is often only possible using combined LM/SEM. Combined analyses will result in a more complete and accurate palynoflora (segregate similar pollen types; find rare and small elements). Data compiled in a combined LM/SEM analyses is more reliable than that of a conventional LM study. The biggest problem when using combined LM/SEM is the lack of modern material to compare with the fossils, hence the many unknown angiosperm pollen types.

O322

THE CARNIAN HUMID EPISODE - A MOMENT OF MAJOR ORIGINATION FOR PLANTS

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In the late early Carnian (Late Triassic) an important, but yet poorly understood, phase of global climate change occurred. This is roughly synchronous with a global carbon-cycle perturbation revealed by a sharp negative carbon-isotope excursion in terrestrial and marine organic matter, and marine carbonate carbon, attributed to the Wrangellia Large Igneous Province volcanism, basalts of which outcrop today in British Columbia, Yukon and Alaska. This "most distinctive climate change within the Triassic", is known also as Carnian Pluvial Episode (CPE) and generally described as a shift from arid to more humid conditions. The onset of the CPE is very well constrained in many stratigraphic sections in Italy, Austria, Hungary and China) and placed at the Julian 1 – Julian 2 boundary. During this period of time a major biological turnover occurred during which important groups diversified or spread, e.g., dinosaurs and coccoliths. Moreover, at different latitudes is observed a shift of floral associations towards elements more adapted to humid conditions at different latitudes, and extensive resin production. These associations are among the most abundant and diverse floras of the Triassic. Paralic and lagoonal environments permit an exceptional preservation of the plant fossils as well as findings of amber, megaspores and charcoal associated with the macroremains. Typical hygrophytic elements such as ferns and sphenophytes are often the most abundant groups in the flora, although bennettitaleans become locally also very abundant. Conifer remains are dominant in allochthonous assemblages of marine sediments and reflect a high transport bias. Several families and orders make their first appearance or start at least their first radiation during the Carnian. This includes bennettitaleans, modern fern (e.g., Dipteridaceae) and conifer families (Pinaceae, Araucariaceae, Cheirolepidaceae) as well as putative angiosperms (e.g., *Furcula*, *Sanmiguelia*), although angiosperm-like pollen have been described already from Middle Triassic successions.

O323

TWO IN ONE! RECONSTRUCING THE SEED-FERN *LEPIDOPTERIS* AND RESTORING PROF. BRITTA LUNDBLAD´S LEGACY - A HOLISTIC APPROACH FROM MUSEUM ARCHIVES

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The end-Triassic mass extinction event in Northern Hemisphere terrestrial successions is typified by a significant turnover in vegetation. Extinction within the seed-ferns is recorded followed by a short period of fern-dominance and subsequent conifer invasion. In the Northern Hemisphere vegetation record, the notable extinction of the peltasperm *Lepidopteris* characterises the end-Triassic event. Curiously, knowledge of this interesting seed-fern is limited. The palaeobotanical collections of the Swedish Museum of Natural History (NRM) host a unique archive of fossil *Lepidopteris ottonis* remains, including wood, leaves (impressions and compressions), cuticles, seeds, seed coats, and pollen sacs with *in situ* pollen. Much of the material was prepared and described in detail by Professor Britta Lundblad during the 1950s. Her legacy however, like *Lepidopteris*, seems to have been somewhat overlooked. She was generally perceived as peculiar, possibly because she focused on science and not on building a family during times when a career in science was less accessible to women. The abundant fossil material of *Lepidopteris* and extensive records of Prof. Lundblad's documents and letters in the collections of the Swedish Museum of Natural History, NRM now allows for a holistic reconstruction of the plant and of Lundblad's scientific achievements, ideas and theories.

O324

PLANT RELICTUALISM IN THE POLAR REGIONS OF THE MESOZOIC–PALEOGENE GREENHOUSE WORLD

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We present the unexpected finds of *Dicroidium*, perhaps the most typical plant fossil of the Gondwanan Triassic, in Jurassic strata of the Beacon Supergroup, East Antarctica. The specimens consist of dispersed cuticle fragments of three *Dicroidium* species (*D. odontopteroides*, *D.* sp. cf. *D. elongatum*, and *Dicroidium* sp. indet.) that occur in reliably dated Sinemurian and late Pliensbachian deposits at Section Peak and Shafer Peak. Reworking can be excluded because of the similar aspects of preservation of these cuticle fragments compared to those of co-occurring cheirolepid conifers and other seed plants. Our finds thus represent the first robust evidence to suggest that *Dicroidium* survived the end-Triassic mass extinction and persisted with relictual high-latitude populations well into the Jurassic. Based on this report, we provide an overview about similar patterns of unexpectedly young, relictual high-lat-

itude occurrences of plant taxa in the Mesozoic and Paleogene, including various 'seed ferns' and Bennettitales. It appears that during warmer times in Earth History, the ice-free Polar Regions provided refugia for plant groups that had long disappeared elsewhere.

O326

NEW SPECIES OF CENOMANIAN *ANEMIA* (CZECHIA)

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A new species of fossil Anemia, which is assigned to the most ancient extant fern family Anemiaceae, is described from the Cenomanian of the Peruc-Korycany Formation, Bohemian Cretaceous Basin (Czechia). Anemia cenomanica sp. nov. is characterised by fertile and sterile foliage. Sterile fronds show a bipinnate lamina bearing lanceolate pinnules. Fertile fronds display a bipinnate lamina with highly modified pinnules bearing sporangia and in situ spores. Spores are tetrahedral, radially symmetrical, with a triangular amb, ca 40 mm in diameter, striate with slightly undulate ridges. Although the sterile foliage is never found attached, it always occurs in intimate association with fertile material. Comparison with other fossil representatives of the genus is discussed. According to diagnostic characters (dimorphism between fertile and sterile pinnae and striate tetrahedral spores) we are able to demonstrate the fern belongs to the Anemiaceae, but assignment of the taxon to the subgenus requires more details which are not preserved in the material available for the present study.

O327

SUTUROVAGINA INTERMEDIA (CHEIROLEPIDIACEAE) FROM THE UPPER LOWER CRETACEOUS DALAZI FORMATION OF WANGQING, NORTHEAST CHINA: CUTICLE ULTRASTRUCTURE AND PALAEOENVIRONMENTAL INSIGHTS

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The cheirolepidiaceous conifer Suturovagina intermedia Chow et Tsao is reported from the Lower Cretaceous of Wangqing, Jilin Province in northeastern China, and its leaf cuticles were studied in detail using scanning and transmission electron microscopies and EDS. The data obtained were compared with those of the previous study on the same species from the Lower Cretaceous of the type locality Nanjing, Jiangsu Province in eastern China. In spite of the general similarity in gross morphology and leaf cuticular structure, there are a number of differences in leaf cuticular ultrastructure and element composition (EDS data) between specimens from the two localities. Among them, 14 insignificant differences are potential taxonomical characters. Of them, 7 might be of importance at the species/genus level and 7 are possible characters at Family level. There are also 23 differences, i.e. 7 cuticle ultrastructural characters of ordinary epidermal cell cuticles and 5 of subsidiary cell cuticles, plus 11 EDS ratios of cuticles, believed to be of ecological significance. It is the first case to make comparative palaeoenvironmental analyses based on the leaf cuticle ultrastructure and element composition of the same taxon from different areas. It shows that Suturovagina intermedia was an inhabitant of a lower xerothermic environment in Wangqing, instead of being a higher xerothermic environment as in the type locality in Nanjing. The conclusion obtained is well-supported by the evidence of the elemental composition (EDX data) of the matrix, and the associated biotic composition of the fossil-bearing beds from the two localities. It is the first attempt to search for the environmental footprint in fossil plant cuticles based on their elemental composition.

O328

DIVERSIFICATION OF CROWN GROUP *ARAUCARIA*: A SEED CONE FROM THE MID-CRETACEOUS (CAMPANIAN) OF VANCOUVER ISLAND, BRITISH COLUMBIA, CANADA

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Exceptional anatomical preservation of an araucarian fossil from a marine carbonate concretion from Vancouver Island, British Columbia, Canada provides unusually complete evidence for the seed cone, seeds, megagametophytes, and embryos of an Upper Cretaceous (Campanian) species of Araucaria. The nearly spherical cone, 6 X 6 cm in diameter, has helically arranged cone-scale complexes 3 cm wide. Complexes consist of a large bract with an upturned tip and a small, fleshy ovuliferous scale separating from

the bract near the seed chalaza. The cone peduncle bears fleshy rhomboidal leaves and modified cone-scale complexes. Pith of the peduncle and cone axis is parenchymatous with scattered sclereids and resin canals. Secondary xylem of the peduncle separates into bundles in the cone axis, where the pith expands. Cortex of the cone axis is parenchymatous with scattered sclereids. Vascularization of the cone-scale complex is single at its origin, dividing in the cortex into bract and ovuliferous scale traces. Winged bracts, with a bulging base, contain numerous vascular bundles with accompanying resin canals. Abaxially, bract hypodermis contains numerous, regularly spaced fiber bands interspersed with rows of crowded stomata. The ovuliferous scale closely adheres to the bract surface bending upward along with the bract tip. Stomata occur on adaxial surfaces of ovuliferous scales and abaxial surfaces of bracts. Seeds are ovoid, 1.2 cm long, 1.2 cm in diameter, tapering to a mouth-shaped micropyle and vascularized by two bundles from the ovuliferous scale. Sclerotesta is thick, composed of branched, interlocking sclereids, and endotesta contains thin-walled elongate cells. Nucellus is free from the integument, except at its base, with a highly convoluted cellular apex, containing possible pollen tubes. Megagametophyte and mature cellular embryos occur in several seeds. The structure of this cone most closely resembles those of Araucaria Section Eutacta, with embedded seeds, small free ovuliferous scale tips that follow the course of the upturned bract tip, and a single trace to the cone-scale complex. While the cone is small, the imbricate bracts are very wide, and seeds are unusually large for fossil cones of this type. Width and continuity of secondary xylem in the cone axis, and intact cone-scale complexes indicate that, unlike extant Araucaria Section Eutacta, this cone probably did not disarticulate at maturity. The novel combination of characters displayed by this cone add to our understanding of araucarian cone evolution, and when added to phylogenetic analyses help resolve the pattern of phylogeny for crown group Araucariaceae.

O329

X-RAY TOMOGRAPHY USING SYNCHROTRON RADIATION REVEALS THE MORPHOLOGY OF A CHEIROLEPIDIACEAE CONE FROM THE LATE CRETACEOUS OF NEW ZEALAND.

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Cheirolepidiaceae is a minor component of Cretaceous floras in Gondwana. The distinctive pollen is widespread, being recorded from Antarctica, South America, Australia and New Zealand. However, its pollen occurs in low numbers and is a minor component of most of these palynofloras. Leaf macrofossils attributed to this family are equivocal and sparse. Two ovuliferous cones have been described from South America (Kachaikestrobus acuminatus, Tomaxellia biforme). Here we report on a new permineralised cone preserved in a concretion from the Late Cretaceous of New Zealand. Synchrotron X-ray facilitated a tomographic reconstruction of the cone and its enclosing matrix, and the differential X-ray attenuation of the various components revealed an elongate cylindrical cone bearing numerous, helically-arranged ovuliferous scales. The ovuliferous scales consist of a bract subtending a three-lobed ovuliferous scale with a single long apical process, and one inverted ovule.

O330

NEW INFORMATION ON PHYTODEBRIS IN PALYNOLOGICAL AND PALYNOFACIES SAMPLES FROM THE TRIASSIC TO EARLY CRETACEOUS OF THE NORTH SEA, INCLUDING EVIDENCE OF ABUNDANT BRYOPHYTES

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Microscopic plant remains known as phytodebris are generally a major, or dominant component of acid insoluble organic residues mounted for palynological and palynofacies analyses. Individual phytoclasts have traditionally been interpreted as randomly broken fragments of embryophytes. Evidence is presented to illustrate that a substantial proportion of phytoclasts are complete, constituent units of larger plant and/or algal structures. These include archegonia and antheridia of ferns, peristomal teeth of mosses, leaf stomata, prothalli and thalloid gametophytes of pteridophytic and bryophytic plants, thalloid cells of larger plant/algal structures, bracts, bracteoles, stem leaves, underleaves and a variety of vegetative propagules procuced by hepatic plants, including gemmae, rhizoid tubers, bulbils and leaf margin propagula. A review of palynofacies and palynological publications has identified similar phytoclasts illustrated in numerous articles.

Samples from certain terrestrial environments where transportation of eroded plant material is minimal, may contain large quantities of connected phytoclasts that remain linked together in life position. Linkage varies from just two or three adjoining cells and small clusters, to more substantial remnants of plant structures, including sporangia with attached microspores, leafy shoots and gynoecia/perianths of hepatic plants and other variably mature fruiting bodies on unknown affinity.

Further study of this material offers new line of palaeopalynological research, requiring greater integration with palaeobotany. These new observations have very significant implications for existing palynofacies models and counting procedures, which will need to be reassessed in order to access more detailed and accurate palaeoenvironmental and paleoecological information contained in the phytodebris.

O331

CIGARS, VASES, AND DEAD CENTIPEDES: NON-POLLEN PALYNOMORPHS FROM THE MIDDLE TO LATE MIOCENE BRASSINGTON FORMATION, UK

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The Middle to Late Miocene (Seravallian to Tortonian) Brassington Formation exposures in Derbyshire, UK contain an abundant palynoflora, especially in the Kenslow and Bees Nest Members. In many samples, the palynoflora is dominated by non-pollen palynomorphs (NPPs). NPPs in the stratigraphic succession from the top of the Bees Nest Member through the Kenslow Member as exposed in the Bees Nest Pit record variations in immediate depositional environment (sphagnum-bearing bogs with common amoebae *Arcella* sp., *Assulina muscorum*, *Assulina seminulum*, and *Difflugia pulex* vs. open-water settings with the rotifer *Keratella quadrata*, and fungus *Tetraploa aristata*), as well as changes in the surrounding ecosystems. Fungi encountered in this study are identified using modern morphological methods, allowing the majority to be assigned to extant taxa. Some, such as *Pesavis* sp., do not yet have modern analogues and are referred to by their existing type-names. Fungi typically referred to as coprophilous fungi (*Sporormiella* sp.) occur most frequently in clays scraped out of deep cracks in fossilized wood samples, as do many known wood saprophytes, including newly-described taxa and *Zopfiella neogenica*. This association may help explain the ecology of ambiguous fungi, such as *Pesavis tagluensis*, here reported for the first time from the Neogene of Britain. In this study, *Pesavis* only occurs in association with known wood saprophytes in samples that contain abundant gymnospermous pollen.

O332

USING NON POLLEN PALYNOMORPHS TO EXPLORE FIRE AND VEGETATION DYNAMICS AND THE IMPACT OF MESOLITHIC TRIBES IN THE PEAK DISTRICT, U.K.

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Fire has a long history of interaction with vegetation dynamics, climatic conditions and people involving feedback mechanisms and the creation of complex layers of environmental conditions that are difficult to unravel. Although broad Holocene landscape changes and general climatic conditions are generally known for the U.K., there is still a need for detailed, high resolution long term studies that provide insights into the local changing environmental conditions of fire prone habitats. This is vital information for the parametrisation of vegetation dynamic model, such as LPJ-GUESS, tasked with forecasting scenarios under changing climatic conditions and increasing our understanding of these complex relationships.

Here, a multi-proxy approach using charcoal fragments, pollen and Non Pollen Palynomorphs (NPPs) has been applied to a 500 m asl site in the Peak District, U.K. A number of NPPs previously linked with local hydrological conditions such as changes in the water table and the presence of dry hummocks or wet hollows have been recorded here. This is only the second known recorded occurrence in North West Europe of the hyper parasite of *Calluna vulgaris*, *Isthmospora spinosa*. Its presence, along with *Melioi Ellisii* spores and *Cladocera* mandible remains have been found to occur within 2 of the fire zone phases (6200 to 4400 years BP) indicated in results from CharAnalysis. These NPPs are thought to indicate local wet conditions. During this time the mean fire return interval increases from 115 yrs to 144 yrs; macro charcoal fragments, indicative of local fire events, significantly reduce (3700 yrs BP).

Using the proxy, coprophilous fungi, for the presence of dung, a peak in grazing by herbivores can be seen 6600 yrs BP where there is a clear correlation with a high level of fire events and a high percentage of *Poacea* pollen. This could indicate the presence of hunter-gatherer Mesolithic tribes, thought to have increased the openness of upland landscape and encouraged the initiation of blanket peat. Evidence for the presence of these early people is difficult to find and establish. This study aims to encourage the use of NPPs to increase their use in identifying often overlooked small changes in environmental conditions that show their long term impact on ecosystems and the part they play in complex environmental relationships as well as highlighting the implications for the future of fire prone landscapes.

O333

NPP AND POLLEN IDENTIFICATION AS PART OF A STUDY ON THE RELATIONSHIPS BETWEEN LAND USE AND CLIMATE CHANGES DURING THE BRONZE- AND IRON AGE AT SPOONERS AND GREAT BUSCOMBE, EXMOOR, UK

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High resolution NPP (non-pollen palynomorph) and pollen identifications from peat samples from two sites on Exmoor, Spooners and Great Buscombe, have been carried out in order to understand the relationship between past vegetation changes, land use changes and climate changes on Exmoor. The data ranges between 3800 and 2200 BP, based on radiocarbon dates. This time period is known for significant changes in the landscape of Exmoor, but the relative roles of human land use and climate are yet to be better understood.

During previously funded research in 2015 carried out by Prof. R. Fyfe and dr. K. Head at The University of Plymouth, both arable cultivation and burning had been identified at Great Buscombe. These phases are now being compared with the newly analysed fungal spore data during this project, and placed alongside the known field archaeology in areas surrounding Spooners and Great Buscombe. Newly retrieved pollen and NPP data from Spooners carried out for this project have indicated the presence of several phases of burning and grazing in the area and are compared to the evidence found at Great Buscombe.

Thus far, the combination of pollen and NPP data have shown to often agree on identifying changes in vegetation patterns and providing evidence of different types of land use. The presentation will focus on the comparison of NPP data to pollen and charcoal data from both Spooners and Great Buscombe and on how this can be interpreted as the relative importance of the identified types of land use.

Humification analysis was carried out on samples from a third site on Exmoor, The Chains, in order to gain an indirect climate proxy for the area. The humification data is used to further understand the relative roles between human land use changes and/or climate changes that were identified in the vegetation patterns at Spooners and Great Buscombe.

O334

THE ROLE OF CLIMATE, FOREST FIRES AND HUMAN POPULATION SIZE IN HOLOCENE VEGETATION DYNAMICS IN FENNOSCANDIA

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Better understanding of the complex interactions between natural- and human-induced changes in the past regional vegetation dynamics can provide means to predict the influence of changing environmental conditions on ecosystems that are heavily influenced by human activity. We investigated the changing role of climate, regional fires and human population size in the broad-scale compositional changes in Holocene vegetation dynamics before and after the onset of farming in Sweden (at 6000 cal yr BP) and in Finland (at 4000 cal yr BP).

The relative importance of climate, regional fires and human population size on changes in vegetation composition throughout the Holocene was statistically assessed by variation partitioning and moving window approach. Regional changes in forest composition were reconstructed using the REVEALS model on selected fossil pollen records from 33 lakes. Regional fire variable was reconstructed from sedimentary charcoal records and climate variable was derived from the LOVECLIM -climate model. The estimated trend in human population size was based on the temporal distribution of archaeological radiocarbon dates.

Our results demonstrate that Mesolithic hunter-gatherer populations did not significantly affect vegetation dynamics in Fennoscandia and climate was the main driver of forest dynamics during pre-agricultural period. Agricultural communities, however, had greater effect on vegetation dynamics and the role of human population size became more important factor during the late-Holocene. In general, regional fires explained relatively low proportion of the changes in vegetation during the whole study period in Sweden (10 000 – 4000 cal yr BP) and in Finland (10 000 – 1000 cal yr BP). However, a higher influence of regional fires on vegetation composition during the pre-agriculture was detected for both Sweden and Finland. Furthermore, the results demonstrate increased joint effect of human population size and fires on variation in forest composition after the onset of farming suggesting change from a natural- to more human-induced fires affecting vegetation dynamics during the late Holocene. The relatively high importance of climate throughout the Holocene suggests that – still after the onset of farming – climate, together with human impact, remained an important driver of changes in broad-scale vegetation dynamics. However, in some regions the influence of human population size on Holocene vegetation change exceeded that of climate.

O335

ROPES - RECONSTRUCTING PAST PLANT ABUNDANCES WITHOUT POLLEN PRODUCTIVITY ESTIMATES

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Recent methodological developments such as the Landscape reconstruction algorithm now allow widespread quantitative reconstructions of past plant abundances. Application of the present approaches is limited, however, by the need for pollen productivity estimates (PPEs). Such PPEs have been calibrated with modern pollen data in numerous studies mainly in Europe and China, yet gaps remain. The ROPES approach aims to produce reconstruction without a priory calibrated PPEs.

The approach employs the REVEALS model but extends application by using not only pollen counts but also pollen accumulation rate data (PAR). PARs in theory provide for each taxon an independent record of past abundances. However, direct interpretation is far from simple because PARs may differ substantially between neighbouring sites, e.g. due to sediment focusing in lakes. Still, in large lakes, changes in PAR data are expected to represent true changes in mean regional abundances of plant taxa. For example, a doubling in PARs of *Pinus* at some point in time is expected to represent a doubling in the mean regional cover of that tree.

ROPES uses this relationship; it searches for a reconstruction that shows the changes indicated in PAR values, such as the doubling in abundance of *Pinus*. To that end the approach initially applies REVEALS with random PPEs. The PPEs are then adjusted using an optimization algorithm until the reconstructed cover of each taxon indeed shows similar changes as the respective PAR values, e.g. the doubling of *Pinus*. If successful, the approach hence arrives at the mean regional abundance of all taxa through time and additionally produces PPEs. Successful application of ROPES requires high resolution pollen data with excellent time control for little error in the PAR values. Furthermore, because the approach relies on changes in the PAR values and not on the actual values, it requires records with sufficient variation.

The approach will be illustrated with pollen records from three annually laminated lakes in NE-Germany.

O336

HERBACEOUS PLANTS AND THEIR POLLEN SIGNAL; WHICH RARE POLLEN TYPES CAN WE INTERPRET AND OVER WHAT SOURCE AREAS?

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Pollen analysts have often struggled to interpret the rare type herbaceous pollen signal. Often we ignore many of the rare taxa in our pollen diagrams, taking a necessarily broad-brush approach to reconstructions of key taxa. However, at the ecological scale, for use in site management for nature conservation, and for interpretation of local environment around archaeological sites, it would be helpful to derive detailed information on plant community structure and change. Subtle differences in community structure such as those described in the vegetation classification systems may be beyond the scope of palaeoecological interpretation; but, how far can we go? Early analysts such as Behre (1981) encouraged the development of botanical skills in interpretations of anthropogenic indicators; and indices of association on binary data (Davis 1984) have been used since by several analysts. However, a more focussed quantitative approach to the individual rare-type taxa has been limited. This paper will present the results of a detailed analysis of modern pollen and plant surveys, using binary indices and source area, to add a new approach, to determine which herbaceous species produce an interpretable pollen signal, and over what source area.

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Davis, O.K., 1984. Pollen frequencies reflect vegetation patterns in a Great Basin (USA) mountain range. *Review of Palaeobotany and Palynology*, *40*(4), pp.295-315.

O338

UV-B-INDUCED CONIFER STERILITY: IMPLICATIONS OF OZONE SHIELD FAILURE DURING THE END-PERMIAN CRISIS

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While Siberian Trap volcanism is considered to have been a primary contributor to the end-Permian crisis, the connection between its activity and vegetation turnover is unclear. However, fossilized gymnosperm pollen malformations from crisis intervals suggest biological stress coinciding with pulsed gymnosperm decline. These grains are hypothesized to indicate enhanced ultraviolet-B (UV-B) irradiation from Siberian Traps-induced ozone shield deterioration. We tested this proposed mechanism by observing effects of previously modeled end-Permian UV-B regimes on pollen development and reproductive success in the living conifer, *Pinus mugo*. We find pollen malformation frequencies in *P. mugo* increase significantly under high UV-B intensities. Surprisingly, though all trees survived, they were sterilized under enhanced UV-B. These results not only support the hypothesis that heightened UV-B stress could have contributed to pollen malformation production, but also gymnosperm declines during Permian-Triassic crisis intervals.

O339

TO WHAT EXTENT DID PLANT EVOLUTIONARY INNOVATIONS IN PLANT TRAITS BETWEEN THE PERMIAN AND JURASSIC INFLUENCE THE NATURE AND BEHAVIOUR OF ANCIENT FIRES

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The transition from the Early Permian to the Late Jurassic, saw marked changes in the evolution and dominance of vegetation types. Of particular interest is the diversification in leaf morphologies of coniferales during this period. During the Permian, scale-leaved morphotypes such as the voltzian conifers were common. Yet, as flora diversified into the Triassic, new families with diverse leaf morphologies appeared, including the Podocarpaceae and Cuppressaceae in the early Triassic (broader flat leaves) and the Pinaceae in the late Triassic (needle-leaf morphologies).

Typically, fuels with high surface area-to-volume ratio are more likely to promote fire spread and flammability. Hence, the evolution and diversification of seed plants and the alteration in conifer leaf morphologies may have not only have provided an increasingly extensive fuel source for ancient wildfires across the globe, but may have also influenced fire behaviour during this time period. In order to consider this, we reconstruct global vegetation data from published macro-fossils and use the observed innovations in plant traits to assess their likely impacts on variations in fire behaviour.

We achieve this by undertaking experiments that test the likely flammability of these conifer morphotypes using state-of-the-art fire testing equipment that enables us to measure the time to ignition, the heat release rate and the effective heat of combustion for each fuel morphotype. We then use these data to inform a fire behaviour model that allows us to estimate changes in the rate of fire spread, flame lengths, fireline intensity and scorch height for each major phase in the evolution of conifers. The model additionally allows us to consider any relevant variations in climate and atmospheric oxygen throughout the Permian through to the Jurassic and how these fed into altering the fire behaviour of each fuel type.

O340

TESTING THE APPLICABILITY OF LEAF PHYSIOGNOMIC PROXIES FOR CLIMATE ON EQUATORIAL AFRICAN FLORAS

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The size and shape (physiognomy) of woody dicot angiosperm leaves are correlated to climate, and these relationships have been used to develop proxies for mean annual temperature (MAT) and mean annual precipitation (MAP). In general, MAT is most strongly correlated with the presence of leaf teeth and the circularity of leaf shape, and MAP is most strongly correlated to leaf size. Most leaf physiognomic proxies for climate have been developed using modern floras primarily from the temperate Northern Hemisphere, with relatively fewer sites from the tropics and almost no sites from Africa. However, relatively limited research of African floras indicates that they have a different relationship between climate and leaf physiognomy than Northern Hemisphere floras. Therefore, in order to estimate paleoclimate from sites in the low-latitudes, and particularly from Africa, it is important that ex-

isting proxies be tested using modern data from across Africa and that leaf physiognomic data from these regions be added to the calibration dataset to develop new models applicable to African fossil floras. We measured leaf physiognomic characters of woody dicot angiosperms from modern sites across tropical Africa with known climate data including sites from Cameroon, Côte d'Ivoire, the Democratic Republic of the Congo (DRC), Gabon, Kenya, Liberia, Nigeria, the Republic of the Congo, Senegal, Sierra Leone, Tanzania, Togo, and Uganda. The sites were chosen in an effort to sample a wide range of climatic, geographic, altitudinal, and phylogenetic diversity. We then estimated climate parameters for each modern site using the univariate physiognomic models Leaf Area Analysis (LAA) and Leaf Margin Analysis (LMA) and the multivariate model Digital Leaf Physiognomy (DiLP). In general, the LAA, LMA, and DiLP estimates were within uncertainty of the climate for tested sites. However, the uncertainty for the LAA and LMA estimates was very large, and much larger than those for DiLP. Additionally, DiLP often overestimated MAT and underestimated MAP, and in some cases, MAT was overestimated by as much as 10 °C. These results indicate that the existing LMA and LAA physiognomic models should be applied with caution to African floras and that the current DiLP calibration dataset is unsuitable for estimating paleoclimate from tropical Africa. Therefore, it is important that the breadth of geographic, climatic, altitudinal, and phylogenetic diversity be added to these physiognomic models in order to accurately estimate paleoclimate for tropical African floras.

O341

PROXIMAL EJECTA BLANKETS OF SMALL IMPACT CRATERS AS TIME CAPSULES PRESERVING A TIMELAPSE OF PALEOENVIRONMENT

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Impact craters are formed when an asteroid strikes the surface with the velocity higher than ~1km/s. The kinetic energy of impactor is released as an explosion, and target material is displaced from the point of impact. When large craters are formed the amount of energy is so large that it instantaneously destroys practically all remains of living organisms. However, recent field work showed that in case of smaller (~30-100 m in diameter) impact craters (Kaali Main and 2/8 craters, Ilumetsa Large and Small and Morasko strewn field) plant material enclosed within proximal ejecta may survive crater formation process and be preserved as charcoal for at least thousands of years.

Even though the average temperature of the ejecta blanket is believed to be up to a few of degrees above the temperature of the surrounding rocks, laboratory hypervelocity experiments show that there may be a small amount (<0.1%) of particles heated above ~1000°C. This indicates that locally, temperatures could be raised in impact ejecta for a short amount of time (<hour), enough to produce charcoal.

We have performed a set of experiments that reproduce the process of formation of charcoals within proximal ejecta blankets of small impacts. Charring experiments were done using the iCone Calorimeter that can recreate the full range of heating possibilities that might results from small impact cratering processes. The iCone allows samples to be heated, with or without ignition at a range of radiant heat fluxes for given durations; these heat fluxes can be static or transient, both of which may be relevant to different impact formation mechanisms. We have buried leaves and fragments of different woods in sand and heated using various heat fluxes, durations and cooling regimes to assess the potential for relatively cool ejecta to cause transformations of organic material to char. All the chars created in the experiments were analysed via reflectance microscopy and compared with the charcoal found in the field.

This not only allows us to better understand the process of formation of small impact craters especially in terms of their effects on the environments in which they were formed, but also to study preservation mechanism of organisms killed during such violent events.

O342

SEM INVESTIGATION OF MID-EOCENE POLLEN FROM HAINAN (S CHINA) AND A FEW PALAEOGEOGRAPHIC IMPLICATIONS.

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Mid-Eocene samples from Hainan (S China) have been palynologically analysed using LM and SEM. The palynoflora is dominated by 80% Fagaceae pollen (Quercoideae) and other angiosperm pollen. We describe the first fossil occurrence of mid-Eocene *Sarcandra*-type pollen (*Sarcandra/Chloranthus* lineage). A *Laurelia*-type (Atherospermataceae) is further evidence for the wide geographical range of the family. The *Fagus*-type resembles Paleogene *Fagus* pollen from Greenland and Canada and from extant *F.* subgenus *Engleriana,* suggesting an amphipacific distribution of *F.* subgenus *Engleriana* lineage during the Eocene. The *Juglans*-type found resembles *Juglans* from section *Cardiocaryon*; this occurs contemporaneously with fossil diaspores of *J.* section *Rhysocaryon* in the USA, pushing the divergence-time of *Juglans* back in time. The presence of a *Cornus*-type from the "blue-or-white-fruited clade", as are several *Cornus* diaspore fossils from Europe, suggests a Eurasian origin of this clade and its contemporaneous occurrence with "cornelian cherry clade" fossils (USA) demonstrates that divergence time within *Cornus* was earlier than estimated. The Hainan *Nyssa*-type resembles extant *N. sinensis* and Eocene *Nyssa* pollen from Europe, but not American *Nyssa*, suggesting an Eocene Eurasian *Nyssa sin-*

ensis lineage. The three *Symplocos* types are closely related to the early diverging *Symplocos* subgenus *Palura* and, together with Upper Eocene subgenus *Palura* pollen from Germany, demonstrate a Eurasian origin. Further, pollen from Trachycarpeae (Arecaceae) that, together with co-occurring *Flueggea*-type (Phyllanthaceae), are known from Europe during the Lower Eocene, pointing towards a Eurasian origin of the two taxa. In contrast, a *Phyllanthus* subgen. *Eriococcus*-type is described for the first time and, so far, seems to be only Chinese in occurrence. The same is true for the oldest *Lagerstroemia*-type, which resembles the Miocene *Lagerstroemia cathayensis* from China. Two Dipterocarpaceae pollen types (*Dipterocarpus*- and *Dryobalanops*-type) are here described for the first time from Eocene strata. Of three Malvaceae pollen present, one is a *Craigia*-type; two *Mortoniodendron*-types witness an unknown palaeo-geographical history: Central American *Mortoniodendron* was present during Lower and mid-Eocene in Europe and during the Miocene in Central America, indicating a now wider distribution of this genus. The two *Iodes* types, one African/Madagascan taxon and one Melanesian taxon, imply that the Old World disjunction of *Iodes* in Africa/Madagascar and SE Asia is a Paleogene relict; members of this genus were previously more widespread. A third Icacinaceae resembles species of the S American *Mappia* and SE Asian *Nothapodytes,* both from the *Mappia/Nothapodytes* clade that was widespread in the boreotropical realm during the Eocene.

O343

SEM INVESTIGATION OF THE LATE OLIGOCENE CHILGA PALYNOFLORA, ETHIOPIA, EAST AFRICA

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The late Oligocene (28-27 Ma) Chilga locality in the highlands of north-western Ethiopia is well known for its plant and animal fossils. The sediments have yielded numerous large mammal remains and well preserved plant macrofossils with delicate cuticles allowing precise affiliation to modern taxa. The palynological spectrum has also been the subject of three previous studies using conventional light microscopy (LM) to reconstruct the paleovegetation. Here we present preliminary results of our combined LM/SEM investigation, using the single-grain method, of the Chilga palynoflora, and compare our results with previous accounts on both the macro- and palynoflora. It is interesting that despite the many documented palm (Arecaceae) macrofossils none of the previous palynological studies have reported any such pollen grains. Until now the palm macrofossil record of Chilga includes among others *Eremospatha* and *Hyphaene*, with both extant genera producing distinctive sulcate pollen grains that would be easily affiliated to Arecaceae if found in fossil state. We also have not encountered any such pollen so far, but we do find two other unique palm pollen types affiliated to *Sclerosperma*. At present this genus composes three species restricted to equatorial rainforests of West Africa, where the plants are usually occurring in lowland swampy areas. One of the most frequently occurring sulcate pollen type, assigned in a previous LM study to Commelinaceae, is from *Heteranthera* (mud plantains), a special aquatic plant of the water hyacinth family Pontederiaceae. *Heteranthera* is a small genus composing c. 7 species at present, most of them occurring in South America, but a single extant species is also found in Africa. The African species occurs throughout tropical Africa and into the Transvaal and southwestern Africa, where it grows in freshwater swamps and pools. The sample is further characterized by various fern spores representing a range of families and a rich dicot angiosperm pollen spectrum dominated by Sapotaceae. Other groups include Anacardiaceae, Apocynaceae, Asteraceae, Euphorbiaceae, Fabaceae, Nyctaginaceae, Rubiaceae and Sapindaceae.

O344

PALDAT – A USEFUL TOOL FOR IDENTIFYING RECENT AND FOSSIL POLLEN

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Pollen grains are highly valuable for various branches of science (e.g., palaeobotany, forensic palynology, melissopalynology, aeropalynology). For scientists, a fast and efficient access to pollen data is essential. *PalDat* (www.paldat.org) is the world's most comprehensive pollen database. It provides a large amount of pollen data on a variety of plant families, and currently contains more than 24,000 pictures from more than 2,800 plant species. *PalDat* was founded in 1997 and is online since 2000. ***PalDat* 3.0** is the second revision of the database in 2015 with a new web interface and new tools for pollen identification as well as global, free online submission and publication with review and editorial process. From the beginning, *PalDat* aspired to cover a wide spectrum of users, by providing pollen data including different techniques and preparation methods. Each taxon entry (online publication) ideally includes the plant taxonomy, a detailed pollen description (e.g., shape, size, aperture, ornamentation, structure, cell number, Ubisch bodies), light- and electron-microscopy images of the pollen grain, images of the plant/flower, and information on relevant literature.

PalDat is an **identification tool for recent and fossil pollen.** Two **search tools** can be used in *PalDat*, an alphabetical (plant genera) and a combined search. The "Combined Search" is a tool for directed search, based on selected pollen characters in any combination. The search results are displayed in a taxonomic tree (currently based on APG III, but upgraded to APG IV soon). Within the taxonomic tree, the user can select an order, a family, genus or species. Moreover, species can be sorted, selected and compared.

Furthermore, *PalDat* is a **tool for global online submission and publication** with review and editorial process. The database is freely accessible. Following a free registration it is open for

contributions from all those willing to publish their pollen data online. Registered authors may also contribute as co-authors to existing publications. All changes are reviewed to guarantee the high standard of *PalDat* and are recorded in the database history. Each contribution is citable and accessible for all users. Registered users can download publications in pdf form.

PalDat 3.0 is designed in a modular way so that extensions to new APG systems and other fields of science may be implemented in an easy and agile process. Future plans include, among other features, a database for fossil pollen and spore data (*FosPal*), with an interface to *PalDat*.

O346

THE LATE CAMPANIAN JOSE CREEK FLORA FROM NEW MEXICO, A UNIQUE WINDOW INTO THE ECOLOGY OF CRETACEOUS FORESTS DURING THE RISE OF ANGIOSPERMS

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The diversification of angiosperms and their ecological radiation had profound effects on forest structure and composition. Late Cretaceous floras spanning the North American Western Interior (WI) document important patterns, notably that increases in taxonomic diversity of angiosperms appear to have outpaced increases in their ecological diversity and abundance across landscapes. Here we report on an exceptional late Campanian macroflora (74.7 +/-1 myr) from the southern WI that is preserved in a single-horizon of recrystallized volcanic ash exposed over a 1.2 km long transect. The flora is from the Jose Creek Member, McRae Formation of south-central New Mexico, which was deposited on an alluvial plain >200km inland from the Western Interior Seaway. The fossil bed overlies a paleosol indicative of well-drained conditions and contains abundant, well-preserved plant macrofossils showing little to no evidence for transport, including in-situ tree stumps. To reconstruct landscape patterns, we established 26 quarries along the full length of the exposure, and censused fossils at each quarry to determine relative abundance and percent cover of leaf morphotypes. To date over 150 leaf morphotypes have been recognized (>89% angiosperms) from the census of over 6,350 specimens and 30,860 2-cm line increments of rock surface. Rarefaction suggests that increased sampling will recover new non-monocot angiosperms, but that diversity of other groups will not likely increase appreciably. Angiosperms are the most abundant plant group within and across all quarries (74% of specimens, 84% cover), followed by conifers, cycads, and ferns. The community shows strong dominance structure. The most abundant five taxa by all metrics are a sequoioid conifer, Zingerberopsis-type monocot, Sabalites palm, Dryophyllum eudicot (Fagales), and a Brachyphyllum conifer. Diverse non-monocot angiosperms are mostly represented by locally abundant to rare taxa (totaling 47% of specimens, and 38% cover). The spatial turnover of non-monocot angiosperms drives significant taxonomic heterogeneity between quarries, a pattern recognized in modern tropical forests. The overall picture that emerges is one of a diverse, spatially heterogeneous, non-analog flora consisting of redwoods, gingers, palms, diverse non-monocot angiosperms, and low-abundance ferns and cycads that grew under moist to wet megathermal conditions. This flora is among the earliest leaf macrofloras from the WI to demonstrate ecological dominance (by abundance) of angiosperms across the landscape. Its location relative to similarly aged sites suggest that this transition may have occurred earlier at lower latitudes, and/or that dominance patterns of inland vegetation differed from that of coastal vegetation and swamps.

O347

TRENDS AND REGIONAL DIVERSIFICATION OF LATE CRETACEOUS VEGETATION AS EVIDENCED BY CENTRAL EUROPEAN MEGAFLORAS

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Up to about 2010 Upper Cretaceous (post-Cenomanian) megafloras of Central Europe were considered as unpromising because they consist mostly of leaf imprints without either cuticles or fine details. However, successive revisions of Coniacian to Maastrichtian assemblages from Poland, western Ukraine, Czechia, and southern Sweden have shown their utility for vegetation reconstruction, palaeoclimate studies, and even taxonomic questions. In particular, each newly revised palaeoflora brings an "added value" to the regional picture of vegetation, allowing to more fully appreciate temporal (diachronic) trends and regional (synchronic) diversification.

Coniacian assemblages are known from southwestern Poland (Idzików beds, Nysa Graben and Czerna Fm., North Sudetic Basin) and northern Bohemia (Chlomek beds and Březno beds, Bohemian Cretaceous Basin). The palaeofloras of Idzików beds (33 species), Chlomek beds (20 species), and Březno beds (15 species) are relatively similar and interpreted as representing salt marsh, coastal wetland, riparian forest, and mesophytic forest communities. The assemblage from the North Sudetic Basin (main localities: Rakowice Małe and Bolesławiec) is broadly similar (ca. 15 species; study in progress), but a few characteristic morphotypes, like *Menispermites*, are unknown in the above-mentioned palaeofloras.

Campanian assemblages were described from southern Poland and western Ukraine (Krasnobród and Potelych; 25 species), southern Sweden (Köpinge; 10 species), and western Germany (Haldem, unrevised). Their general character is broadly similar (*Dewalquea*-conifer coastal forests), yet regional diversification can be traced through the number of *Dewalquea* species present (Scania – 1; Haldem – 2; eastern Poland – 3) and presence or absence of *Rarytkinia*. These three assemblages stand in sharp contrast to

the flora from Grünbach (Austria; 53 species) characterised by presence of several angiosperms with large leaves (*Theiaiphyllum*, *Juglandiphyllites*) and palms; this may be due to difference in age (early vs. late Coniacian), palaeogeography (more southern location), or palaeoecology (coastal vs. swamp setting).

Platanoids are an important constituent of most of the studied assemblages independently of their age. On the contrary, there is no post-Coniacian record of *Frenelopsis* (regional extinction), whereas the "*Debeya* group s.s." is common solely in younger (Campanian and Maastrichtian assemblages).

The study of the Cretaceous vegetation and flora of the North Sudetic Basin was financed through the grant 2016/21/B/NZ8/02443 of the National Science Centre (Poland) to ATH.

O348

ORIGINATION OF *NUPHAR* AND NYMPHAEACEAE CLADE BASED ON LEAF ARCHITECTURAL CHARACTERS OF A MIDDLE EOCENE WATER LILY FROM MESSEL NEAR FRANKFURT, GERMANY

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While the leaf architecture of the living Nymphaeales is well understood, the leaf morphology and venation for fossil water lilies is poorly known, for there are no leaf fossils for several clades in the order, such as for *Nuphar* and *Barclaya*. Fossil evidence for *Nuphar* is particularly important, because the yellow pond water lily is thought to be basally placed in the family Nymphaeaceae. Up to now, although *Nuphar* fruits, seeds, rhizomes have been reported from the Eocene, fossil leaves have remained elusive in the Cenozoic record. Here we describe the first fossil *Nuphar*-like leaves from the middle Eocene lake of Messel near Frankfurt, Germany. The vegetative and leaf architectural characters of the leaf morphotype were coded and analyzed phylogenetically using PAUP and an existing data matrix with leaf characters of living Nymphaeales. The *Nuphar*-like characters of the leaf morphotype are its elongate leaf shape, peltate petiole attachment, actinodromous basal venation, pinnate venation along the rest of the midvein, and weakly brochidodromous to cladodromous secondary venation. Phylogenetic results show that the Messel water lily is sister to all Nymphaeales, sister to the *Nuphar* clade, or sister to all Nymphaeaceae excluding *Nuphar*. In any case, the Messel water lily was clearly a member of the order Nymphaeales and the family Nymphaeaceae, and also illustrates the character transition at the base of the family. Thus, this leaf morphotype provides supporting evidence for the emergence of the *Nuphar* clade at least 47 million years ago, as well as for vegetative and leaf architecture characters found in the basal members of the Nymphaeales. This middle Eocene leaf appears to be oldest *Nuphar*-like leaf known in the fossil record.

O349

MUCH MORE THAN "LIVING FOSSILS": A NEW PHYLOGENETIC HYPOTHESIS OF THE CYCADALES.

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The Cycadales are commonly perceived as quintessential "living fossils", with the peak of their evolutionary history traditionally placed in the Jurassic. Even if this view is due at least partially to the confusion between cycadophytic foliage produced by the Bennetittales and truly cycadalean leaves, the view of the Cycadales as a Mesozoic group has persisted in the scientific and popular literature. However, the results of recent molecular dating seem to indicate that most of the extant species diversity originated during the Late Miocene and the Pliocene.

The resolution of this conundrum is hindered by our insufficient understanding of the relationship between fossil and extant diversity in the cycads. Some fossils have been compared to extant species without a formal phylogenetic assessment, generating a host of potentially misleading relationship hypotheses. Most phylogenetic analyses of the cycads including fossil taxa have included non-overlapping sets of stem and leaf genera, and obtained relationships between the extant taxa that conflict with results from molecular phylogenies.

We use recent advances in the integration of fossils and molecular phylogeny to generate a new phylogenetic framework for the Cycadales. We generated a matrix of 31 macromorphological and cuticular characters for 57 cycadalean fossil leaf species and combined this dataset with a molecular and morphological dataset for 237 extant cycad species. We then analysed the data using the fossilized birth-death prior, which integrates information about the ages of the taxa, the order of branching and the rate of the molecular and morphological clocks. The resulting tree shows that most of the cycad fossil diversity falls outside the two crown groups (Zamiaceae and Cycadaceae). The monophyly of most fossil genera is rejected. A clade that includes most leaves with anastomosing venation, spanning from the Triassic to the Miocene, receives moderate support. The Zamiacae appear to originate in the Late Jurassic, with a host of Early Cretaceous fossils potentially representing an early radiation of the group. The stem of the extant genera appears to originate between the late Cretaceous and the early Palaeogene, with both fossils with recognizable morphologies and non-analogous character combinations.

In conclusion, our analysis shows both radiations, like the Early Cretaceous radiation of crown group Zamiaceae, and major extinctions that involved most of the Mesozoic lineages, some of which disappear completely during the Miocene. The cycads appear as a dynamic group, with a different and more complex evolutionary history than expected from the living fossil hypothesis.

POSTER PROGRAM IN FULL

MONDAY & TUESDAY (5PM – 6PM)

No.	Title	Presenting	Special Session
P001	Chitinozoan biostratigraphy in the Ordovician of Saudi Arabia	Cesari Christian	1
P002	Upper Famennian Dasberg Event due to palynological investigation (Kowala, Holy Cross Mountains, Poland).	Marcelina Kondas	2
P003	Fossil Prasinophytes in fluid inclusions of halite from the Lower Permian evaporite deposits (Upper Pechora Basin, Russia)	Natalya Ilyina	2
P004	Palynological evidence of early Devonian short-term transgressions on the southern edge of the Old Red Sandstone Continent (central and eastern Poland)	Magdalena Kruszyna	2
P005	City slickers versus country yokels: differences in the foraging behaviours between urban and rural bees in northeast England.	Jessica McCoy	7
P007	Plant pollen in the air of SosnowiecPlant pollen in the air of Sosnowiec.	Katarzyna Dąbrowska-Zapart	7
P008	Botanical origin of honeys from NE Poland based on pollen analysis	Magdalena Fiłoc	7
P009	Comparison of pollen composition in bee-collected pollen pellets and honey from hives in two different geographical locations	Tiiu Koff	7
P010	The palynology applied in study about bees-nectariferous plants interaction in a Brazilian Savanna	Cláudia Silva	7
P011	Allergenic and melliferous palynoflora profile of Pakistan	Mehwish noor	7
P012	False rings of fossil wood as an indicator of monsoon type of climate in the Cenomanian of the Bohemian Cretaceous Basin, Czech Republic	Josef Greguš	10
P013	An updated overview of fossil wood from the Cenozoic volcanic area of Doupovské hory and České středohoří Mts., Czech Republic	Vít Koutecký	10
P016	Palaeofloristics of early Miocene lignite basins in the Soma area based on plant macrofossils - preliminary results and prospects	Tuncay Güner	13
P017	Elaeocarpaceae fruits from the Oligocene of the Petroșani Basin, Romania	Roxana Pirnea	13
P019	Palynology of the Central Myanmar Basin corroborates Eocene–Oligocene monsoonal conditions in south-east Asia	Huasheng Huang	14
P020	Palynological Signal of Heinrich Event 1	Irina Delusina	17
P021	Vegetation and climate changesof the Plio-Pleistocene phase in Nihewan basin	Yuecong Li	17
P022	Palaeoenvironments, palaeoclimate and palaeofloristic composition in central Spain (Madrid Basin) during the Middle Miocene Global Cooling Event	Manuel Casas Gallego	17
P023	Plant-soil interactions and weathering within cryptogamic ground covers (CGCs): applying a novel multi-modal and multi-scale analysis via correlative imaging and Focussed Ion Beam (FIB) Microscopy	Ria Mitchell	21
P024	New data on peltaspermalean in situ pollen from the Permian of the Russian Platform	Tatiana Foraponova	22
P025	Trebecenia sarcocalycalis, Late Cretaceous capsular fruit from the Czech Republic.	Zuzana Heřmanová	22
P026	A carbon stable isotopic shift recorded by the Kungurian flora of Tregiovo (Val di Non, northern Italy)	Giuseppa Forte	22

P027	Geochemistry of Cedrus atlantica pollen and the potential for long-term reconstruction of moisture availability and summer UV-B flux across North Africa.	William Fletcher	23
P028	Stable carbon isotope composition of n-alkanes in Cretaceous plants from the Bohemian Cretaceous Basin as an indicator of palaeoecology	Petra Zahajská	23
P029	Reconstruction of solar ultraviolet irradiance: implications for future climate	Phillip Jardine	23
P030	Holocene fire history and vegetation dynamic in Komi Republic, Urals region, Russia	Chéïma Barhoumi	26
P031	The Holocene development of lower mountain forest and its fire history in the Beskid Makowski Mountains (Western Carpathians, southern Poland)	Piotr Kołaczek	26
P032	New data about ancient distribution of Abies alba and Fagus sylvatica in low mediterranean mountain areas (Northeastern Iberian Peninsula): relict species or human intervention?	Marc Sanchez Morales	26
P033	Fire in the Near East: Different Relations of Paleofire Activity and Vegetation Change in the Southern Levant and Eastern Anatolia	Andrea Miebach	26
P034	Vegetation dynamics, human impact and fire history in the temperate deciduous forest zone of Central European Russia during the last 4000 years	Natalia Mazei	26
P035	Diet of extinct Stephanorhinus kirchbergensis on the basis of palaeobotany research	Anna Hrynowiecka	26
P037	The Late Holocene vegetation changes in the Beskid Wyspowy Mountains (Western Carpathians, Central Europe) based on palynological analysis of small rich fen	Sambor Czerwiński	26
P038	Biotic controls on Holocene biomass burning in the temperate forest zone of central Europe	Přemysl Bobek	26
P040	Towards the palaeoecological reconstruction of Madeira Island vegetation (Portugal): first results from Fanal and Caramujo ponds	Carlos A. Góis-Marques	26
P042	Palynology and micropalaentology of Holocene lacustrine sediments of the Layla Lakes, central Saudi Arabia: Implications for changes of palaeoenvironment and palaeoclimate	Jürgen Mutzl	26
P043	Plant landscape dynamics of west Attiki (south Greece) since the Late Glacial	Styliani Kyrikou	26
P044	Preliminary results of a palynological study in lake Koronia, (NC Greece)	Maria Aspasia Moutzouri	26
P045	Cold climate changes in middle Holocene including the 8.2 ka event - evidence from Suchar Wielki Lake, NE Poland	Magdalena Fiłoc	26
P046	The extraction of macroscopic charcoal from sedimentary sequences	Margarita Tsakiridou	26
P047	Developing altitudinal training sets of pollen rain-site specific temperatures in the Alps as a base for paleoclimate reconstructions of high-altitude fossil records	Maria Antonia Serge	27
P048	After landslide forest recolonisation: a 4000 years old case study from Kalavan Red Lake (Armenia)	Sebastien Joannin	27
P049	Reconstruction of vegetation and palaeoclimate of Late Glacial and Holocenein Western Sayan mountains (south Siberia, Russia) according topollen data from Yuzhno-Buibinsky mire.	Tatiana Blyakharchuk	27
P050	Reconstructed climate variability over the last 17000 years in the Dessarete region inferred from new pollen records of Lake Ohrid and Prespa	Konstantinos Panagiotopoulos	27
P051	Building up a pollen-vegetation-climate-enviroment training set from Gran Canaria as a tool for palaeoenvironment and palaeoclimate reconstructions	Maria Antonia Serge	27
P052	The Holocene development of supramontane vegetation based on pollen analysis	Malvína Čierniková	27
P053	Holocene vegetation and fire dynamics at Crveni Potok, a small mire in the Dinaric Alps (Tara National Park, Serbia)	Walter Finsinger	27
P054	Plant remains from fossil faeces (coprolites) of a large predatory archosaur from the Upper Triassic of Silesia, Poland	Artur Górecki	32
P055	Enigmatic evidence of plant-insect interaction from the Middle Jurassic of Poland	Agata Jarzynka	32

P056	Seed ferns and cycads in the Rhaetian flora of Wüstenwelsberg, Bavaria, Germany	Christian Pott	32
P057	A comparison of the North American and European Carnian and Norian palynofloras	Viktória Baranyi	32
P058	Ferns from the family Matoniaceae with in situ spores from Jurassic Grojec clays near Cracow (Poland)	Jadwiga Ziaja	32
P059	The plant mesofossil flora of the Upper Cretaceous Ajka Coal Formation – Preliminary results	Emese Bodor	32
P060	A new look at the Cretaceous pinaceous cones of Belgium.	Cyrille Prestianni	32
P061	Quantitative analysis of epidermal characters of late Permian conifer leaf cuticles and its taxonomic value	Ivo Duijnstee	33
P062	The Avellino event: a Bronze Age environmental reconstruction from the Pontine plain and the Fondi basin, southern Lazio, central Italy	Michael Field	35
P063	Postglacial dynamic of quillwort populations (Isoëtes) in Prášilské lake, Bohemian Forest	Alice Moravcová	35
P065	Vegetation history of spring-fed fen on Westren Pomerania (N Poland)	Danuta Drzymulska	35
P066	A modern pollen dataset from the north Sikkim area, eastern Himalaya: implications for palaeovegetation reconstruction	Jyotsna Dubey	35
P067	Palynological reconstruction of the Late-Glacial to Holocene flora, vegetation and landscape changes in the Northern Lake Attersee region (Austria) and climatic variability based on the past abundance of the annual water plant Najas flexilis	Melissa Sehrt	35

THURSDAY (5PM – 6PM) & FRIDAY (12.30PM – 2PM)

P100	Stratigraphic distribution of miospores in the Ladinian (Middle Triassic) deposits at Cape Tsvetkov section, East Taimyr, Northern Middle Siberia, Russia	Natalya Ilyina	3
P101	Palynostratigraphic correlation of the Lopingian to Middle Triassic	Hendrik Nowak	3
P102	New dinoflagellate cyst species from the Bathonian-Kimmeridgian of the Laminaria High, Bonaparte Basin, North West Shelf, Australia.	Joe Scibiorski	3
P103	Palynostratigraphy from the Lower Cretaceous Peñaferruz Formation, San Pedro de Antromero Beach (NW Iberian Peninsula).	Iván Rodríguez-Barreiro	3
P104	Toward a palynological calibration of the Barremian-Aptian boundary	Nicoletta Buratti	3
P107	X-ray computed tomography as a tool for bioerosion analysis on foraminiferal tests.	Zuzana Heřmanová	4
P108	Basal angiosperms and angiosperm-like pollen from Aptian/Albian strata of Austria and Mongolia.	Christa-Ch. Hofmann	4
P109	Exine ultrastructure of fossil ginkgoalean pollen: the first data from an in situ material	Natalia Zavialova	4
P110	Fine structure of Wodehouseia pollen	Svetlana Polevova	4
P111	Lamellate structures in sporoderms of Isoetes microspores and angiosperm pollen grains	Darya Ashikhmina	4
P112	Pollen Morphology of Gnetum in Thailand	Wongkot Phuphumirat	4
P114	Pollen in karst caves provides new insights into the environment background of fauna evolution in Pleistocene, Guangxi, South China	Su-Ping Li	4
P115	Sculptures of Quercus pollen from the late Middle Pleistocene of Northeastern Thailand	Paul J. Grote	4
P117	Development of riparian forest and oxbow lake ecosystems along the Early Holocene warming in the San River Valley (Central Europe): a multi-proxy study	Piotr Kołaczek	5
P118	Three centuries of forest changes and peatland development along economical and national turnovers central in Greater Poland (western Poland, Central Europe) – preliminary results	Sambor Czerwiński	5

P119	A comparative study of the modern pollen taxa observed in surface deposits from Tripura and Mizoram in northeastern India	Nivedita Mehrotra	5
P120	High-resolution palaeoecological analyses of the small Alpine peatland „Blackenalp-Oberes Moor“ (Canton Uri, Switzerland) revealed possible artificial creation of a pond as watering place for livestock around AD 1575	Jean Nicolas Haas	5
P121	From bog to fen - palaeoecological development of a calcareous spring fen in Saaremaa, Estonia	Ansis Blaus	6
P123	The relationship of pollen-floristic diversity in poor-species and rich-species regions of Czech Republic	Vojtěch Abraham	6
P124	Small scale studies of pollen productivity based on moss samples from calcareous meadows in Estonia – special attention to Helianthemum	Tiiu Koff	6
P125	Environmental history and vegetation dynamics in the area of central Croatia	Dario Hruševar	6
P127	Vegetation dynamics and human activity in the Middle Oka River Basin (European Russia) during the Middle and Late Holocene	Vlada Batalova	6
P128	Coniferous species of Azerbaijan and their role in forming Holocene landscape	Yelena Taghiyeva	6
P129	The Pollen Monitoring Programme; the first two decades	Heather Pardoe	6
P130	Pollen Productivity Estimates of Mediterranean taxa – first results from southern France	Laurent Marquer	6
P131	Filamentous cyanobacteria in Jurassic geothermal paleoenvironments from Patagonia, Argentina	Michael Krings	8
P132	A fire regime framework for understanding paleowildfire in hyperoxic times: combustion, simulations, and paleoenvironmental reconstructions	Benjamin Muddiman	9
P133	A Chemical and Morphological Study of Nitraria (Nitrariaceae) Pollen, with Implications for Historical Biogeography	Amber Woutersen	9
P134	Guard Cell Regulation in Plants: Abscisic Acid Sensing in Stomata Derived by the Late Paleozoic?	William Matthaeus	9
P135	Plant-Animal Interactions in the Carnian (Upper Triassic) of Northern Italy (Cortina d’Ampezzo, Belluno Province)	Doriano Fossen	11
P136	Middle Triassic Amber from the Southern Alps of Italy	Guido Roghi	11
P137	New stratigraphical data on amber from northern Apennines (Italy)	Mirco Neri	11
P138	Plant cuticles from the Albian of El Soplao, Cantabria, northern Spain	Bernard Gomez	11
P139	Origination of the Sacred lotus family: Preliminary phylogenetic placement of the Nelumbonaceae, with new Nelumbo-like leaves from the late Oligocene fossillagerstätte of Rott near Bonn, Germany	David Taylor	16
P141	Phoenicopsis (Leptostrobales) and Pseudotorellia (Ginkgoales) in the Cretaceous of North Asia	Natalia Nosova	16
P142	The Bletterbach Biota and the Lopingian (late Permian) ecosystems	Evelyn Kustatscher	16
P143	Whole-plant reconstruction, updated phylogeny and pollination mechanism of Austrohamia acanthobractea (Cupressaceae) from the Middle Jurassic of NE China	Chong DONG	18
P144	Palynofloral evolution on the northern margin of the Indian plate, southern Qinghai-Xizang plateau, China during the Cretaceous Period	Jianguo Li	18
P145	Early Permian palynomorphs and their palaeoclimatic implication: A case study from Rajmahal Basin, India	Srikanta Murthy	18
P146	Wildfires are not only important for land ecosystems but may provide essential regulation of ocean habitat conditions	Sarah Baker	24
P147	Milankovitch forcing of Early Jurassic wildfires	Teuntje P. Hollaar	24
P148	Environmental influences on Ancient Maya Land-Use in Belize	Adam Bermingham	24

P149	Another maar lake, another story: Palynological study of Eocene lacustrine sediments at Groß Zimmern (Hesse, Southwest Germany)	Jürgen Mutzl	24
P150	Refining plant cuticle-based leaf mass per area proxies to unlock plant responses to climate change in the past and the future	Emily R. Calvin	24
P151	Palaeoenvironments, vegetation and climate from the Middle to Late Miocene Brassington Formation, UK	Matthew Pound	25
P152	Fossil evidence for the diversification of crown-group Cunoniaceae from the early Paleocene (Danian) of Patagonia, Argentina	Maria A. Gandolfo	25
P153	Cyclic changes in plant diversity and paleoecological characteristics during the Middle Miocene in Carpathian Foredeep and Central Paratethys (Czech and Slovak Republics).	Marianna Kováčová	25
P154	Palynomorphs from Neogene sediments of the Banatsko Aranđelovo local depression (Serbia)	Jelena Milivojević	25
P155	Diversity patterns in microfloras recovered from Miocene brown coals of the Lower Rhine Basin reveal distinct coupling of the structure of the peat-forming vegetation and continental climate variability	Torsten Utescher	25
P156	The Late Oligocene Flora from Western Serbia (The Zapadna Morava Graben)	Zorica Lazarević	25
P157	Palynological analysis of the middle Miocene in the E8-X core in the North Sea	Ella Quante	25
P158	Climate and vegetation dynamics during the Eocene greenhouse of central Europe: Palynological investigation of lacustrine sediments from Lake "Prinz von Hessen" (Southwest Germany)	Maryam Moshayedi	25
P159	Efficacy of grass phytoliths in discriminating deltaic sub-environments of Indian Sunderbans: implications in late Quaternary environment reconstruction	Madhab Naskar	28
P160	History of Sami society and reindeer herding in northern Fennoscandia in light of the coprophilous fungal spores	Mari Kuoppamaa	28
P161	West African hydrological variability over the past 150,000 years inferred from a marine non-pollen palynomorph record	Fabienne Marret	28
P162	Non-pollen palynomorphs from drained and rewetted fens	Almut Mrotzek	28
P163	The phenomenon of Kungur forest-steppe (pre-Urals): implementation of pollen and non-pollen palynomorphs	Lyudmila Shumilovskikh	28
P164	Testate amoebae as a proxy for reconstruction of palaeo-hydrological regime in peatlands: a case study from the Eastern-European plain	Yuri Mazei	28
P165	Stamps of pollen as an artistic technique for palynological divulgation	Vojtěch Abraham	29
P166	The Maastrichtian Kakanaut flora of the North-East of Russia	Anastasia Gnilovskaya	31
P167	Palaeoenvironmental reconstruction of the Late Cretaceous Iharkút (Hungary) dinosaur locality based on angiosperm mesofossils	Emese Bodor	31
P169	Plant mesofossils from the Campanian–Maastrichtian of Lo Hueco, Cuenca, Spain	Véronique Daviero-Gomez	31
P170	The Cretaceous flora of Westphalia, Germany, revisited	Christian Pott	31
P171	Non-pollen palynomorphs (NPPs) from alder carr surface samples (NE Germany)- A tool for reconstructing past site conditions	Anja Prager	28
P172	Reconstruction of atmospheric CO_2 concentration during the late Changhsingian based on fossil conifers from the Dalong Formation in South China	Hui Li	20

10TH EUROPEAN PALAEOBOTANY & PALYNOLOGY CONFERENCE

POSTER ABSTRACTS

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P001

CHITINOZOAN BIOSTRATIGRAPHY IN THE ORDOVICIAN OF SAUDI ARABIA

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Chitinozoans are a major component of the palynological assemblages recovered from the Ordovician marine sediments of Saudi Arabia, making them a powerful tool for biostratigraphic study in this region. The current Saudi Aramco operational zonation scheme comprises eight palynozones in the Ordovician. In addition, the First Downhole Occurrences (FDOs) of fifteen chitinozoan species are routinely used as correlative events on a regional scale over Ordovician section, allowing reliable and accurate correlations of stratigraphic horizons as well as identification of sequence boundaries and possible flooding surfaces.

The Sajir Member of the Saq Formation contains the oldest Ordovician sedimentary rocks of Saudi Arabia, it was mainly deposited in proximal marine settings resulting in impoverished chitinozoan assemblages. The upper part of the Sajir Member is characterized by rare *Desmochitina bulla* and *Belonechitina henryi* occurrences indicating a Darriwillian age. The Saq Formation is overlain by the Qasim Formation deposits of Middle to Late Ordovician age. The Qasim Formation is composed of four units, the Hanadir, Kahfah, Ra'an and Quwarah members, listed in ascending stratigraphic order. The shales of the Hanadir Member yield moderately to highly diverse and often abundant chitinozoan faunas. *Linochitina pissotensis*, *Laufeldochitina clavata* and *Siphonochitina formosa* have their First Downhole Occurrences (FDOs) in these deposits indicating a Darriwilian age. Chitinozoans from the Kahfah Member, which is more silt- and sand-prone, are usually rare and poorly diverse; *Sphaerochitina compactillis* is one of the few key species used to identify this unit and is believed to range from the Sandbian to the lower Katian (Upper Ordovician). The Ra'an Member is considered to be a potential source rock in some areas, its upper boundary is characterized by the FDO of *Tanuchitina fistulosa* indicating a mid-Katian age. The Quwarah Member displays the greatest chitinozoan diversity in the Ordovician record of Saudi Arabia, it contains the FDOs of species such as *Armoricochitina nigerica*, *Tanuchitina contracta*, *Calpichitina bernardae* and *Alhajrichitina adamantea* among others, indicating a late Katian age. The Sarah Formation is the youngest stratigraphic unit of the Ordovician in Saudi Arabia, it has been extensively studied in recent years due to its hydrocarbon reservoir potential. The deposition of the Sarah Formation was largely controlled by subglacial erosion linked to advances and retreats of the icecap during the Hirnantian, as a result most of the chitinozoans recovered from it are reworked from older strata and *in-situ* specimens are usually very scarce (e.g., *Calpichitina lenticularis*, *Spinachitina* spp.) or absent.

P002

UPPER FAMENNIAN DASBERG EVENT DUE TO PALYNOLOGICAL INVESTIGATION (KOWALA, HOLY CROSS MOUNTAINS, POLAND).

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The investigated section is located in active Kowala Quarry in the southern limb of the Gałęzice-Kowala syncline (Holy Cross Mountains, Poland). The Kowala Quarry is place known for its well-preserved record of the Late Devonian extinction events. The analyzed section comprises two horizons of the black shales, related to the global Dasberg event.

The Dasberg event section from Kowala has been already the object of the palynological investigation (Marynowski, Filipiak et al., 2010). The results of the previous researches were very prospective, so the palynological investigation has been done once again, but with higher resolution. Samples were taken directly from the outcrop and for all 23 samples a palynological investigation was carried out.

Based on the miospore assemblage the age of the investigated samples was established as VF (*Diducites versabilis–Grandispora famenensis*) and LF (*Retispora lepidophyta–Grandispora facilis*) of the Middle/Upper Famennian.

A palynofacies analysis was done as well. The ratio of acritarchs and prasinophytes (as a marine component) and miospores together with phytoclasts (as a terrestrial component) were used to characterize palynological organic matter. All samples taken from the black shales horizons contained large amounts of well-preserved palynomorphs, mostly represented by phytoclasts and prasinophytes (mainly *Leiosphaeridia*). Miospores were less numerous, and the whole assemblage of them was dominated by few taxa (*Auroraspora* sp., *Diducites* sp., *Grandispora* sp., *Knoxisporites* sp.). Acritarchs occurred only as a single specimens. In general, there were small changes in the palynofacies composition in both analyzed black shales horizons. Upper black shale horizon contained more miospores and less prasinophytes than lower one. The tetrads of miospores were found in upper horizon as well.

The presence of prasinophytes and very limited number of acritarchs might indicate low-oxygen conditions (Tyson, 1995). All samples contained high amounts of amorphous organic matter, which supports the previous conclusion. Taking into account the proportions of various components, the depositional environment may be determined as sub-oxic-anoxic shelf (Batten, 1996).

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P003

FOSSIL PRASINOPHYTES IN FLUID INCLUSIONS OF HALITE FROM THE LOWER PERMIAN EVAPORITE DEPOSITS (UPPER PECHORA BASIN, RUSSIA)

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Finds of microfossil, known in the literature as Tasmanites, are developed in a variety of oil bearing deposits around the world. These green algae are usually presented in the form of disc-shaped cysts, since their initial spherical shape was changed as a result of fossilization (Efremova, 1990).

In fluid inclusions of halite from the Upper Pechora basin, the presence of various palynomorphs was detected. Among them, cysts of fossil green algae (Prasinophyta) were found. Cysts retained their initial spherical shape, they were not melted, and their surface was not exposed to corrosion by microbes that usually occur during fossilization. Therefore, the study of such well-preserved Permian prasinophytes may help to recognize morphological features inherent in this group of algae. The size of the cysts varies from 20 to 40 μm. The cysts have a smooth surface of the sphere, sometimes with particular hills; often the surface of the sphere is wrinkled. They have a specific yellowish or else lemon yellow color, more rarely a reddish-brown color. Some forms have a well-marked pylome. Probably they can be attributed to the fossil algae of the families Tasmanitaceae and Leiosphaeridiaceae (Tappan, 1980; Guy-Ohlson, 1996).

The formation of tasmanites cysts found in fluid inclusions in halite, associated with the onset of adverse environmental conditions. In the salty Kungurian sea, these algae are usually found only on the sites of local freshening, and their findings are confined to terrigenous packs (Guy-Ohlson, 1996). They were brought by fresh sea waters in evaporate basin and with increasing salinity formed cysts with a thick walls.

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P004

PALYNOLOGICAL EVIDENCE OF EARLY DEVONIAN SHORT-TERM TRANSGRESSIONS ON THE SOUTHERN EDGE OF THE OLD RED SANDSTONE CONTINENT (CENTRAL AND EASTERN POLAND)

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On the southern edge of the Old Red Sandstone Continent, in the early Devonian, a series of epicontinental sedimentation basins have been developed. Deposits filling the basins were recognized in cores drilled in central and eastern Poland. The sedimentary sequence of the basins starts with open-shelf deposits and ends with thick red beds. It reflects the eustatic sea-level drop during early Devonian.

The subject of the study presented here is a thick, homogeneous alluvial sequence named Zwoleń Fm, which represents the maximum of early Devonian regression. Due to its terrestrial nature, lack of outcrops and macrofossils the attempts to separate it from the under- and overlying formations and to track changes in the depositional environment were made mainly on the basis of sedimentological data. However the results are not convincing enough.

The palynostratigraphic studies carried out so far indicated that palynomorphs are in an excellent state of preservation and shows their high taxonomic diversity. The detailed stratigraphic analysis showed that the sporomorphs which are characteristic for middle Lochkovian *Streelispora newportensis-Emphanisporites micrornatus* (NM) Zone/Si Lineage Zone in the lower part of the alluvial sequence and late Lochkovian *Breconisporites breconensis-Emphanisporites zavallatus* (BZ) Zone/Z Lineage Zone in the top part of the underlayed formation in the eastern part of the basin. In the northwestern part of the basin the deposition of Zwoleń Fm ended in the late Emsian *Emphanisporites foveolatus-Verruciretusispora dubia* (FD) Zone or early Emsian *Emphanisporites annulatus - Brochotriletes bellatulus* (AB) Zone, whereas in the northeastern part it ceased already in the late Pragian/early Emsian *Verrucosisporites polygonalis-Dibolisporites wetteldorfensis* (PoW) Zone/Su Lineage Zone. This means that even between closely located sections boundaries are not isochronous, which is typical for terrestrial deposits.

Palynological methods allow to trace diachronous boundaries, secondary sea level changes during Zwoleń Fm sedimentation and to correlate individual sections. Careful palynofacial analysis is a key argument supporting the not always sufficient sedimentological data indicating the occurrence of short-term sea transgressions in the studied area. Some samples contain at least two generations of palynomorphs- small diverse assemblages of immature marine palynomorphs as Acritarcha, Leiosferida and Chitinozoa mixed with highly alterated spores and terrestrial tissues are proof of redeposition induced by erosion during rapid transgression.

P005

CITY SLICKERS VERSUS COUNTRY YOKELS: DIFFERENCES IN THE FORAGING BEHAVIOURS BETWEEN URBAN AND RURAL BEES IN NORTHEAST ENGLAND.

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Urban areas offer opportunities for honeybees where there is often an unexpectedly rich diversity in flowers in gardens, allotments, "wild" areas and increasingly because of the sowing of wildflower meadows or strips by local authorities. Beekeepers have acknowledged this, and the past few years have seen an increase in the number of urban and suburban hives in the UK.

With the ongoing process of urbanisation and the continued promise of successive governments to build more houses it is timely to raise awareness of the plight of urban biodiversity, including honeybees, and the to ensure that urban and suburban areas are managed in a bee-friendly manner. This is important for both beekeepers and the wider population of urban areas. However, though the interests of both groups are similar, they are not necessarily identical. City councils, schools and local conservation groups will be interested in creating habitats supporting a rich pollinator diversity. Councils also have to take into account the aesthetics of their planting schemes: which flowers "fit" into the urban landscape, and how they are (especially wild flowers) perceived by the general public. Beekeepers will want to know whether the right pollen and nectar sources for their honeybees are available so that their enterprises can be productive.

We present melissopalynological data and pollinator surveys from urban & suburban from Newcastle-upon-Tyne, through suburban areas and into the more rural Tyne Valley. Melissopalynology has been conducted on honey and pellet samples at a fortnightly and weekly time interval, respectively. Pollinator surveys were conducted at fortnightly intervals in the vicinity of the studied hives. All of this data has been collected with the assistance of trained volunteers, (who have been trained in both data collection techniques). Our (student) 'citizen science' approach not only provided a valuable and unique educational experience- the student learning experience was extended beyond the classroom and across traditional subject disciplines. It has allowed a significantly bigger data set to be generated than might have been possible with only the project leads and increased the number of students wanting to undertake pollinator or pollen based undergraduate research.

P007

PLANT POLLEN IN THE AIR OF SOSNOWIECPLANT POLLEN IN THE AIR OF SOSNOWIEC.

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The aim of the work is analyzing the course of pollen seasons and developing a calendar of pollen concentrations in the air of Sosnowiec in the period 1997 - 2017. Pollen calendars are an important source of data on the course of pollination, especially the one that has a strong allergenic effect.

The volumetric method using the Burkard apparatus was applied for the following tests. The measuring point was located at a height of about 20 m above ground level. The calendar was made on the basis of average daily concentrations, that have been reported for 21 years. Pollination was registered from January to October. Taxa are summarized in the order in which the pollen appears in the air in growing seasons. The calendar presents 23 taxa with allergic properties or occurring in the air in high concentrations, including: trees, herbaceous plants, cryptogams and fungi.

Taking into account the duration and course of pollen seasons in Sosnowiec, we can distinguish short, medium and long seasons. Short pollen seasons are characteristic for the majority of tree species and for ragweed, while long for pinaceae, grasses, sorrel, nettle and plantain, and for fungal spores that are present in the air practically throughout the year. April and May are months in which allergenic pollen concentration is the greatest - these months account for pollen grains with the largest number of taxa in the air plus fungal spores. The most asymmetrical pollen seasons with a short pre-peak period were characteristic for birch, pinaceae and mugwort, which means that these taxa reach their seasonal maxima soon after the start of the season. The fungal spores prevailed and accounted for as much as 84% of the total amount of the examined sporomorphs, while the pollen grains of trees and herbaceous plants accounted for 9 and 7% of this sum respectively. The cryptogams were few and their share in the composition of the Sosnowiec aeroplankton did not exceed even half a percent.

It is worth noting that several-peak course of curves of some taxa is caused by the fact that various species of particular type start to bloom, especially herbaceous plants. Tree taxa, on the other hand, especially early blooming species, with its multi-peak course of pollen grain concentration are caused by differences in occurrence of pollen and periods of its maximum concentration in subsequent years, due to unstable weather conditions during this period.

P008

BOTANICAL ORIGIN OF HONEYS FROM NE POLAND BASED ON POLLEN ANALYSIS

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Melisopalinological studies were carried out on honeys collected during 2014–2017 in NE Poland. These honeys were obtained mainly from beekeepers affiliated in the Regional Association of Beekeepers in Białystok. The main focus of investigations was on the floristic spectrum of plants and on the identification of the most common and important plant sources for honey. The pollen content of 201 honey samples was analysed with at least 300 pollen grains counted in a sample. Each analysed sample was 20 ml volume. Melissopalynological analysis followed the standard acetolysis method (Moore & Webb, 1978). Microscopic slides were prepared by performing a smear on a slide. 24 samples have an very low content of pollen. In the remaining samples the number of pollen grains ranged from 300 to 1939. More than 90 000 pollen grains and more than 100 pollen taxa were identified in the examined honeys, including 78 of entomophilous (nectariferous) taxa. All of these plant species are relatively common in NE Poland. The results showed that the pollen types of Brassicaceae, Cichorioideae, *Salix, Sorbus, Frangula alnus, Centaurea cyanus,* and *Fagopyrum* were the most abundant among the samples (more than 50%). The pollen of Apiaceae, Fabaceae, Asteraceae, Rosaceae, Poaceae, and *Filipendula* were present in more than 25% of samples. Based on the microscopic analysis results, 94 multifloral and 83 monofloral honeys were classified by botanical origin to determine their floral sources. In the unifloral honeys, the predominant pollen types were Brassicaceae (38 samples), *Fagopyrum* (27 samples), *Centaurea cyanus* (5 samples), *Tilia* (5 samples), *Sorbus* (4 samples), *Phacelia* (2 samples), Rosaceae (1 sample), and Rubiaceae (1 sample); the latter 4 honey varieties are not covered by Polish Standard. Usually, honey was considered unifloral when 45% of the relative frequency of all counted pollen was identified as belonging to a single taxon. However, because of the numerous over- or under-represented pollen types, pollen percentages can vary considerably between different unifloral honeys. Because the pollen of rape (Brassicaceae pollen type) in honey is over-represented, honey samples with over 60% Brassicaceae pollen are considered unifloral. In contrast, as the pollen of lime is under-represented, even honeys with 20% pollen identified within this taxon may be considered unifloral.

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P009

COMPARISON OF POLLEN COMPOSITION IN BEE-COLLECTED POLLEN PELLETS AND HONEY FROM HIVES IN TWO DIFFERENT GEOGRAPHICAL LOCATIONS

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This study analyzes the composition of pollen in bee-collected pellets and in honey from hives in the Central Valley of California and in southern Estonia over a three month period and compares the median pollen assemblages in honey and bee-collected pellets from the same hive. The resultsof the study are of broad interest to beekeepers who want to know about the source of nectar and pollen collected by bees for honey production. The pollen composition of honey normally correlates one-to-one with the amount nectar from which the honey is derived), but it can also be over-represented (percentage of pollen grains is higher than the amount of nectar from which the honey is derived), or under-represented (the percentage of pollen grains is lower than the amount of nectar from which the honey is derived) in honey samples.

In the case of Estonia (Puusepp and Koff, 2014) honey samples showed that pollen grains of some plant species (e.g. *Tilia cordata, Epilobium angustifolium, Fagopyrum esculentum* and *Taraxacum* spp.), which are described as very good nectariferous plants, are probably under-represented in the honey spectra. Therefore, we have to evaluate the floral origin of the honey by studying not only the honey but also the pollen pellets. Further studies should also consider this aspect.

However, this work also addresses a more particular environmental question and we cannot exclude climatic changes that can influence the overall process of pollination. We also have to consider that the loss of pollinators has grown and the richness of bee species and insect-pollinated plants has decreased. These factors may also have an effect on the pollen content of honey.

Puusepp, L., Koff, T. 2014. Pollen analysis of honey from the Baltic Region, Estonia. Grana: aninternational journal of palynology and aerobiology, 53 (1), 54-61.

P010

THE PALYNOLOGY APPLIED IN STUDY ABOUT BEES-NECTARIFEROUS PLANTS INTERACTION IN A BRAZILIAN SAVANNA

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Nectariferous plant species are more generalists than poliniferous plants and therefore maintain interactions with specialist and generalist bees at the same time. In nectariferous species, nectar is the main resource available to floral visitors and its production can determine the successful pollen dispersion among individuals in the population. In this study the aim was to understand the bees-nectariferous plants interactions in a Brazilian Savanna. For this reason palynology was used to support our direct observation of bees visiting flowers. The study was conducted in the Jataí Ecological Station (EEJ), located in Luís Antônio, São Paulo State, Brazil. Brazilian Savanna vegetation is present inside the EEJ where was demarcated two transects measuring 500 m x 10 m. These transects were run twice per month from August 2013 to July 2014. All the nectariferous plants blooming were sampled, identified and counted the number of individuals for each one of them. In these plants were observed the bees visiting flowers and subsequently the pollen grains deposited on their body were removed. The pollen collected was submitted to the acetolysis process and afterward identified at the more specific level. To identify the prevalence of the nectariferous plant species used in the bees' diet were considered the first 400 pollen grains founded in each sample. Were collected 262 bees of 42 species visiting 12 nectariferous plant species, and identified 93 plant species through of the pollen grains deposited in their body, most of them was considered nectariferous species. Was observed an intermediate level of specialization (*H2'* = 0.41) through direct observation and a more specialized level when analysing the interaction through pollen grains deposited on the body of bees (*H2'*= 0.62). In this study the palynology was important to better understand the interactions between bees and nectariferous plants.

P011

ALLERGENIC AND MELLIFEROUS PALYNOFLORA PROFILE OF PAKISTAN

Mehwish Noor

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Current study is focused on taxonomic investigation of allergenic and melliferous spore and pollenflora of Pakistan. Detailed studies were carried out under various techniques of microscopy. Forty one pollen grain of twenty six botanical families of allergenic and melliferous importance was studied. Six spore types were also carried out. Significant botanical families are Asteraceae, Myrtaceae, Poaceae, Brassicaceae, Rosaceae, Pinaceae etc. Detailed pollen features are elaborated in the light of taxonomy. mathematical aspects of pollen and spore surface, apertures, exine, number and arrangements of apertures. Sculpturing of pollen and spores were diverse viz., Psilate, echinate, scabrate, reticulate, bireticulate or echinolophate etc. Present studies prove useful guide for identification of pollen and spore of allergenic and melliferous in aerobiological and honey product identification.

P012

FALSE RINGS OF FOSSIL WOOD AS AN INDICATOR OF MONSOON TYPE OF CLIMATE IN THE CENOMANIAN OF THE BOHEMIAN CRETACEOUS BASIN, CZECH REPUBLIC

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Fossil wood from the Cenomanian of the Bohemian Cretaceous Basin was studied. The most productive locality Pecínov Quarry provided large amount of material preserved as xylitic coal, charcoal and permineralized wood from freshwater mudstone and sandstone sediments of the Peruc The paleoenvironment of this locality is characterized as a succession of deposits from a shallow, gravelly braided river (Unit 1), tide-influenced braided river (Unit 2), supratidal marsh (Unit 3) and tidal flat (Unit 4) to ebb-tidal delta to estuary mouth fill (Unit 5). Three-dimensionally preserved charcoal wood is partly permineralized and comes from Unit 5. This wood shows anatomical features providing characters of the family Cupresaceae s.l. Some specimens show atypical type of growth rings termed false rings in latewood which are caused by abiotic stress factors. We interpreted them as indicators of seasonal alternation of precipitation volume. Similar type of false rings occurs in related extant species as *Taxodium distichum*, *T. mucronatum* occurring in areas influenced by monsoon climate. This interpretation is independently supported by paleoclimatic data estimated for the Peruc and Klikov floras using CLAMP analysis. In these studies it was discovered that ratio of average precipitation of three driest and three wettest months is close to 1:5 and precipitation of three wettest months is close to be equal or higher than 55% of total annual precipitation. Occurrence of false rings and mentioned climatic parameters gained by CLAMP indicate monsoon type of climate.

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P013

AN UPDATED OVERVIEW OF FOSSIL WOOD FROM THE CENOZOIC VOLCANIC AREA OF DOUPOVSKÉ HORY AND ČESKÉ STŘEDOHOŘÍ MTS., CZECH REPUBLIC

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Doupovské hory and České středohoří Mts. are two volcanic complexes situated in the area of the so-called "Ohře Rift" (NW Bohemia, Czech Republic), which represents a fault zone oriented NE-SW and formed in late Eocene–early Miocene time period. In total, there are about 22 different wood types identified so far from 10 localities in various volcano-sedimentary settings. Recently, a fossil wood locality Rokle was discovered in the bentonite pit near Kadaň with three wood types (Cupressaceae s.l., Lauraceae, Platanaceae). The last investigation has also shown new fossil woods in Dvérce, Bečov and Divoká rokle localities (unknown conifer, Platanaceae, Fagaceae, Malvaceae s.l.). This updated overview extends our knowledge about the systematics of fossil wood and its stratigraphical position in the area of the north-western Bohemia.

The megaflora includes pteridophytes like *Selaginella* strobilus, *Azolla* Microsporocarp, Isolated *Salvina* Megaspore and *Marsilea* petiole, Angiosperms like Monocot roots, *Viracarpon* and *Baccatocarpon* fruits and *Sahnianthus* flower are found in Maraipatan exposure whereas scattered palm stem and isolated palm roots, few dicot woods, *Enigmocarpon* fruit and *Sahnianthus* flowers found in silicified black cherts of Pudiyalmohada locality. Few scattered palm wood also found Bhari locality. Other exposures show black ill-preserved cherts.

Key Words:- Fossil, Deccan, Intertrapps, petrified, angiosperms.

P016

PALAEOFLORISTICS OF EARLY MIOCENE LIGNITE BASINS IN THE SOMA AREA BASED ON PLANT MACROFOSSILS - PRELIMINARY RESULTS AND PROSPECTS

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The Soma lignite Basin is located in the western part of Anatolia. The main exploited coal (lignite) seam formed in the mainly NE-trending karstic and possibly fault bounded topographic depressions and synclinal troughs (İnci, 2002). Due to the fact that it is an important coal basin in Turkey, it has been studied geologically by various researchers (Nebert, 1978; Brinkmann et al., 1970; Takahashi & Jux, 1991; İnci, 2002; Ersoy et al., 2014). A recent study provided a radiometric age constraint for the floras of the Soma Basin. Ersoy et al. (2014) dated volcanic rocks of the Soma and Deniş formations between 20.42 ± 0.12 Ma and 18.76 ± 0.05 Ma. This would suggest a late Aquitanian to early Burdigalian (MN3) age for the macro fossils recovered from the marls above the main coal seam.

The Soma basin is of paramount importance for understanding palaeofloristics in the early Miocene of the East Mediterranean region and along with the roughly coeval plant-bearing layers in Lesbos perhaps the only late Aquitanian plant macrofossil site in this region. Previous plant macrofossil studies provided the following data: Mädler & Steffens (1979), 2 gymnosperms and 15 angiosperms, Gemici et al. (1991), 3 cryptogams, 7 gymnosperms and 61 angiosperms (many of them stored at Natural History Application and Research Centre, Ege University, Izmir), Erdei et al. (2010) described an extinct genus and species of cycadalean leaves as *Pseudodioon akyoli*, Güner & Denk (2012) described two new species of Berberidacea as *Mahonia grimmii* and *Mahonia somaensis* based on very few leaves, and Denk et al. (2014) described a new species of *Dracaena* as *Dracaena tayfunii*.

The present project includes the determination of recently collected about 1500 plant macrofossils from the Soma basin. Preliminary results of this project report a number of genera that are commonly found in early Miocene strata of western Eurasia (*Pinus, Glyptostrobus, Alnus, Carpinus, Mahonia, Fagus, Quercus, Acer, Salix, Populus, Zelkova, Ulmus, Myrica, Pterocarya, Ziziphus* etc.). At the species level some interesting novelties include a finding of oak foliage very similar to *Quercus* subsect. *Galliferae*. In addition, some taxa that appeared to be rare turn out to be very abundant, e.g. *Mahonia*. The composition of the associated angiosperm fossils point to a warm temperate and subhumid climate.

P017

ELAEOCARPACEAE FRUITS FROM THE OLIGOCENE OF THE PETROȘANI BASIN, ROMANIA

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Well preserved fructifications have been found in a the Paroșeni coal mine, Petroșani Basin. The specimens are preserved in a dark grey fine grained sandstone intercalation of the Chattian Dîlja-Uricani Formation.

The fruits are spherical, slightly elongate, attached to a short peduncle, with a husk covered by long spines. The locules are elliptical in shape and display a pit-like scar on the inner side, representing the arillus. The location (position?) of the seed inside the locules influences the shape and the size of the fruit (seed?). The collected specimens are represented by single or double grouped locules, but the arillus is not always visible. The size of the husks is uniform, while spine size is variable. All characters point to the Elaeocarpaceae. On each collected hand specimen the fruits are associated with different leaf taxa, most of the leaf fragments belonging to the family Lauraceae. In the European Cenozoic, representatives of the Elaeocarpaceae were described in mesophytic forest assemblages. Nonetheless, the taxonomic assemblage of the studied flora from the Petroșani Basin points to a subtropical climate. The overall character of the depositional conditions indicates a flatland with surrounding uplands, within a typical intramontane depression, and the palaeoflora is mainly autochthonous.

Although the Oligocene deposits of the Petroșani Basin are very rich in fossils, the Elaeocarpaceae fructifications are very rare. This is the first report of Elaeocarpaceae fossils for the Petroșani Basin.

Dipterocarpaceae, Meliaceae, Annonaceae and Fabaceae. In situ occurrence of these fungi on the angiosperm leaf cuticles suggest incidence of parasitic/pathogenic interaction in the phylloplanes of the ancient moist evergreen forest of Arunachal, sub-Himalaya, favoured by a high rate of precipitation during deposition of the Siwalik sediments.

P019

PALYNOLOGY OF THE CENTRAL MYANMAR BASIN CORROBORATES EOCENE–OLIGOCENE MONSOONAL CONDITIONS IN SOUTH-EAST ASIA

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The Cenozoic vegetation history of Central Myanmar is only sparsely documented and yet of great interest in the context of regional paleogeographic and climatic changes. The Kalewa section, situated in the Central Myanmar Basin and recently dated by our group (Myanmar Paleoclimate and Geodynamics research group), presents an excellent opportunity to study the vegetation development from the Cretaceous to the Miocene. Here, we focus on the late middle Eocene to Oligocene time interval and document the palynoflora using 138 samples that were collected from the Pondaung, Yaw, and Letkat formations. The sediments exposed along a 1436.1 m section were formed in a predominantly fluvio-deltaic environment. Our study shows that the late middle Eocene to Oligocene Kalewa palynoflora includes at least 126 sporomorphs, belonging to 53 families and 91 genera. The dominant sporomorphs of this palynoflora are Dicolpopollis (e.g. Dicolpopollis kalewensis, derived from the rattan group Calamoideae within Arecaceae), Sapotaceoidaepollenites (from trees within Sapotaceae, such as Palaquium), and fern spores. Other typical palynofloral elements are also derived from mountain ranges (Podocarpidites, Taxodiaceaepollenites, and ?Piceaepollenites), and taxa from fluvial and deltaic floodplains such as Liliacidites (from Liliaceae), Myriophyllum type (Haloragaceae), Corsinipollenites oculus (from Jussieua within Onagraceae), cf. Florschuetzia (possibly sonneratioid), Zonocostites ramonae (from Rhizophoraceae), dinoflagellate cysts, and foraminiferal chitinous linings. In addition, the megathermal elements constitute the most significant fraction of all sporomorphs, such as Discoidites (from Brownlowia within Malvaceae), Margocolporites (from Caesalpinia within Leguminosae), Striatricolporites catatumbus (from Crudia within Leguminosae), Lanagiopollis (e.g. Lanagiopollis emarginatus, from Alangium sect. Conostigma, which has significant biogeographic significance), Palmaepollenites kutchensis (from Iguanurinae within Arecaceae), Meyeripollis naharkotensis (possibly from Myrtaceae, indicating the age from late Eocene to basal Miocene), while the temperate elements are very rare. Generally, the late middle Eocene to Oligocene Kalewa palynoflora is a seasonally dry flora characterised by moist deciduous and semi-evergreen forest that is consistent with monsoonal conditions in south-east Asia.

P020

PALYNOLOGICAL SIGNAL OF HEINRICH EVENT 1

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The role of vegetation through intervals of abrupt climate change is one of the most challenging paleoclimatological problem.

The post-Glacial transition of vegetation that occurred at the beginning and the end of Heinrich event 1 and that stretched up to the beginning of the Younger Dryas is related to the magnitude, timing and non-linear response of the Earth system to H1 in different geographical locations.

The main problem that arises is the uncertainty in the interpretation of the pollen assemblage due to its mixed nature, particularly the presence of both "warm" and "cold" pollen and its variable representation in different locations. We have compared the initial- and post-H1 event pollen signal for a longitudinal tropic – subpolar transect, using published and our own data. We find that despite regional peculiarities, most of the pollen assemblages demonstrate a similar pattern.

One of the most prominent common features at the beginning and after H1, is the appearance of "saw-tooth"-like shapes in the variables of the pollen diagram, independent of sites, vegetation composition and other factors. The most noticeable "saw-tooth" occurs at ~ 18-17 Kya and after H1, between about 14 and 12 Kya, the interval that roughly followed the transition from the Bølling/Allerød to Younger Dryas. The common features of a "saw-tooth" appear in this order: 1) following the LGM, an increase in upland herbs assemblages and/or in ferns, coinciding with a general decrease in the percentage of arboreal pollen. 2) A second stage, which follows the Bø/Al stadial, is similar with the previous one, but the amplitude of the "saw-tooth" is lower, since it lasts as long as 2 Kya. 3) Each "saw-tooth", no matter where it occurs, terminates with an increase in arboreal taxa. For all sites, the isotopic evidence is that this period corresponds to warming, but the pollen records tell a more complex story. Despite the individualities of each pollen record for different geographical locations, they all indicate that these almost chaotic changes in vegetation have something in common. This response to global warming has to be related with the fraction of local plants which were able to adjust fast to climatic changes and growing CO2 in the atmosphere. In turn these pioneer plants consumed a substantial amount of CO2, altering the situation backward. The "saw-tooth" like chaos lasts until the stabilization of the system to the new "normal" after the Younger Dryas cooling.

P021

VEGETATION AND CLIMATE CHANGESOF THE PLIO-PLEISTOCENE PHASE IN NIHEWAN BASIN

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In this study, Haojiatai NHA drilling core in Nihewan Basin was selected to discuss the vegetation and climate changes in the Plio-Pleistocene phase (2.92-2.56Ma) based on pollen analysis. The results show that four stages can be divided into. In stage 1 (2.92-2.8Ma), most *Pinus* pollen content was more than 30% and *Picea* were less than 20%. The broad-leaved trees had the highest percentage in the full section with about 13%. *Artemisia* and Chenopodiaceae were the main herbaceous types with about 10-20%, indicating that broad-leaved forest should be the main research object of the sampling point, that spruce forest and pine forest existed in the mountainous regions, and that the climate was relatively warm and humid. In stage 2 (2.8 -2.71Ma), the pollen content of *Picea*, A*rtemisia* and Chenopodiaceae increased significantly, with the maximum reaching to 90% for *Picea* and 80% for *Artemisia* and Chenopodiaceae; On the contrary, the pollen content of *Pinus and* broad leaved trees significantly reduced to lower than 10% and 5% seperately, suggesting that the surrounding vegetation became pruce forest or steppe and climate tended to become chilly and dry, companied by dramatic changes of humidity . In stage 3 (2.71-2.66Ma), *Pinus* pollen content increased significantly, with more than 40% in most samples. The content of fern spore was about 11%, reaching the highest in the whole profile; Instead, most of the *Picea* content decreased clearly, with less than 30%, broad-leaved trees pollen was rare and the content of *Artemisia* and Chenopodiaceae was less than 10%, indicating that the surrounding vegetation was dominated by pine forests, the spruce forest retreated to the mountainous regions, and the climate became relatively warm and wet. In stage 4(2.66 -2.56Ma), the spruce became dominated pollen type with percentage more than 80% for most samples, but *Pinus* was less than 10%. Broad-leaved forest almost disappeared and dark coniferous forest expanded and the climate was getting much colder. According to the pollen analysis, there were two relatively obvious cold stages,2.8-2.71Ma and 2.66 -2.56Ma , which had a good correspondence with the marine isotope stages MIS102, 104, G2, G6 and G10.

P022

PALAEOENVIRONMENTS, PALAEOCLIMATE AND PALAEOFLORISTIC COMPOSITION IN CENTRAL SPAIN (MADRID BASIN) DURING THE MIDDLE MIOCENE GLOBAL COOLING EVENT

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The Madrid Basin was one of main continental, endorheic basins of the Iberian Peninsula in the Early and Middle Miocene. During the years 2004-2008, the numerous works carried out in the city of Madrid for the underground system and highway tunnels allowed a rich paleontological dataset from this sedimentary basin to become available, including palynological records from hundreds of core and outcrop samples. For this study, palynological analysis of 4 sections dated biostratigraphically as Aragonian (Middle Miocene, upper part of the MN zone 5; ~14.8-13.8 Ma) have been conducted. Sequences mainly consist of greenish claystones that belong to the so-called "Peñuela" facies of the Intermediate Unit. These sediments were deposited under a marginal lacustrine and palustrine setting.

Overall, the 4 studied sections yield moderately diverse palynological assemblages dominated by herbaceous taxa that indicate an arid climate and the development of steppe-like vegetation in the area. These data provide evidence for the onset of the expansion of open ecosystems in the Iberian Peninsula, which became extensive during the Langhian-Serravallian transition, probably associated with the Middle Miocene Global Cooling Event.

Palaeoclimatic reconstruction based on Coexistence Approach suggests ranges of 16.5-18.5° for the mean annual temperature, 5.5-13.1° for the mean temperature of the coldest month and 20.3-23.1° for the mean temperature of the warmest month.

Within this general arid context, differences in composition observed on the assemblages of the studied sections reflect slightly different types of palaeoenvironments, which were related to local conditions. Thus, the Puente de Toledo and Tierno Galván Park palynofloras reveal a near-shore lacustrine depositional setting, as indicated by the abundance of hygrophilous taxa such as fern spores and *Cyperaceaepollis*. Linked with these ecosystems was an original flora including Convolvulaceae, *Armeria* and *Ricinus*. The latter genus, which has been identified previously in a very limited number of studies, is documented with pictures and described in detail for the first time.

The Metro Line 7 sequences, on the other hand, yield a palynoflora with abundant *Ephedra* pollen and lower numbers of hygrophilous taxa reflecting a drier, probably more hinterland depositional environment.

P023

PLANT-SOIL INTERACTIONS AND WEATHERING WITHIN CRYPTOGAMIC GROUND COVERS (CGCS): APPLYING A NOVEL MULTI-MODAL AND MULTI-SCALE ANALYSIS VIA CORRELATIVE IMAGING AND FOCUSSED ION BEAM (FIB) MICROSCOPY

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Colonization of the land by primitive plants during the Early Palaeozoic was fundamental to the evolution of terrestrial ecosystems, in particular soil development and biologically-mediated weathering. The first plant-dominated ecosystems (e.g., the 407 Ma Rhynie Chert) are akin to modern cryptogamic ground covers (CGCs), which are composed of a consortium of bryophyte plants (e.g., mosses, liverworts, hornworts), lichens, fungi, algae, and bacteria. Comparable associations are present in Rhynie Chert and modern CGCs (e.g., mycorrhizal associations between plants and fungi/cyanobacteria). Previous investigation of modern CGCs from Iceland reveal that CGC soils have specific surface and internal structures, which are governed by the colonising organisms (e.g., moss, liverwort, lichen) and the below-ground interactions (e.g., rhizoids, symbionts). It was found that smectite clays developed in CGC soils dominated by basal liverworts (e.g., *Blasia pusilla*), and that symbiosis with cyanobacteria (cyanobionts) and nitrogen fixation potentially play a role in weathering and soil developmental processes. In addition, numerous biologically-mediated weathering features have been identified on grains within CGC soils, and can be attributed to different organisms (e.g., bacteria, fungi) and interaction (e.g., symbiosis, root-mediated dissolution). However, the challenge is to study these biologically-mediated features in-situ, and relate their formation to the complex processes in CGC soils.

Here, we have used the correlative workflow of numerous 2D and 3D imaging and analytical systems to understand fossil and CGC soil interactions and weathering in more detail. We have used a combination of multi-modal and multi-scale techniques including optical light microscopy (LM), scanning electron microscopy (SEM-EDS), high resolution X-ray microscopy (X-ray CT) and focussed ion beam (FIB) microscopy to ascertain variations in chemistry, structure, and in-situ interactions present in Icelandic CGC soils and fossils from within the Rhynie Chert. With the aid of Zeiss Atlas 5 correlative workspace spftware, it is possible to pinpoint and target internal regions of interest (ROIs) within 3D X-ray CT volume data and accurately target sub-surface regions using the FIB. This enables us to create nm-scale tomographic volumes of the ROI, creating ultra-high resolution volumes detailing structural properties, chemistry, and orientations. In particular, this workflow is improving our ability to image Rhynie Chert cyanobacteria in high resolution. We propose that correlative imaging provides a novel opportunity to study fossils and soil to quantify interactions at varying length-scales, and further understand soil processes both in the present and the geologic past.

P024

NEW DATA ON PELTASPERMALEAN *IN SITU* POLLEN FROM THE PERMIAN OF THE RUSSIAN PLATFORM

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The order Peltaspermales is a unique group characterized by various palynological types; nonetheless, data on *in situ* pollen are rare, poorly studied or even lacking for some time spans. In this regard we have investigated synangia of the genus *Permotheca* Zalessky, 1929 from Kazanian sediments of the Russian Platform. LM and SEM were used. We examined about 90 synangia from the Kostovaty locality (Russia, Udmurtia) and managed to extract pollen grains from 10 of them.

The synangia were divided into three groups by morphological features, one of which was attributed to *P. vesicasporoides* S. Meyen, Esaulova et Gomankov, 1986 (earlier registered in the Late Permian of the Russian Platform) by the presence of *Vesicaspora* pollen type and cuticle characters. The second group is quite similar to *P. colovratica* Naugolnykh, 2013 by the morphology of the synangia, but there are distinctions in pollen morphology. The third group shows several minor morphological differences (such as the number and outlines of sporangia, synangia organization, and the type of attachment to fertile axis), which do not allow to attribute this group to *P. colovratica*; the pollen grains resemble those extracted from the synangia of the second group. By contrast to previous reports of *P. colovratica*, the pollen grains of the second and the third groups are clearly bisaccate and their corpus is bigger than the sacci. The distal surface is characterized by peculiar rugulate-fossulate sculpture; orbicules are occasionally present on the surface of pollen grains.

The *Vesicaspora*-type pollen is known from synangia of *Permotheca* during the Permian period. Nevertheless, at least two morphotypes of pollen grains are found in *Permotheca* in the Kostovaty locality. Furthermore, striate saccate pollen grains of *Protohaploxypinus*-type are known from *Permotheca* from younger deposits. In addition, there are data that non-saccate striate pollen of *Vittatina*-type can be found in synangia of this genus in the same deposits (Gomankov, Meyen, 1986). Such a diversity of pollen types found *in situ* in synangia of the same genus confirms its formal status and highlights the need for a more detailed study of the genus *Permotheca*.

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P025

TREBECENIA SARCOCALYCALIS, LATE CRETACEOUS CAPSULAR FRUIT FROM THE CZECH REPUBLIC.

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Trebecenia sarcocalycalis Knobloch et Mai is a rare fossil from the Klikov Formation (upper Turonian – Santonian age). Sediments of the Klikov Formation constitute the thickest and most widely distributed stratigraphic unit in South Bohemia Basins. In 2007, a new tafocenoza of small charcoalified reproductive plant structures was found in this Formation, in the locality Zliv – Řídká Blana. Specimens of *Trebecenia sarcocalycalis* come from newly collected material, as well as older material from E. Knobloch's collections. This taxon was examined using our Bruker SkyScan 1172 X-ray micro-tomograph, and reconstructed with the supplied software (NRecon). For SEM studies, the specimen was observed using our Hitachi S-3700N. All specimens are preserved as three dimensional charcoals.

Trebecenia sarcocalycalis is a young fruit. It consists of trimerous gyneceum surrounded by a pentamerous perianth arranged in one whorl. The periant is very thick. The gynoecium is superior, three carpelled, unilocular and synovarious: ovary fused, styles and stigmas are free. Only basal parts of the three styles are preserved. The central columella is present. The surface of the fruit is covered by numerous trichome bases. *T. sarcocalycalis* probably matured into capsular fruit.

Based on the pentamerous perianth and trimerous gynoecium, we interpret *T. sarcocalycalis* as having affinities to Saxifragales or Ericales. Most Cretaceous ericalean fossils are apparently tricarpellate, but whether this is a plesiomorphic character for the order as a whole is not yet established.

P026

A CARBON STABLE ISOTOPIC SHIFT RECORDED BY THE KUNGURIAN FLORA OF TREGIOVO (VAL DI NON, NORTHERN ITALY)

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The Tregiovo Basin is a small sedimentary basin in the upper Val di Non (Trento Province, NE-Italy). The fossil locality "Le Fraine" (Tregiovo Formation) near Tregiovo village yielded one of the few well-documented Kungurian (early Permian) floras of eastern palaeoequatorial Pangea. Two rich plant assemblages, 45 m and 105 m from the base of the section (respectively Assemblage A and B), both consist of sphenophytes (*Annularia*), taeniopterids (*Taeniopteris*), seed ferns and/or ferns (*Sphenopteris*, *Peltaspermum*), ginkgophytes (*Sphenobaiera*), and conifers (e.g., *Hermitia*, *Feysia*, *Quadrocladus*, *Dolomita, Pseudovoltzia*), but with different quantitative compositions. Both plant assemblages are dominated by conifers, which also form the most diverse group. A taxonomical and morphological study of foliated conifer shoots has been carried out, with the aim to increase our understanding of the distribution and diversification of this important group of plants in the Kungurian of eastern palaeoequatorial Pangea. Four conifer taxa, *Feysia* sp., *Quadrocladus* sp., *Hermitia* sp. and *H. geinitzii*, were identified, based on branch and leaf morphometrics. Moreover, a geochemical study performed on the bulk organic carbon from the "Le Fraine" section, provided a $\delta^{13}C$ curve that shows a negative shift along the section with the most negative values of the curve corresponding to the upper floral assemblage (Assemblage B). A taxon-specific study on the stable carbon isotopic composition of coalified Tregiovo conifer tissues showed that there are no significant differences between different taxa from the same plant assemblage, but conifers of the same taxon have lighter isotopic composition in the upper floral assemblage. This allowed to exclude that the shift resulted from a change in floral composition along the section. The geochemical investigation on the bulk organic matter and charcoal from another section (Tregiovo village section, Tregiovo Fm.), coeval with the upper part of the "Le Fraine" section, confirmed the same negative shift recorded from "Le Fraine" section. The $\delta^{13}C$ curve of Tregiovo and the magnitude of the negative shift obtained (4–5‰ VPDB), are very similar to the Kungurian trend observed from other contemporary continental records (e.g., China, South Africa) that extend from Carboniferous to late Permian. This suggests that the Tregiovo negative shift may represent a global signal given by a global change of the carbon atmospheric composition.

P027

GEOCHEMISTRY OF *CEDRUS ATLANTICA* POLLEN AND THE POTENTIAL FOR LONG-TERM RECONSTRUCTION OF MOISTURE AVAILABILITY AND SUMMER UV-B FLUX ACROSS NORTH AFRICA.

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Geochemical analysis of pollen allows quantitative relationships to be established with environmental and climatic conditions which influence the geochemistry. *Cedrus atlantica* (Atlas cedar) is an endemic tree found across North Africa, growing in sub-humid and semi-arid mountainous environments. It has been present in the region throughout the Holocene, which, along with its summer pollination period, makes it an ideal species for reconstruction of summer climate conditions. We investigated two geochemical approaches using 93 modern pollen samples collected from Morocco, Europe and the USA. Firstly, an analysis of the stable carbon isotope ratio of pollen and moisture availability, finding significant relationships with summer precipitation ($r^2 = 0.63$, $p < 0.0001$) and scPDSI ($r^2 = 0.86$, $p < 0.001$). Secondly, analysis of the abundance of ultraviolet absorbing compounds (UACs): *para-coumaric* acid and *ferulic acid* in pollen, finding significant relationships with summer UV-B flux in native Moroccan samples ($r^2 = 0.84$, $p < 0.0001$), but not across a larger environmental gradient including non-Moroccan samples ($r^2 = 0.00$, $p = 0.99$). These relationships suggest that fossil pollen could be used for quantitative climate and UV-B reconstructions in the region, although the possible genetic influence on UACs requires further investigation. Efforts are now underway to analyse fossil *Cedrus* pollen from two sites in the Middle Atlas, Morocco: Lake Sidi Ali, and Col du Zad, which span at least 10,000 years BP and are rich in *Cedrus* pollen. Pollen concentration and isolation methods were developed that do not use any chemicals, which could potentially alter the geochemical signal. It is hoped that geochemical analysis of fossil *Cedrus* pollen could resolve some of the open questions about climate change in Northwest Africa, due to the often conflicting signals found in the pollen record, and whether UV-B or solar radiation may be driving these changes.

P028

STABLE CARBON ISOTOPE COMPOSITION OF N-ALKANES IN CRETACEOUS PLANTS FROM THE BOHEMIAN CRETACEOUS BASIN AS AN INDICATOR OF PALAEOECOLOGY

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Stable carbon isotopes became one of the methods providing us with information about humidity in palaeoreconstructions. The method, based on measuring isotopes in bulk material – carbonates, palaeosols or fossil plants, is used for reconstruction of relative humidity changes through time. Local water availability, salinity and humidity are not captured in the bulk measurements. A suitable method to separate regional signal from local (individual) signal, the compound-specific isotopic analysis (CSIA) can be used. It gives us more detailed information about the reaction of the plant to environmental changes (water stress, salinity, drought). We introduce this method used in biology into the fossil record in order better to understand the local palaeoenvironmental conditions.

Vegetation of complex fossil environments such as estuaries and deltas can be studied using stable carbon isotope composition in n-alkanes, providing information on water stress. These tidally influenced environments typical for large changes in salinity during certain periods within a year. The flora growing there is hypothesized to be under water stress caused by high salinity, floods and dry episodes. The Cretaceous fossil flora from these environments does not have living relatives, therefore all the information we know about it is based on morphology and cuticle anatomy.

The poster will present preliminary results of calibration of stable carbon isotope composition of n-alkenes (leaf waxes) in flora from recent coastal areas (salt marshes, mangroves). It will also compare the calibration dataset with data on fossil flora from "similar" palaeoenvironments in the Bohemian Cretaceous Basin, the Saxony basin and Spanish Cretaceous basins. The study sites are considered as deltaic/estuarine environments with gradual intrusion of sea during the Late Cretaceous. These conditions influenced formation of a unique ecosystem which is not present today anymore. The closest recent environments are considered as mangroves and salt marshes. A new type of ecosystem is arising in New Zealand where original salt marshes are invaded by mangroves. This environment has a high potential to act as the calibration set, due to the presence of both trees and herbaceous plants, similarly to the fossil record. The data from these environments will be presented.

Using recent and fossil isotopic data enables us to compare the water stress effect and response of the plants to it in the fossil record, which will complete the image of palaeoenvironmental reconstructions and the fossil plant physiology.

P029

RECONSTRUCTION OF SOLAR ULTRAVIOLET IRRADIANCE: IMPLICATIONS FOR FUTURE CLIMATE

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Variations in solar ultraviolet (UV) irradiance are an important driver of regional climatic change. The challenges of reconstructing UV irradiance prior to the satellite era mean that there is uncertainty over long-term UV patterns, and whether UV follows total solar irradiance (TSI) over centennial to millennial timespans. Here, we reconstruct past surface UV irradiance over the last 650 years using a novel UV-B proxy based on the chemical signature of fossil pollen grains. Plants produce UV absorbing compounds (UACs) to protect their cells from the harmful effects of UV-B, and up-regulate production in response to increased UV-B doses. Therefore, by measuring the concentration of UACs in fossil and sub-fossil pollen grains, UV-B flux in the past can be reconstructed. We use Fourier Transform infrared (FTIR) microspectroscopy to analyse *Pinus* pollen UAC concentrations, sampled from Nar Gölü in central Turkey. We then compare our UV reconstruction to two independent TSI proxies: cosmogenic radionuclides and sunspot group counts.

We demonstrate a statistically significant positive relationship between the abundance of UV absorbing compounds in *Pinus* pollen and the TSI proxy records. This shows that trends in UV follow the overall TSI pattern over centennial timescales, and that variations in solar output are the dominant control on surface level UV-B flux, rather than solar modulated changes in ozone thickness. These findings confirm the potential for secular changes in UV to impact upon regional climatic patterns over long timescales.

P030

HOLOCENE FIRE HISTORY AND VEGETATION DYNAMIC IN KOMI REPUBLIC, URALS REGION, RUSSIA

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Wildfire is a major perturbation in boreal ecosystem. Current global warming could favor the occurrence of this perturbation with heavy consequences in term of ecosystem functioning global climate, and socio-economical point of view. In order to better predict effects of these changes on fire activity, long-term paleoecological data are required notably to understand the complex interactions between climate, human, fire and vegetation trough time. In the frame of the PREREAL project (http://www.prereal.org/index.htm) funded by the Belmont program, we provide fire history and vegetation dynamic during the Holocene, in Komi Republic, Ural mountain (Russia). Fire history is based on the analysis of charcoal particles sequestered in forest peat deposits and dendrochronological analysis. Results indicate a gradual increase of fire frequency over time. The fire return interval has oscillated between ca 300 years at 11000 years cal BP to a value inferior to 100 years since 250 years.

This increase in fire frequency could be driven by human activities, climate and vegetation. Human density of this area remained very low throughout the Holocene and only increased recently. In order to highlight the interactions that have occurred between fires, vegetation and climate, palynological analysis of peat deposits is being processed to be related to fire activity.

P031

THE HOLOCENE DEVELOPMENT OF LOWER MOUNTAIN FOREST AND ITS FIRE HISTORY IN THE BESKID MAKOWSKI MOUNTAINS (WESTERN CARPATHIANS, SOUTHERN POLAND)

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The aim of this study was a reconstruction of forest and fire history recorded in a small mire that developed within a landslide depression. The analysed site is located in the Beskid Makowski Mts., on the southern slope of the Koskowa Mountain range (675 m a.s.l., lower mountain forest zone). From 11,200 cal. BP *Pinus sylvestris*, with an admixture of *Betula*, *Picea abies*, *Populus*, *Pinus cembra*, and *Larix decidua* were main constituents of the woodlands. From ca. 11,145 cal. BP *Ulmus* started to spread (pollen values >2%), and from ca. 11,090 cal. BP it advanced rapidly (>10 %) contributing to the withdrawal of *L. decidua* and *P. cembra*. About 10,280 cal. BP *P. abies* started to expand. Next, ca. 10,030 cal. BP the expansion of *Corylus avellana* began, and ca. 9930 cal. BP that of *Tilia*, which contributed to the retreat of the *Pinus-Betula* woodlands. During the period of ca. 9570–8980 cal. BP *C. avellana* reached an optimum, whereas *Tilia* reached an optimum ca. 7380–7320 cal. BP (>20 % of pollen). The first occurrence of *Abies alba* macrofossils was dated at ca. 5000 cal. BP, but ca. 4400-4000 cal. BP *A.alba* expanded rapidly restricting the occurrence of *C. avellana* and *Tilia*, and gradually of *P. abies*. About ca. 2700 cal. BP *Fagus sylvatica*, being earlier an admixture in *Abies-Picea* forests, became more frequent, whereas ca. 2020 cal. BP it reached an optimum. The layer of the topmost 50 cm, consisting of the mineral cover, was probably established in the period not older than last ca. 1300 years. This layer is characterized by the increased frequency of Poaceae, anthropophytes', and cereals' pollen, and coprophilous fungi spores, which point to human-induced deforestations that contributed to the establishment of this mineral layer. An analysis of microcharcoal (0.01-0.1 mm) and macrocharcoal (>0.1 mm) revealed that periods of (i) ca. 11,230–10,710 cal. BP (*Ulmus, P. sylvestris* and *Betula* optimum) and (ii) the last 400 years (acceleration of human impact) were of the highest fire activity. Moreover, higher local fire activity (macrocharcoal) was identified in the period of (i) ca. 7600–6700 cal. BP, simultaneously with the fluctuations of *P. abies* and decline of *Ulmus*, and (ii) ca. 1900–1400 cal. BP, simultaneously with the spread of *F. sylvatica* at the expense of *A. alba*.
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P032

NEW DATA ABOUT ANCIENT DISTRIBUTION OF *ABIES ALBA* AND *FAGUS SYLVATICA* IN LOW MEDITERRANEAN MOUNTAIN AREAS (NORTHEASTERN IBERIAN PENINSULA): RELICT SPECIES OR HUMAN INTERVENTION?

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The current silver fir (*Abies alba*) and beech (*Fagus sylvatica*) distribution areas in the northeastern Iberian Peninsula spread almost exclusively on the northern slopes of mid and high mountain areas. However, some fir and beech forest are found near the Mediterranean coast. These populations are believed to be relict areas of ancient glacial refuges from the last glacial period. Likewise, their anthropogenic origin cannot be excluded. Our research focuses on these Mediterranean populations with the aim to shed light on their Holocene evolution in these environments and to provide data to discuss their natural or anthropic origin.

The methodology is based on soil charcoal analysis. Pedoanthracolgy offers high spatial precision and extended chronological information (Holocene period). The first study area is located at the Montseny massif (1400m-1706m a.s.l.), where the silver fir southernmost populations of the Iberian Peninsula are found. In the Montnegre area (600m-727m a.s.l.), the second study location, reduced beech population is found at 8 km from the Mediterranean coast. Three pedoanthracological pits were excavated in both areas across the different insolation areas (top área, north and south slopes). The pits depth varies from 40 to 110 cm.

First results show fir presence in the past in these areas and a much wider extension that is outside our current understanding of topographical and microclimatic paradigms. During the Holocene, its distribution area was reduced in periods of significant climate change and in periods of important human activity (Bronze Age, Romanization and Middle Ages).

P033

FIRE IN THE NEAR EAST: DIFFERENT RELATIONS OF PALEOFIRE ACTIVITY AND VEGETATION CHANGE IN THE SOUTHERN LEVANT AND EASTERN ANATOLIA

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Fire is one of the severest landscape disturbance factors. Yet, the connection between fire, vegetation, and climate differs regionally and is often poorly understood. Here, we examine the relationship between micro-charcoal and pollen from sediment cores of two key archives in the Near East: the Dead Sea in the Southern Levant and Lake Van in Eastern Anatolia. The study has a temporal focus on the last glacial and Pleistocene-Holocene transition. We aim to get a better understanding of fire-vegetation-climate interactions in both regions.

Our analysis shows major regional differences of charcoal-pollen relations. At the Dead Sea, fire activity is positively correlated with the reduction of woodland and steppe vegetation. In contrast, in Eastern Anatolia fire activity increases with the expansion of forest-steppe, i.e. with the spread of trees and shrubs. To interpret and explain these contrasting patterns, we address the following questions: Which climate parameters affect the paleofire activity? What is the role of available biomass? Do we find indications for human-driven fire regimes?

P034

VEGETATION DYNAMICS, HUMAN IMPACT AND FIRE HISTORY IN THE TEMPERATE DECIDUOUS FOREST ZONE OF CENTRAL EUROPEAN RUSSIA DURING THE LAST 4000 YEARS

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Climate changes and human activity strongly affected the European temperate deciduous forests through the Holocene, anthropogenic influences were detected even in strongly protected areas, which were assumed to be "pristine forests". The present study is focused on the area of the "Kaluzhskie Zaseki" Nature Reserve, which is considered to contain the remnants of primary broad-leaved forests in central European Russia. New multi-proxi records including pollen, plant macrofossils, micro- and macro-charcoal, peat humification, loss on ignition and radiocarbon dating from a small forest peatland Mochulya supplemented by 15 radiocarbon dates of soil charcoal from the area of the Reserve are presented. Obtained results have shown that during the last 4200 years the study area was occupied by broadleaved forests of *Quercus, Ulmus* and *Tilia,* after 2300 cal yr BP *Picea* become relatively abundant. Despite long-term human impact on vegetation fragments of these forests still existed there until present. Three main periods of deforestation and frequent fires were revealed: 3700-3200 cal yr BP, 2000-1600 cal yr BP (the Early Iron Age) and 1000-400 cal yr BP (the medieval time). Whereas human-induced vegetation changes were obvious for the last two periods, vegetation dynamics during 3700 - 3200 cal yr BP were caused partially by climatic reasons.

This study was supported by the Russian Science Foundation (Grant 16-17-10045).

P035

DIET OF EXTINCT *STEPHANORHINUS KIRCHBERGENSIS* ON THE BASIS OF PALAEOBOTANY RESEARCH

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In western Poland (near Gorzów Wielkopolski) almost complete rhino remains of a female *Stephanorhinus kirchbergensis* were found in lake sediments. From the rhino's teeth, it was possible to extract material that probably corresponds to her last meals.

11 samples of sediments filling of teeth caverns (teeth P^2dex, P^3dex, P^4dex, M^1dex, M^2dex, P^2sin, P^3sin, P^4sin, M^1sin, M^2sin, M^3sin) and 6 sediment samples directly adjacent to the jaw were analysed.

Preliminary results of pollen and macrofossil analysis of 6 sediment samples directly adjacent to the jaw show dominance of *Carpinus* and *Corylus* communities as the rhinoceros' living environment. This species composition allows to determine the rhinoceros' lifetime on the end of the Middle Eemian Interglacial defined for the terrain of Poland as *Carpinus-Corylus-Alnus* R PAZ (E5), considered as the climatic optimum of this interglacial. The abundance and variety of remains of aquatic plant species, especially *Trapa* sp., characteristic for sediments of the Eemian Interglacial *Aldrovanda* sp. or *Najas marina* indicate a warm climate and shallowing lake.

Pollen analysis of 11 samples of sediment extracted from cavern teeth indicates that the majority of samples consists of lake sediment that penetrated into the spaces inside the teeth *post mortem* and also suggests the species composition of *Carpinus* and *Corylus*.

Only four samples differ in their pollen composition indicating mainly *Betula* and *Corylus*, as the source of food of the *Stephanorhinus kirchbergensis*. The intriguing discovery turned out to be *Taxodium* sp. pollen in amounts up to 4% in these 4 samples. This species has not been found yet in the Eemian Interglacial sediments.

The analysis of plant macro-remains allowed to determine only a small fragment of heavily damaged seed scales of *Betula* sp. Among the plant remains found in the teeth caverns, fragments of wood were also found. The majority of them represented twigs of 1-2 mm in diameter and were in a bad preservation state due to chewing, permitting only a determination up to the level of angiosperms. However, *Corylus*, Maloideae and cf. *Viscum* were identified.

Based on research of woody plant remains found in the teeth of this rhinoceros, and on the basis of the construction of the teeth, it is considered that the rhinoceroses of the *Stephanorhinos kirchbergensis* species nourished themselves with branches and twigs of trees and shrubs - hard, deciduous vegetation, woody and shrubby, hence it is sometimes called a "forest rhinoceros".

P037

THE LATE HOLOCENE VEGETATION CHANGES IN THE BESKID WYSPOWY MOUNTAINS (WESTERN CARPATHIANS, CENTRAL EUROPE) BASED ON PALYNOLOGICAL ANALYSIS OF SMALL RICH FEN

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Mountain areas host plant communities sensitive to climate changes and human activities. The main aim of the study was a reconstruction of the Late Holocene vegetation changes within lower mountain forest zone in the Beskid Wyspowy Mountains (Western Carpathians, southern Poland), the region of weakly recognised vegetation history. The study site is a rich fen developed in a depression situated at the foot of landslide scarp formed in the northern slope of the Mount Mogielica (at the altitude of 845 m. a.s.l.). The onset of accumulation of biogenic deposits is tentatively estimated at ca. 4800 cal. BP. The samples, collected from the peat core, were subjected pollen, selected non-pollen palynomorphs (NPPs) and microscopic charcoal (0.01-0.1 mm) analyses. In the period between ca. 4800 and 4160 cal. BP *Picea abies* dominated in local forests. Up to ca. 4660 cal. BP *Acer* pollen revealed substantial share in pollen spectra (>15%), which was probably associated with the development of the forests dominated by sycamore (*Acer pseudoplatanus*). Nowadays, this kind of deciduous forest occupies steep slopes, often covered with rock debris. About 4100 cal. BP forests with a predominance of fir (*Abies alb*a) and beech (*Fagus sylvatica*), a natural type of forest for the lower montane zone, started to expand. The spread of these forests was preceded by a short episode of the dominance of small-leaved lime (*Tilia cordata*), which distinguish studied site among others in the Western Carpathians. From ca. 2500 cal. BP to the present, a contribution of pioneer trees such as *Pinus sylvestris* and *Betula* increased, which may indicate higher landscape openness. Simultaneously, human activity was marked by the regular pollen presence of Cerealia type and *Plantago lanceolata*. However, the rapid decline of the accumulation rate (ca. 0,3 mm/yr) between ca. 2500 and 0 cal. BP might suggest possible sedimentary gaps in this section. Together with the expansion of *Abies-Fagus* forests an increase in the frequency of fungi spores such as *Kretzschamria deusta*, HdV-572 and *Cercophora* type was detected. The highest microcharcoal concentrations coincide with the spread of *Acer* at the beginning of the pollen succession and to increase in human impact reflected in the topmost deposits. Scientific work financed from the budget sources for scientific activity in 2016–2019, project number 0342/IP1/2016/74.

P038

BIOTIC CONTROLS ON HOLOCENE BIOMASS BURNING IN THE TEMPERATE FOREST ZONE OF CENTRAL EUROPE

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Fire occurrence is driven by complex interplay between vegetation, climate, landforms and humans what makes challenging to derive individual effect of each variable. In our study we have reconstructed Holocene biomass burning history of two regions located in the Central European temperate zone which differs in a timing of expansion of broadleaved-dominated forest communities. This allowed us to investigate effect of biotic changes on the past fire activity. A multiple-site charcoal accumulation records were used to estimate regional-scale trends in biomass burning and to compare them with major trajectories of vegetation development inferred from Czech Quaternary Palynological Database (PALYCZ). An extensive ^{14}C-dated soil charcoal record collected within both regions were analyzed using cumulative probability density function (CPF) to infer stand-scale proxy for past fire activity. Our results suggest increased biomass burning in the conifer-dominated vegetation types of early to mid Holocene. The

increased fire activity during this period was driven by both, drier and warmer-than-present climate, as well as flammable fuels produced by resinous trees. We identified inhibiting effect of *Fagus sylvatica* expansion on levels of biomass burning that occurred asynchronously within mountain and lowland regions at 6.5 ky and 4.9 ky, respectively. Such alternation of tree taxa composition leaded to exclusion of fire, evidencing its incidental role in broad-leaved forest vegetation dynamics during the Late Holocene. The divergent timing of fire decline in a response to *Fagus* expansion implies biotic control over biomass burning independent from direct climatic influence.

According to the data of macrofossil analysis each peat samples were investigated with using an ecological moisture condition scale by Ramenskii (Ramenskii, 1971). The indices of moisture condition of the habitat of peat-forming plants were calculated.

After the results of a comprehensive study of the peat sediments of the three floodplain peatland the following regularities in the variation of river water availability and changes in the palaevegetation were identified:

The end of the Boreal period - the beginning of the Atlantic period - a decrease in the overall moisture condition of the territory. The peatland formation started with the tree stage on elevated and protected from erosion parts of the floodplain.

The Atlantic period - the area of peatlands in the Esaulovka River basin has expanded in warm climate and high moisture condition. The trees plant communities are widespread in the peatlands.

Sub-Boreal period is characterized by variable moisture conditions for the territory, reduction of the participation of tree species in the composition of plant communities, predominance of herbaceous communities.

Sub-Atlantic period - decrease in the moisture condition of the territory, gradual restoration of the tree stage domination were marked.

P040

TOWARDS THE PALAEOECOLOGICAL RECONSTRUCTION OF MADEIRA ISLAND VEGETATION (PORTUGAL): FIRST RESULTS FROM FANAL AND CARAMUJO PONDS

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Discovered six centuries ago, in 1419, and settled in 1425, Madeira Island was historically depicted as covered by pristine forests from sea level to mountaintop. Early accounts state the use of fires and timber exploitation to manage the forested landscape, streams with permanent water and the absence of rodents. These accounts differ from the present reality, where a clear anthropogenic landscape dominates most of the island. Attempts to investigate the palaeoecological changes are scarce and restricted to Pleisto-Holocene aeolian deposits. Reconstructing the Madeira Island palaeoecology through limnic sediments and their palynological content was never performed, most probably due to the apparent lack of taphonomical suitable sites to sample, such as lakes or bogs. However, the existence of Holo-Pleistocene impermeabilized cinder cones craters that originate temporary ponds were investigated and cored for the first time. Preliminary field prospection and laboratory results revealed the presence of two suitable sites: the Caramujo and the Fanal ponds. Recent field work allowed the recovery of two sediment cores in Caramujo and Fanal ponds, 460 cm and 689 cm-long, respectively. Laboratory prospection with a 20-cm resolution sampling revealed the presence of pollen, spores, macro and microcharcoal fragments and carpological remains in both cores. Moreover, six AMS ^{14}C dates for both lagoons indicate a record from Upper Pleistocene to present. It is expected that the palynological record from both localities reveal how Madeira Island vegetation changed under natural climatic conditions and how anthropogenic impacts altered these insular ecosystems.

P042

PALYNOLOGY AND MICROPALAEONTOLOGY OF HOLOCENE LACUSTRINE SEDIMENTS OF THE LAYLA LAKES, CENTRAL SAUDI ARABIA: IMPLICATIONS FOR CHANGES OF PALAEOENVIRONMENT AND PALAEOCLIMATE

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The Layla Lakes in central Saudi Arabia, located 300 km south of Riyadh, are fed by groundwater, but dried up in the late 1980's due to extensive groundwater use, revealing a series of 23 sinkholes in the Jurassic Hith formation. In one of them with a size of 400 x 100 m and a depth of 10 m several samples were taken during a field campaign in 2011. Furthermore a sediment core was drilled near the sinkhole, revealing a lacustrine succession of 10.8 m. Mineralogical and geochemical analyzes show two distinct types of sedimentation: Sediments with an average content of 85% calcite (carbonates) and sediments, which consist almost entirely of gypsum and anhydrite (sulfates).

The carbonates precipitated when the exchange between groundwater and lake water was too large to achieve supersaturation of gypsum, while the sulfates mark periods of strong evaporation with limited rates of water exchange. First radiocarbon ages of mollusc shells and U/Th dating of carbonates indicate that the sedimentary succession covers 6000 years. Autochthonous microfossil assemblages comprise pollen, spores, diatoms, freshwater algae, testate amoebae, phytoliths and other non-pollen palynomorphs as well as zoological remains and offer the application of various multi-proxy methods to reconstruct Holocene palaeoclimate and palaeoenvironment in the center of Saudi Arabia in detail, a region, where such a complete sedimentary record is unknown so far.

Our study shows that the shore lines of the Layla Lakes were covered by a dense herbaceous vegetation during humid times. The environment was characterized by grasslands, interspersed with Chenopodiaceae. Wet places at the lake shore were vegetated by ferns. At peak periods of humid climate even water lilies, cattails and Ceratophyllaceae (hornworts) existed, which were spread on the lake water surface or grew completely submerged. During dry phases the lake level decreased significantly and the vegetation was replaced by plants that were adapted to arid conditions. A first semiquantitative analysis of the samples reveals distinct frequency fluctuations in various microfossil groups, which indicate cyclic climate variations between dry and more humid phases on a millennial scale. XRF and visual analyses of sediment composition confirm at least four changes between arid and more humid phases based on the frequency of carbonate and sulfate sediments.

P043

PLANT LANDSCAPE DYNAMICS OF WEST ATTIKI (SOUTH GREECE) SINCE THE LATE GLACIAL

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Late Glacial and Holocene flora composition of Greece demonstrates significant dissimilarities attributed to heterogeneity of local geological, environmental and climatic factors. Even though in northern Greece vegetation patterns are thoroughly studied due to the well preserved pollen archives, south Greece suffers from the inadequacy of long continuous pollen records. Under this perspective the shallow marine core S2P, originated from the landlocked shallow bay of Elefsis, offers a unique opportunity to study in detail the Late Glacial and Holocene vegetation patterns of Attiki (S. Greece) featuring the passage from the climate controlled vegetation to the human-induced one during Late Holocene. S2P core retrieved from the deepest part of Elefsis bay by the Hellenic Centre for Marine Research (HCMR), covering the past 14000 years, has been the subject of high-resolution palynological analysis of the top 300 cm, recording the successive plant landscape development. Overall, it is apparent that in west Attiki the plant ecosystem has been detrimentally affected by climate oscillations during the Late Glacial. Specifically, open oak woodlands along with the significant presence of the Mediterranean *Pistacia* established around 13000 BP in the surroundings of Elefsis, reflecting temperate conditions during the Bolling-Allerod interstadial, were temporally replaced by low vegetation with steppe elements like Chenopodiaceae, indicative of the short-term climatic deterioration. At the beginning of the Holocene the major boost of mixed deciduous oak woodlands, coupled with the spread of *Pistacia* and *Quercus ilex*, signpost the establishment of dense thermophilous forests, implying warm and wet conditions. Shortly after and especially throughout the Middle Holocene evergreen Mediterranean woodlands, mainly consisted by *Olea* and evergreen oaks are expanding, whereas the composition of deciduous oak woodlands is becoming diversified with *Carpinus/Ostrya* type being spread amongst other deciduous species. Pine trees are gradually becoming the dominant feature in the plant landscape around 4000 BP. Signs of human activities in the area are evidenced since 6000 BP. The presence of crop plants such as olive and cereals, the gradual occurrence of several anthropogenic and soil erosion indicators as well as the abrupt increase of microcharcoal concentrations in Elefsis pollen spectra, signal human activities in the broader area. Successive oscillations of various anthropogenic indicators are possibly linked to historical events in Elefsis area.

P044

PRELIMINARY RESULTS OF A PALYNOLOGICAL STUDY IN LAKE KORONIA, (NC GREECE)

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This study investigates the palynological content of a sediment core taken from Koronia Lake (NC Greece). Grasslands, shrublands, deciduous forests and reforestations are the main vegetation units of the surrounding mountains. In the lower altitudes (below 200–300 m), the climate is thermo-Mediterranean. The vegetation (maquis) consists of evergreen and sclerophyllous Mediterranean species (mainly with Greek kermes oak *Quercus coccifera*). In the hilly relief (200–300 and 600–800 m), the climate is Mediterranean sub-humid. The vegetation is thermophilous deciduous, mainly oak forests (*Quercus frainetto* and *Q. pubescens*) as well as stands dominated by chestnut (*Castanea sativa*). In the sub-mountainous areas (600–700 and 1000 m), the climate can be characterized as continental. The vegetation in this zone is dominated by beech stands (*Fagus sylvatica*). The region can be characterised as rural with important agricultural and livestock activities spread all around. The preliminary results of this analysis, containing several samples from the lower part of the core, are presented here, showing the strong presence of evergreen and deciduous oaks. In all depths analyzed a variable human pressure manifests itself as farming, olive groves and animal husbandry. The presence of charcoals in all samples indicates management of vegetation through fire. Moreover, the appearance of several *Pediastrum* species and varieties – *P. boryanum (var. boryanum, longicorne, brevicorne), P. simplex (var. simplex, sturmii, echinulatum, clathratum), P. duplex* – as well as some other significant algae of the *Zygnemataceae* family (*Zygema, Spyrogyra)* and other non-pollen palynomorphs are also worth mentioning, owing to the essential numbers they come in.

P045

COLD CLIMATE CHANGES IN MIDDLE HOLOCENE INCLUDING THE 8.2 KA EVENT - EVIDENCE FROM SUCHAR WIELKI LAKE, NE POLAND

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The best-known climate change in the middle part of the Holocene is an abrupt cooling around 8200 cal. yrs BP (e.g. Bond et al., 1997). However, on the European continent, many different records suggest that during climatic optimum of the Holocene not one, but several cold periods occurred in middle part of Holocene.

The best example of this is our study, where research area is located in the transition zone between oceanic and continental climate in north-eastern Poland. It is the best place to study influence of climate changes on flora and fauna, because the natural environment is particularly sensitive to climate changes and very quickly responds to them. Therefore, on this area, thermophilous tree species occur at their ecological tolerance limit so their abundance, regeneration, and pollen production are constrained by climate.

The multi-proxy data (pollen, diatoms, Cladocera, ^{14}C) from the sediments of Lake Suchar Wielki (54°01'41" N, 23°03'21" E) representing the period ca. 9250-5800 cal. BP have allowed the reconstruction of the influence of five Atlantic cold oscillations on terrestrial and aquatic environments, including the 8.2 ka event. These events were registered as a temporal increase in *Pinus* and/or *Betula* representation and transient decrease proportion of *Corylus* and other thermophilic taxa – their concentration and pollen percentage values. Pollen data were mostly confirmed by results of Cladocera and diatom analyses, suggesting different intensity of theses climate oscillations. The most pronounced cold climatic anomaly in our study was dated to 8700-7800 ka and lasted about 9 centuries. It is equated with the 8.2 ka event (Bond et al., 1997). Such a long duration of this oscillation is recorded quite rare in the literature. However, the climate proxy records of this oscillation in Europe and the world confirm that the duration of this event in different regions amounted from 400 to 600 years (Rohling and Pälike 2005), This allows for very accurate tracing changes in vegetation and aquatic communities at this time precisely showing the complex nature of this cooling.

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P046

THE EXTRACTION OF MACROSCOPIC CHARCOAL FROM SEDIMENTARY SEQUENCES

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An increasing need to better understand past wildfire expression, and especially its controls, has in the recent decades driven extensive research into the reconstruction of past wildfire regimes. The most commonly employed proxy for this purpose is charcoal, with fragments classified as microscopic (<100 μm) or macroscopic (>100 μm) charcoal. Especially the latter is being widely used to reconstruct local wildfire frequency. However, to this day, no standardized laboratory method exists, despite the fact that charcoal is especially fragile, meaning that variations in the laboratory process could potentially have a varying effect on charcoal fragmentation and, thus, the results obtained. This is because commonly used chemicals such as sodium hypochlorite or hydrogen peroxide might digest the less inert charcoal produced in low temperature wildfires. Furthermore, defflocculation of sediments such as peat cannot be achieved with milder chemicals, and therefore might lead to extensive fragmentation through mechanical pressure during the wet sieving process. A final issue that has also been overlooked is the effect abrupt lithological changes potentially have on charcoal accumulation, and, thus, on the comparability of charcoal values coming from different lithological units. For all these reasons, 12 contiguous sequences from Sluggan Bog, Northern Ireland, are analysed with a range of chemicals commonly used in paleofire research. The sequences partly span the Last Glacial-Interglacial Transition (LGIT, c. 16 – 8 ka cal. BP) and exhibit the classic tripartite lithology with abrupt lithological changes commonly identified in sequences of NW Europe spanning that period. Cutting-edge techniques in image analysis are used to quantify the charcoal fragments obtained from each sequence and the results are compared to highlight potential biases arising from abrupt changes in lithology and the use of various chemicals and sampling volumes. It is hoped that this will encourage further research in establishing a standardized technique for the extraction of macroscopic charcoal from sedimentary sequences.

P047

DEVELOPING ALTITUDINAL TRAINING SETS OF POLLEN RAIN-SITE SPECIFIC TEMPERATURES IN THE ALPS AS A BASE FOR PALEOCLIMATE RECONSTRUCTIONS OF HIGH-ALTITUDE FOSSIL RECORDS

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The potential of high mountain pollen records for quantitative climate reconstructions has been widely debated but seldom tested. We analyzed the pollen rain captured in 53 surface samples (mosses), in relation to July temperature, recorded along two altitudinal training sets of the Western and Central Alps (respectively La Thuile Valley training set and Upper Brembana Valley training set), from the montane to the alpine vegetation belts.

The aim is to improve paleoecological and paleoclimate interpretation and the challenges are the following: (1) to derive consistent pollen-climate correlations, both collectively and individually in regions of the Alpine area bearing differences in local climates and intensity of human impact; (2) to find potential indicator taxa useful for paleoclimate reconstructions; (3) to estimate the effect of local parameters on the relationships linking pollen percentages variations, elevation and climate and put forwards new hints for calibration of fossil sites; (4) to obtain quantitative climate reconstructions for each plot of the two altitudinal training sets and compare the results with instrumental modelled data (Brunetti et al., 2012, 2014) and finally (5) to integrate the newly-obtained pollen spectra into a large, continental dataset of modern pollen samples (EMPD - European Modern Pollen Database; Davis et al., 2013). The overall and individual pollen responses to July temperature were tested by canonical correspondence analysis (CCA), generalized linear regression (eHOF) and weighted averaging (WA). In order to obtain quantitative climate reconstructions for each plot of the two altitudinal training sets, an alpine calibration set of 234 modern pollen samples was selected from the EMPD. We paid special attention to valorize the potential indicator taxa maintaining the maximum taxonomical resolution, we kept *Alnus* distinguished in *Alnus viridis* and *Alnus glutinosa/incana* type, so the former calibration set has been reduced to 170 EMPD modern samples used for the second reconstruction. Transfer functions were derived by weighted averaging (WA) and weighted averaging partial least squares (WA-PLS) regressions. In each calibration set (234 and 170 EMPD sites), around 30% of the pollen taxa show a relationship with July temperature through monotonic or unimodal functions. The best transfer function obtained has a good statistical performance, as shown by the determination coefficient ($r^2 = 0.74$). The correlation between pollen inferred climate reconstructions and instrumental modelled data gives the opportunity to determine which model better reconstructs the climate of the two study areas.

P048

AFTER LANDSLIDE FOREST RECOLONISATION: A 4000 YEARS OLD CASE STUDY FROM KALAVAN RED LAKE (ARMENIA)

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Kalavan Red Lake (N 40°39.254 ; E 45°08.773 ; 1912m a.s.l.) is located on the northern side of the Miapor mountain ridge (Armenia). The lake forms in a large landslide erosion zone north of Gora (peak) Dzhantapa (2427m). This mass movement of about 0.86 km² occurs thanks to combining water saturation in the substratum and slope steepness (average 24%). Accumulation zone created foldings and depressions today occupied by Kalavan Red lake and a mire eastward.

Pollen and XRF analysis are provided on a 5 meters long core which covers the last 3800 years. Basal age of Kalavan sediment may approximate landslide age which produces a new, not vegetated slope, including the lake catchment. Erosion and sedimentation processes brought at first coarse and heavy minerogenic elements, then erosion in the catchment decreased operating a shift in the sedimentation. Along the whole stratigraphy, it is noteworthy that arboreal pollen increases thanks to the increasing rate of *Quercus* (oak), *Carpinus orientalis* (oriental hornbeam) and *Fagus* (beech). This afforestation took place on grass meadow while steppe meadow remains stable. Whereas oak development is known from Aparan valley in Armenia and may therefore relate to regional vegetation shift, beech, which is a known indicator of forest development climax stage, appears first as single stands at 1700 cal. BP. Upward, two forested phases are observed. The last, starts 700 years ago, is similar to today's forest pollen signal (evidenced in moss pollen trap) both in composition and proportion.

This work shows a different pattern of vegetation succession compare to interglacial succession and to primary succession. Two main characteristics here are the absence of pioneer stage and the time range for forest recolonisation which is operating during few millennia.

P049

RECONSTRUCTION OF VEGETATION AND PALAEOCLIMATE OF LATE GLACIAL AND HOLOCENEIN WESTERN SAYAN MOUNTAINS (SOUTH SIBERIA, RUSSIA) ACCORDING TOPOLLEN DATA FROM YUZHNO-BUIBINSKY MIRE.

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In the mountains of the Western Sayan ridge which represent a part of the Altai-Sayan mountain area and located to the south of Central Siberia east of the Yenisei River a sediments of mountain mire Yuzhno-Buibinsky have been investigated by spore-pollen and radiocarbon analysis. The resulting new spore-pollen diagram from the peat-lacustrine sediments with a thickness of 6 m covers the Late Glacial and the Holocene time. Six radiocarbon dates showed that lake sedimentation began at 13160 cal. yrs BP. About 1000 cal. yrs BP it was replaced by peat accumulation. The spore-pollen diagram is clearly divided into 5 local spore-pollen zones (LSPZ), which is confirmed by cluster analysis. The first LSPZ -1 reflects the Late Glacial time. In the vegetation at this time, open steppe landscapes with groves of spruce-larch forest were common. The climate was relatively dry and sharp continental. The second LSPZ -2 reflects the early Holocene. Probably, considerable humidification and warming of the climate during this period caused the rapid spread of closed forests from Siberian cedar (*Pinus sibirica*) and fir (*Abies sibirica*). The third LSPZ -3 reflects the time of the Middle Holocene, namely, the Atlantic period. Palynological data and quantitative paleoclimatic reconstructions say about a more humid and warmer climate compared to the modern one, when fir forest with the participation of Siberian cedar dominated in the mountain forests of Western Sayan, and birch-pine forests spread in the foothills. The fourth LSPZ-4 reflects most of the late Holocene up to 1000 cal. yr BP. In the vegetation cover, the participation of fir sharply decreased and the areas covered by Siberian cedar increased, which indicates a cooling of the climate and a decrease in the amount of precipitation. The fifth LSPZ-5 falls on the last millennium of peat sedimentation and reflects an unstable landscape-climatic situation, when Siberian cedar, pine and birch alternately dominated in the vegetation cover. The research was supported by Russian Foundation for Basic Researches No. 17-55-52020/MHT_a. and Budget Research Theme of IMCES SB RAS.

P050

RECONSTRUCTED CLIMATE VARIABILITY OVER THE LAST 17000 YEARS IN THE DESSARETE REGION INFERRED FROM NEW POLLEN RECORDS OF LAKE OHRID AND PRESPA

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Here we present the first results of reconstructed climate variability over the Late Glacial and the Holocene as inferred from new pollen records with high-temporal resolution from the Dessarete region in the southwestern Balkans. The Dessarete region comprises the lakes Prespa at 850 m asl, Ohrid at 693 m asl, and the former Lake Maliq at 822 m asl which have been in the spotlight of paleoenvironmental and paleovegetation research over the last decade. The climate of the study area is transitional between temperate and Mediterranean and previous studies have shown the sensitive response of the vegetation surrounding each lake to climate variability over several past climatic cycles. Although existing studies have inferred paleoclimate in the region by qualitative multiproxy means, such as geochemistry and bio-proxies (e.g. stable isotopes, biomarkers, pollen, diatoms, ostracods), so far, only one quantitative pollen-based climate reconstruction using the modern analogue technique (MAT) was published from Lake Maliq. In the present study, we use a new surface sample calibration set (comprising approximately 3600 sites with Eurasian distribution) including a total of 30 modern surface samples collected across an altitudinal transect within the Dessarete region. Mean annual precipitation values reconstructed applying the MAT method are above the 400 mm/year threshold during the last 17000 years. These findings suggest that moisture availability was most likely not a limiting factor for tree growth and support the refugial character of the region. The Holocene is characterized by an estimated twofold increase of mean annual precipitation in comparison to the Older and Younger Dryas, when glacial conditions prevailed. Our findings based on the new high-resolution pollen data of Lake Ohrid and Lake Prespa are in good agreement with the estimated climate of Lake Maliq over the same interval. The integration of the Dessarete region surface samples has significantly improved the reconstructed precipitation and temperature values using the MAT method, especially for the Late Glacial when pines dominate the pollen spectra. Additional climate reconstruction methods will be applied to evaluate the robustness of the reconstructed climatic variables.

P051

BUILDING UP A POLLEN-VEGETATION-CLIMATE-ENVIRONMENT TRAINING SET FROM GRAN CANARIA AS A TOOL FOR PALAEOENVIRONMENT AND PALAEOCLIMATE RECONSTRUCTIONS

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The characterization of modern pollen rain is the first step to understand pollen-vegetation-climate relationships. This training set is useful to improve the interpretation of fossil records when reconstructing past vegetation and climate dynamics. The mountains of Canary Islands display wide climatic gradients and an unusual double gradient, characterized by a thermal inversion above trade winds air mass. The first study of modern pollen rain placed along an elevation gradient (10-2250 m a.s.l.) across main Canarian vegetation types has been carried out in Tenerife (de Nascimento et al., 2015). Here we present a new training set of modern pollen rain (collected from pollen traps, moss polsters and forest litter) and vegetation coupled with topographical and environmental proxies developed in Gran Canaria. We want to investigate the relationships between climatic, ecological (dung fungi and pollen-slide charcoal) and environmental (topography, fires, stocking rate and pedology) parameters and to permit a rating of ecological factors. 30 samples from 13 plots covering an altitudinal gradient of nearly 1800 meters are included in the training set. Whenever possible both a moss and a forest litter samples were collected for pollen analysis and a Behling-type pollen trap was installed, coupled with vegetation surveys at different scales (2 and 10 m around the site). Climate normals (1971-2000) for each plot were obtained from the Climate Atlas of the Archipelagos of the Canary Islands, Madeira and the Azores (AEMET, 2012). Results from statistical multivariate analysis highlight a close relationship between pollen-spores-vegetation occurrences and climate parameters. Next step will be to compare and incorporate modern pollen data from both islands.

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P052

THE HOLOCENE DEVELOPMENT OF SUPRAMONTANE VEGETATION BASED ON POLLEN ANALYSIS

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The general aim of this research was to reconstruct the vegetation of a supramontane vegetation zone on the Kubínska hoľa Mts. (Western Carpathians, northern part of Slovakia) during Holocene. The reconstruction was based on the pollen analysis of one 8 m long profile taken from peatland in the highest part (1 203 m a.s.l.) of the studied locality. We also used a radiocarbon dating of 6 samples, LOI and pollen influx analysis. From the beginning of peat accumulation (ca. 6000 cal. AD), the vegetation on the Kubínska hoľa Mts. was formed mostly by spruce forests with an admixture of pine. In this time the lower areas were covered by temperate deciduous trees such as elm and oak, whereas in higher areas linden and ash were also abundant. The middle Holocene was specific by an expansion of hazel into the open parts, but spruce was still prevalent. Spruce forest persisted also during the late Holocene. During that time a rapid increase in pollen of late successional trees (*Abies, Fagus, Carpinus*) was recorded and their expansion is synchronous with the first occurrence of secondary anthropogenic indicators (*Plantago lanceolata, Rumex acetosa-type, Urtica*). The youngest developmental stages were probably affected by human activities at all altitudes. Approximately from the 14th the composition of vegetation was affected by a significant deforestation due to the extension of the Wallachian colonization in the mountain areas. Later, in order to restore the natural forest vegetation in the higher altitudes, a deliberate planting of spruce and probably also mountain pine is visible from the pollen diagram.

Key words: the Holocene, the Kubínska hoľa Mts., reconstruction of the vegetation, spruce forest, human impact

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P053

HOLOCENE VEGETATION AND FIRE DYNAMICS AT CRVENI POTOK, A SMALL MIRE IN THE DINARIC ALPS (TARA NATIONAL PARK, SERBIA)

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We analysed sediments from the Crveni Potok mire, a key site in the Dinaric Alps because it is located within the restricted distribution range of the endemic conifer *Picea omorika* (Serbian spruce), and thereby bears a unique potential in revealing its Holocene history. We used a set of proxies (pollen, plant-macrofossils, charcoal) to reconstruct the long-term vegetation and fire histories at different spatial scales. The comprehensive snapshot provided by the reconstructions fill an important gap of European long-term vegetation and fire histories in the overall data-coverage poor region of the Dinaric Alps. The reconstructions unfolded an unusual late-Holocene persistence of high forest cover that contrasts with the large majority of European landscape-scale forest-cover records, which show massive anthropogenic land-cover changes in the past few millennia. We also found evidence for good post-fire recovery of the currently threatened endemic *P. omorika* populations. This leads us to suggest that prescribed-burning programmes may be beneficial to reduce the vulnerability of the species, and for ecological restoration and conservation purposes of the declining and endangered populations.

P054

PLANT REMAINS FROM FOSSIL FAECES (COPROLITES) OF A LARGE PREDATORY ARCHOSAUR FROM THE UPPER TRIASSIC OF SILESIA, POLAND

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Numerous studies have shown that fossil faeces (coprolites) may contain well-preserved palynomorphs, phytoliths, cuticles, and other plant remains. Such remains may derive from ingestion of plants directly (as a source of food or swallowed during predation), from ingestion of herbivores by carnivores, or from water, airborne spores, pollen or plant litter that adhered to fresh, moist faeces before being buried. Organic residues of four large, elongated and phosphatic-rich coprolites collected from the Upper Triassic of Lisowice (Silesia, Poland) were studied in detail. The geochemical composition, general shape and size, and numerous bone inclusions of these specimens indicate that a large-sized carnivore such as *Smok wawelski* (known from the site from bone material) was the most likely coprolite producer. One characteristic feature of all the coprolites studied is the presence of highly fragmented or small plant elements. The recovered plant remains were grouped into three main types: 1) plant cuticles; 2) spores and pollen grains; and 3) black, opaque organic particles. It is possible that *S. wawelski* occasionally ingested plant fragments or accidentally swallowed plant material during feeding. The large carnivore coprolite specimens from Lisowice preserve an additional source of data about the local vegetation and environment in which *S. wawelski* lived and hunted.

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P055

ENIGMATIC EVIDENCE OF PLANT-INSECT INTERACTION FROM THE MIDDLE JURASSIC OF POLAND

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The Grojec clays (southern Poland) contain a very well known Middle Jurassic flora studied and described by Raciborski (1894). It consists of numerous species of ferns, horsetails, seed ferns, cycads and bennettites. One new species, *Ctenis potockii*, was ascribed by him to ferns due to dense "sporangia" on the abaxial surface of the leaf blades. However, the shape of the leaf and its venation are undoubtedly of the cycad type. Because these sporangia–like forms are preserved as casts, their detailed structure is unknown, but their distribution between the veins, density, arrangement, ornamentation and shape suggest they are of animal track origins. The structures show a certain similarity to insect ovipositional scars or eggs, insect-galls and remains of Coccoidea. A detailed study shows some slight differentiation between particular tracks in relation to size (smaller and larger structures), fine ornamentation and orientation of bodies. These morphological characteristics are comparable to females and larval forms of scale insects. The mentioned forms of Coccoidea are rare in the fossil record, and usually, they are detected in younger strata and only on angiosperm leaves. Most often, starting from Cretaceous and preserved in amber, it is the male forms that are found. Due to the poor preservation, the unambiguous confirmation that the structures are of the scale insect origin is impossible. Because of the new type of structures, host plant and significant differences from other known forms, a new taxon is proposed. The study was financed by the W. Szafer Institute of Botany Polish Academy of Sciences, through its statutory funds and funds for young researchers (A. Jarzynka 2012).

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P056

SEED FERNS AND CYCADS IN THE RHAETIAN FLORA OF WÜSTENWELSBERG, BAVARIA, GERMANY

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The fossil flora from the uppermost Triassic and Lower Jurassic strata of Upper Franconia (Bavaria, Germany), more widely known as the "Rhaeto-Liassic flora" of Upper Franconia, has received considerable scholarly attention in the last decade. Most of the outcrops include Hettangian (Lower Jurassic) sediments and are spread in a wide area around the towns of Bayreuth and Nuremberg. At a few localities around the town of Coburg, however, purely Rhaetian (Upper Triassic) sediments crop out. Systematic sampling in one of these Rhaetian localities, a quarry near the village of Wüstenwelsberg, resulted in the recognition of over 40 different species of fossil plants, representing a much higher diversity than is known from adjacent outcrops. The flora is exceptionally well preserved and the specimens in most cases allow to obtain excellently preserved plant cuticles for the study of the plants' epidermal anatomy. In the flora, we have so far recognised leaves of bennettites, cycads and seed ferns, leafy twigs of conifers, fronds of ferns, vegetative shoots of sphenophytes and very delicate fertile shoot fragments of lycophytes. Among the seed ferns, notable are *Lepidopteris ottonis*, which is found together with its male inflorescence *Antevsia zeilleri*, a few fragments and seeds of its female fructification *Peltaspermum rotula*, and the male reproductive structure *Hydropterangium roesleri* with associated seeds, possibly belonging to one of the *Ptilozamites* species. Besides, leaf portions assignable to *Pachypteris*, *Rhaphidopteris* and *Ptilozamites* were identified. The cycads are represented by numerous leaves and portions of leaves recognised as *Nilssonia pterophylloides*, *Doratophyllum astartensis*, *Ctenis latepinnata*, and *Pseudoctenis florinii* and *Pseudoctenis cteniforme*. If the flora from Wüstenwelsberg is compared with adjacent Rhaetian floras, distinct local differences in the composition of the seed fern and cycad representatives are revealed. These are most likely caused by different local palaeo-micro-terrains generating different habitats, in which only plants thrived that had the respective adaptations to the local environmental conditions to fill the present ecological niches. The plants' mechanisms and pattern of dispersal might also have played a major role.

P057

A COMPARISON OF THE NORTH AMERICAN AND EUROPEAN CARNIAN AND NORIAN PALYNOFLORAS

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A significant floral turnover recorded in the middle of the Chinle Formation (SW North America) in western equatorial Pangea was previously linked to the termination of the Carnian Pluvial Episode, a wet climate phase in the middle Carnian, and a return to drier climate as seen in Europe in the Tuvalian. Many age-diagnostic species from the European Carnian e.g., *Camerosporites secatus*, *Duplicisporites, Lagenella martinii* and *Brodispora striata* which have their last occurrence in the Tuvalian in Europe, are still present in the lower Chinle Formation which formed the basis for the Carnian-Norian age assignment of the Chinle. However, new magnetostratigraphy and radiometric dating suggested middle to late Norian age. The "final" disappearance of the European taxa is now linked to a gradual shift towards drier climate known as the Mid Norian Climate Shift in SW Pangea due to the northward migration of the North American continent and the uplift of the Cordilleran Arc. Recently, *Perinopollenites elatoides* has been observed in the middle part of the Chinle. So far, it is the only species with an occurrence in agreement with the European range of the species with first appearance date in the mid Norian.

Further difference is the scarcity of the Circumpolles in the Norian palynofloras of the Chinle. The group, especially *Classopollis* is predominant in European Norian assemblages, but they are uncommon in North America until the Rhaetian.

The differences between North American and European palynofloras are mainly manifested in the diachronous stratigraphical ranges of the index taxa which track primarily environmental variations and not biostratigraphical events (Lindström et al. 2016). The heterogeneity of Late Triassic macro- and palynofloras of the Northern Hemisphere is the consequence of the various climate and environments (e.g., topography) on Pangea. This difference between palynofloras may be the result of the generally hot and semi-arid climate in the inner part of Pangea and western Tethyan realm, while a seasonally more humid tropical belt in the SW Pangea perhaps provided a favourbale habitat for the parent plants of the "typical Carnian" taxa until the mid Norian.

Lindström, S., Irmis, R.B., Whiteside, J.H., Smith, N.S., Nesbitt, S.J., and Turner, A.H.. 2016, Palynology of the upper Chinle Formation in northern New Mexico, U.S.A.: implications for biostratigraphy and terrestrial ecosystem change during the Late Triassic (Norian–Rhaetian): Rev.of.Palaeobot.Palynology, 225, 106–131.

P058

FERNS FROM THE FAMILY MATONIACEAE WITH *IN SITU* SPORES FROM JURASSIC GROJEC CLAYS NEAR CRACOW (POLAND)

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Spores *in situ* were obtained by maceration of coalified fragments of pinnules with sporangia from two fern leaf fragments, of matoniacean gross morphology, found at Grojec near Cracow (southern Poland). One of them was described by Raciborski (1894) as *Laccopteris phlippsii* Zigno, and the second by Reymanówna (1963) as *Phlebopteris angustiloba* Presl (Hirmer et Hoerhammer). These specimens are probably conspecific and may belong to *Matonidium goepperti* (Ettinghausen) Harris. Spores *in situ* were described and illustrated earlier by Reymanówna (1963) from *Phlebopteris angustiloba*, and spores from *Laccopteris phlippsii* are described and illustrated for the first time by the authors. Observations by optical microscopy and SEM were made. The spores are trilete and triangular in equatorial outline, with rounded apices and kyrtomes (interradial thickenings). These spores are very similar to fossil (Late Triassic to Early Cretaceous) and extant matoniaceous spores described by Van Konijnenburg-van Cittert (1993) and Van Konijnenburg-van Cittert and Kurmann (1994). Matoniaceae grow under wet and warm conditions; this type of habitat probably prevailed during the Jurassic at Grojec.

The study was financed by funds from the National Science Centre, Poland (no. 2017/25/B/ST10/01273) and by the W. Szafer Institute of Botany, Polish Academy of Sciences, though its statutory funds.

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P059

THE PLANT MESOFOSSIL FLORA OF THE UPPER CRETACEOUS AJKA COAL FORMATION – PRELIMINARY RESULTS

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Numerous well-preserved plant remains have been discovered in the Upper Cretaceous Ajka Coal Formation (Bakony Mts., Hungary). The Ajka Coal Fm. is built up of alternating brown coal, marl, sand and sandstone beds with grey to brownish colored, carbonaceous to argillaceous pelitic sediments, and interbedded mollusc-lumachelle layers. Its structure represents a lacustrine-palustrine sequence. The studied plant material was retrieved from drilling cores and a trial trench. The material is rich in Salviniales and Isoetales-related macrospores, and in *Munieria*-related green algae fossils. Also a high number of *Costatheca* and *Spermatites* fossils have been found, which groups are taxonomically interesting and their Regnum level affinity is still questionable. We studied the mesofossil content of the samples and cores using multivariate analytical methods to outline the palaeoenvironment of the area. The mesofossils from the Ajka Coal Fm. refer to a continuous water surface, i.e. to a lake and a lakeside swamp environment in the area of Káptalanfa. The material was compared to those from the nearby Iharkút locality. Iharkút is dominated by Normapolles and Magnoliaceae-related fruits. The Normapolles-related fruits gradually vanish from the samples in S-SW direction from Iharkút.

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P060

A NEW LOOK AT THE CRETACEOUS PINACEOUS CONES OF BELGIUM.

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At the end of the nineteenth century, numerous fossiliferous beds have been identified in the Wealden facieses (Barremian–Aptian, Cretaceous) of Belgium. These notably contain the famous Iguanodons of Bernissart but also several thousand fishes that are presently under study. Plant remains have been collected as well and include fragments ranging from dispersed micro- and meso-fossils up to plurimetric trunks. Among these, hundreds of pinaceous cones have been collected. The latter, charcoalified, show a pristine preservation of the anatomical details and of the original three-dimensional organisation. Diversified, they represent a major source of information concerning that key period in the evolution of continental environments marked by the rise of angiosperms and the diversification of pinaceous conifers. In this study we quantitatively reinvestigated these cones in order to precisely characterize their diversity. We further focused our investigation on several key taxa in order to precisely determine their different ontogenic stages.

P061

QUANTITATIVE ANALYSIS OF EPIDERMAL CHARACTERS OF LATE PERMIAN CONIFER LEAF CUTICLES AND ITS TAXONOMIC VALUE

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In the 1980s several late Permian conifer taxa have been described based on well-preserved cuticle remains from northern Italy. Recently, a new macrofossil horizon was described from the same area and coeval with the cuticle assemblage. This new flora included a rich assemblage of gymnosperm and spore plants (e.g. seed ferns, putative cycadophytes, ginkgophytes and sphenophytes). Approximately 40% of the gymnosperm-dominated floral assemblage is represented by well-preserved conifer leaves and shoots with cuticles. By combining plant macrofossils with their preserved cuticles, these new finds have the potential to elucidate the gross morphology of conifers that were hitherto only known from small remains and/or dispersed cuticles. In this study, we will focus on an integrated analysis of macrofossil remains and cuticles from the newly discovered locality. Three aspects will be emphasized, that together will shed light on voltzian conifer morphology and taxonomy: (1) quantitative comparison and classification of epidermal cell patterns in the cuticle material of identified macrofossils with previously described taxa from the same area; (2) assess which quantitative characters and their frequency distribution best separate existing taxa using multivariate statistics; and (3) re-evaluate existing conifer taxonomy based on preserved cuticles alone.

P062

THE AVELLINO EVENT: A BRONZE AGE ENVIRONMENTAL RECONSTRUCTION FROM THE PONTINE PLAIN AND THE FONDI BASIN, SOUTHERN LAZIO, CENTRAL ITALY

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The major Early Bronze Age eruption of the Monte Somma Vesuvius (1995+-10 BC) must have had an enormous impact on the landscape and inhabitants of the Campania region. The so-called Avellino (AV) eruption buried the early Bronze Age landscape to the north and south of the volcano in a deep layer of volcanic ash. However, a small initial eruption had probably allowed the population to flee the area before this devastating event, heading inland rather than towards the sea. A multi-disciplinary research involving geology, palaeoaeobotany and archaeology has been set up to unravel the project's hypothesis, that a significant percentage of the refugees must have decided to resettle in the nearest coastal plains to the north - the Pontine Plain and Fondi Basin of South Lazio, and that we should therefore be able to prove this by tracing the ecological, demographic and cultural impacts that this immigrant population must have had. The palaeobotanical research has focused on reconstructing the vegetation in this area before and after the AV eruption, to detect the environmental impacts that should have been brought about by the influx of possible immigrants from Campania. High quality profiles of five locations in Pontine plain and the Fondi basin have been chosen to carry out palynological research for a regional vegetation reconstruction. In addition, macro botanical research has been conducted in four of these case studies, to provide information on the local vegetation and environment around the profile locations. The distal ash from the AV is present in the sediments of the Pontine plain and the Fondi basin and this lithological horizon acts as a stratigraphic marker. Furthermore, where possible plant macrofossils from terrestrial

plants were extracted to obtain accurate radiocarbon dates allowing the construction of a precise chronology for the profiles. With the project about to reach its end, this paper will present a detailed overview of the palaeobotanical investigation, that allowed the reconstruction of the Bronze Age landscape in the Pontine plain and the Fondi basin.

P063

POSTGLACIAL DYNAMIC OF QUILLWORT POPULATIONS (ISOËTES) IN PRÁŠILSKÉ LAKE, BOHEMIAN FOREST

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Studying long-term dynamic of critically endangered species, such as quillworts (*Isoëtes lacustris*, *Isoëtes echinospora*) is crucial for maintaining biodiversity and developing management strategies that preserves their natural habitat. Local quillwort populations have slowly diminished since the Last Ice Age and are thus considered endangered in many European countries. Based on direct observation and field experiments, many recent ecological studies have proposed several hypothetical causes of the decline in quillwort populations across Europe. Unfortunately, long-term studies investigating quillwort dynamics from the Holocene are rare. The aim of this study is to reconstruct postglacial dynamics of quillwort populations using a multi-proxy approach including plant macrofossils, pollen, diatoms, and geochemistry to investigate the long-term occurrence of, and drivers related to their recent extinction in Prášilské lake, Bohemian Forest. Our preliminary results show that quillwort have persisted but with high variation in Prášilské lake since 10400 cal yr BP. Around 4000 cal yr BP, there was a substantial decline in quillwort microspore and macrospore concentrations. This trend seems to be connected with a shift to more eutrophic status of water chemistry as supported by changes in diatom assemblages. Unfortunately, in 1969 the species became extinct locally. While these results are preliminary, the results of this long-term record could serve as a useful template for management towards implementing strategies that will preserve their natural habitat.

P065

VEGETATION HISTORY OF SPRING-FED FEN ON WESTREN POMERANIA (N POLAND)

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Alkaline spring-fed fens belong to the rare group of fens supplied with groundwaters of distinct flow rich in calcium carbonate. What is characteristic for such objects and was observed by several authors (Miner and Ketterling 2003; Mazurek et al. 2014), this is alternately occurrence of peat and calcareous tufa layers, often with distinct periodicity.

Because of their continuous peat-tufa record of carbonate-biogenic deposition these beds are excellent for detailed palaeoenvironmental studies (Dobrowolski et al. 2002; Mazurek et al. 2014). One of the possible method is analysis of plant macrofossils which is useful for reconstructions of subfossil vegetation.

Our study was conducted on Western Pomerania, N Poland, in the vicinity of Bobolice. The core of peat-tufa deposits of 800 cm long, as representative for whole spring-fed fen, was collected with Eijkelkamp drilling for the plant macrofossil analysis. Sediment core was divided into segments of 5 cm. Altogether 140 samples of peat and travertine calcareous tufa were analyzed under light microscope to recognize vegetative macroscopic plant remains. Several samples were dated by radiocarbon method for age determining.

In Bobolice site plant remains of 21 plant taxa were recognized. Quantitative representation of major plant types was as follow: trees and shrubs – 3 taxa, herbs – 6, peat-mosses – 3, brown mosses – 7, pteridophytes – 2. Altogether 10 plant macrofossil zones was described. While during mire history 6 developmental stages were present. The first stage is connected with Younger Dryas (10910-10135 cal. BC), when on the strongly hydrated sands vegetation occurred, probably sedge communities. Spring-fed fen was younger, because its appearance was noted during the beginning of the Boreal period. Vegetation was then represented by sedge-brown moss and sedge with *Cladium mariscus* communities. In the last, contemporary stage of development strong anthropopressure was noted, what means use of mire as meadow and pasture.

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P066

A MODERN POLLEN DATASET FROM THE NORTH SIKKIM AREA, EASTERN HIMALAYA: IMPLICATIONS FOR PALAEOVEGETATION RECONSTRUCTION

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Efficacy of the modern pollen assemblages to differentiate among elevationally stratified vegetation zones is assessed from the north Sikkim, eastern Himalaya, in order to understand their potential for past vegetation reconstructions. Thirty six surface samples from three climatologically sensitive and important glaciated (alpine) valleys of north Sikkim, Himalaya comprising of alpine thicket (3500– 4500 m a.s.l.), alpine scrub (4000–4500 m a.s.l.) and alpine barren (4500–5500 m a.s.l.) vegetation belts have been collected for modern pollen analysis. Pollen spectra from Lashar valley with an elevation of ~4717m a.s.l. reveal highest pollen frequency of non arboreal such as *Aconitum* followed by Poaceae, Caryophyllaceae, Tubuliflorae. Arboreal taxa are represented by *Alnus, Quercus* and *Carpinus*. Conifers make their appearance as extra-local elements and are moderately represented in the pollen rain suggesting up-slope pollen transport from nearby alpine thicket. However, the pollen spectra from Chopta valley (~3990 m a.s.l.) shows over- representation of extra-local conifer taxa such as *Pinus* that can be attributed to its high productivity, good dispersal efficiency and preservation. Other arboreal taxa viz., *Abies, Picea, Juniperus, Betula, Quercus* and *Salix* are moderately and sporadically represented in the pollen spectra and might be coming from the nearby sub-alpine or dry temperate forests suggesting an upslope wind activity. Thus, the study from Lashar and Chopta (closed) glaciated alpine valleys show relatively higher frequencies of arboreals over the non-arboreals. While, surface samples from alpine barren belts exhibit high frequency of non-arboreals over arboreals. Herbaceous taxa like *Poaceae, Tubuliflorae, Liguliflorae*, and *Aconitum* are well represented while the tree taxa viz. *Alnus* shows highest frequency in this area. This study strengthens the fact that pollen spectra can reliably identify the stratified vegetation belts along the rising elevation. A minor disequilibrium between pollen-vegetation relationships may be attributed to the pollen production, preservation potential and wind transport and should be taken into consideration while interpreting regional fossil pollen spectra.

Keywords: Pollen spectra; glaciated valleys; North Sikkim; Himalaya;

P067

PALYNOLOGICAL RECONSTRUCTION OF THE LATE-GLACIAL TO HOLOCENE FLORA, VEGETATION AND LANDSCAPE CHANGES IN THE NORTHERN LAKE ATTERSEE REGION (AUSTRIA) AND CLIMATIC VARIABILITY BASED ON THE PAST ABUNDANCE OF THE ANNUAL WATER PLANT *NAJAS FLEXILIS*

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Palynological and plant macrofossil analyses performed on a 538 cm long clay, lake marl, gyttja and peat stratigraphy at "Gerlhamer Moor" (Salzkammergut, Upper Austria) northwest of Lake Attersee allowed the reconstruction of the past regional flora, vegetation and landscape development (including fire history). The results obtained were compared to local archaeological evidence, especially to the presence of prehistoric human lake-dwelling societies applying their agricultural sustainability systems during the Neolithic and Bronze Periods (ca. 5500–800 BC) at nearby Lake Attersee and in the surroundings of our study site. Recurrent sedimentological changes within the former lake stratigraphy as well as rapid increases in organic matters and distinct variations in chemical element distribution measured by X-ray Fluorescence (XRF) core scanning analyses do hint at past lake level variations. In this context, seed remains of thermophilic water plants such as from the bushy pondweed *Najas flexilis*, also implied changing lake water levels due to regional to global climatic changes. Given, that *Najas flexilis* belongs to the extinct aquatic plant species in Austria and to the highly endangered red-list plant species in Europe, this study highlights the ecological parameters necessary for its growth during the Holocene, and before local extinction, which in turn may be of relevance to nature conservation issues and possible intentional planting of this water plant for protection purposes in the future.

P100

STRATIGRAPHIC DISTRIBUTION OF MIOSPORES IN THE LADINIAN (MIDDLE TRIASSIC) DEPOSITS AT CAPE TSVETKOV SECTION, EAST TAIMYR, NORTHERN MIDDLE SIBERIA, RUSSIA

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Cape Tsvetkov section is one of the most important key sections to study Middle Triassic paleontology and stratigraphy in the Northern Middle Siberia and for the calibration of palynological data with detailed ammonoid scales. Detailed ammonoid zonation of the Middle Triassic was presented by A.S. Dagys and A.G. Konstantinov (Dagys, 2001; Dagys et al., 1991, Dagys&Konstantinov, 1992, 1995; Konstantinov, 2015). The Middle Triassic includes Morzhovaya (Lower-Middle Anisian) and Kul'dima (Upper Anisian-Ladinian) formations. The main part of Kul'dima formation is referred to the Ladinian stage. The lowermost part of the Ladinian is conditionally assigned to the Eonathorstites oleshkoi and Tsvetkovites constantis Zones by the stratigraphic position. Tsvetkovites neraensis, Indigirites krugi, Nathorstites maclearni Zones are distinguished in the overlying beds. The lower boundaries of Zones are determined by the FAD of index-species. The upper boundary of maclearni Zone is conditional because N. maclearni Tozer is established at a single stratigraphic level. The overlying part of the formation is missing age conclusive faunal evidence. Based on palynological study a general palynological characteristic of the Ladinian interval was presented (Krugovykh&Mogutcheva, 2000). The revision of palynological data allow to distinguish three new palynological levels (PL) calibrated by ammonoid scale on the base of the consecutive FAD of stratigraphically important species of miospores. Generally the composition of Ladinian palynoflora in the studied section is very close to those in the Boreal realm (Ilyina, 2001; Vigran et al., 2014 and cited literature). PL 1 corresponds to undivided oleshkoi and constantis Zones and marked by FAD of pollen *Echinitosporites iliacoides* and *Camerosporites pseudoverrucatus*.

PL 2 is characteristic for neraensis Zone and is determined by FAD of pollen Lunatisporites rhaeticus and Pseudenzonalasporites sp. PL 3 corresponds to krugi Zone and is marked by FAD of pollen Patinasporites densus and spores Tigrisporites halleinis and Kyrtomisporis speciosus. Palynological associations from the overlying undated interval show the consecutive FAD upward the section for the following species: Heliosaccus dimorphus, Pseudenzonalasporites summus, Enzonalasporites sp., Tsugaepollenites cf. pseudomassulae, Kraeuselisporites cooksonae. Palynological associations of these levels were compared to other palynological zonations for the Southern Alps and Barents region. It should be noted the oldest record some of the species such as C. pseudoverrucatus, P. densus, P. summus, K. speciosus in the Boreal sections.

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P101

PALYNOSTRATIGRAPHIC CORRELATION OF THE LOPINGIAN TO MIDDLE TRIASSIC

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Terrestrial floras underwent important changes during the Lopingian (late Permian), Early Triassic, and Middle Triassic, i.e., before, during, and after the end-Permian mass extinction. An accurate account of these developments requires reliable correlation. Macrofossils of land plants can only provide a low-resolution biostratigraphy, while detailed zonation schemes based on palynomorphs are available for many regions. Their applicability is still limited due to several factors, such as (micro-) floral provincialism, a lack of suitable marker taxa commonly occurring at important boundaries, and in many cases a lack of independent age control. Nevertheless, these palynostratigraphic schemes are regularly used for dating and correlation of successions between different regions. To support such efforts, the biozonation schemes based on palynomorphs from the Lopingian up to and including the Middle Triassic from across the world are summarized and revised. Thus, a consistent correlation of palynostratigraphic schemes with the currently recognized international stages is established, but not all chronostratigraphic stages are equally well aligned with palynozones. The bases of the Wuchiapingian and Changhsingian are rather indistinct with respect to palynology. The Permian–Triassic boundary by itself is also not always recognizable, but the latest Permian is marked by important changes in palynofloras, which are reflected in palynozones. Spores and pollen might be useful as approximate indicators of the Induan–Olenekian boundary in several regions, but this boundary is not yet defined by a GSSP, and useful palynostratigraphic data is currently only available from one of the candidate sections (Nammal Gorge, Pakistan). In contrast to the Lopingian and Early Triassic stages, the bases of the Anisian, Ladinian, and Carnian are palynostratigraphically distinct in many regions.

P102

NEW DINOFLAGELLATE CYST SPECIES FROM THE BATHONIAN-KIMMERIDGIAN OF THE LAMINARIA HIGH, BONAPARTE BASIN, NORTH WEST SHELF, AUSTRALIA.

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The Late Jurassic strata of the North West Shelf (NWS) of Australia contain numerous world-class oil and gas fields and are still currently the focus of significant investment from major international oil companies. This study investigates the geographic and stratigraphic range of new and informal dinoflagellate cyst species, Bathonian-Kimmeridgian (Middle-Late Jurassic) in age, from cored intervals of the Alaria-1 and Laminaria-2 wells of the Laminaria High, and the Elm-1 and Taltarni-1 wells of the Vulcan Sub-basin, Bonaparte Basin, NWS, Australia. 16 biostratigraphically significant species previously described from the NWS of Australia were imaged using SEM and 9 new/informal dinoflagellate cyst species with marker potential are herein formally described. Third generation FIB/SEM imaging was used to produce cross-sections to investigate the wall structure of several of these species.

High resolution palynological counts were used to identify new biostratigraphic events with marker potential, and determine the applicability of other informal events identified from Northern Carnarvon Basin of the NWS. Preliminary results indicate that most informal events are present across the various basins of the NWS, with only a small number of events observed to have significantly different stratigraphic ranges across this region. This study refines the biostratigraphic resolution of the current Mesozoic Dinocyst Zonation of the NWS (Partridge et. al. 2006).

This work represents the results of a PhD project aiming to refine the biostratigraphic zonation of the *Wanea indotata-Dingodinium swanense* dinoflagelalte cyst zones of the Bonaparte Basin.

P103

PALYNOSTRATIGRAPHY FROM THE LOWER CRETACEOUS PEÑAFERRUZ FORMATION, SAN PEDRO DE ANTROMERO BEACH (NW IBERIAN PENINSULA).

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This study aims to provide the age of the Peñaferruz Formation, as the exact age of this unit has not been resolved hitherto, as well as give comprehensive palaeoclimatic and palaeoenvironmental information.

The study area is located in the Asturian coast of Spain, at San Pedro de Antromero Beach. Here, the Lower Cretaceous deposits (the Peñaferruz and Antromero formations) are overlying the Carboniferous flysch (González-Fernández et al., 2004). The Peñaferruz Fm. corresponds to a fluvial-deltaic depositional system with three well-differentiated depositional units: braided channel infills, delta plain and prodelta. The overlying marine unit corresponds to the Aptian Antromero Fm. (Alonso-García and Bahamonde, 2006).

Ramírez del Pozo (1969) suggested an Early Cretaceous age (pre-Aptian) for this formation and Sánchez de la Torre (1982) attributed it to the Barremian. Dragastan (1982), by its algal content, dated the deposit from San Pedro de Antromero Beach (including the Peñaferruz and Antromero formations) as early Aptian-early Albian. González-Fernández et al. (2004), suggested a Barremian age, by its stratigraphic location, which could reach an early Aptian age.

An Aptian age is suggested by the presence of *Cicatricosisporites berouensis, Ephedripites dudarensis and Reticulisporites semireticulatus*. This age assignment implies a new relationship between Peñaferruz and Antromero formations, being the Peñaferruz Fm. younger than previously thought. Both formations could be contemporaneous, at least at the San Pedro de Antromero Beach section.

This palynological assemblage is the first studied in the Early Cretaceous deposits of the Mesozoic Asturian Basin. It indicates a tropical/subtropical climate and a humid continental environment with a marine influence, correlating with the lateral change of facies between continental and marine formations.

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P104

TOWARD A PALYNOLOGICAL CALIBRATION OF THE BARREMIAN-APTIAN BOUNDARY

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Because of the predominant continental nature of the Lower Cretaceous Pre-salt series of Western Africa and South America, their calibration and correlation with the standard international stratigraphic chart is difficult and the arguments for the equivalences are poor. The chronostratigraphic characterization of the Congo and Gabon biozonation is supported by a few correlations based on sporomorph occurrences in time-equivalent marine sediments elsewhere (Grosdidier *et al*., 1996). One point that needs to be clarified is the position of the Barremian-Aptian boundary. Up to now the index species used to characterize the boundary are calibrated in a few localities of Northern Africa and South America, sometimes some discrepancies exist about their first or last occurrences. The genus *Afropollis*, for example, has been recorded in foraminifera-dated sediments of Algeria and Senegal and has been considered to be not older than early Aptian in age (Doyle, 1992). However, some additional studies revealed its existence near below the Barremian-Aptian boundary in Morocco, Libya, Brazil, and England.

The aim of this study is to review the palynological evolution content across the Barremian-Aptian boundary in some marine series of the Tethyan realm. The overlap in the distribution of Laurasian and Gondwanian elements in these localities assures stepwise correlations with Congo, Gabon (Doyle, 1992).

A database of sporomorph occurrences and their calibration with marine microfossils (i.e. forams, dinoflagellate cysts) is realized in this study. The database includes outcrop and well data from Northern Africa (i.e. Egypt, Algeria, Morocco), South America (Brazil), and Europe (i.e. Italy, Portugal, Spain, France). The objective is to identify some calibrated key taxa to characterize the Barremian/Aptian boundary and to check the stratigraphic distribution of the species already used to identify that boundary (e.g. *Afropollis*).

The database could also reveal a latitudinal control in the distribution of some key taxa, a provincialism that is important to understand in order to select the most helpful species for intercontinental correlations.

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P107

X-RAY COMPUTED TOMOGRAPHY AS A TOOL FOR BIOEROSION ANALYSIS ON FORAMINIFERAL TESTS.

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X-ray computed tomography has seen an enormous rise in popularity in recent years. As resolution rapidly improves, and thereby enables visualizations at microscopic levels, Micro-CT becomes a competitive technique for micro-palaeontological studies. Compared to other available approaches for studying bioerosion on such small scales, Micro-CT has distinct advantages in its non-destructive approach, ability to examine studied objects from surface and under-surface views, along multiple axes, and even the ability to study sediment-filled fossil borings. The aim of this study is to demonstrate a non-destructive approach on bioerosion analysis of benthic foraminifera. The sample material originated from the Mediterranean (NW Crete), from a depth of around two meters. Specimens used for scanning were approximately 500 µm in largest diameter, with boring traces ranging from 8 µm to 2 µm. The diameter of boring structures that can be effectively visualized by micro-tomography starts at about 2 µm. The study was conducted using our Bruker SkyScan 1172 X-ray micro-tomograph, with effective pixel size of 0.54 µm. The supplied NRecon software was used for reconstruction, and photographs were created using Avizo 9.1.1 software. Preliminary scanning via electron microscope (SEM) was employed in order to select samples best-suited for X-ray micro-tomography.

P108

BASAL ANGIOSPERMS AND ANGIOSPERM-LIKE POLLEN FROM APTIAN/ALBIAN STRATA OF AUSTRIA AND MONGOLIA.

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Near coastal sediments from Austria (Rehbreingraben Formation "Gaultflysch) and coal-bearing strata from Mongolia (Khovil-open pit mine) of Albian to middle Aptian age are both contain palynological assemblages dominated by spores of bryophytes and ferns and pollen of Pinaceae, Cupressaceae and Ginkgoaceae. Only a few other taxa can be affiliated with angiosperms or angiosperm-like pollen. The stratigraphic age of the Austrian locality, which is situated near St. Pölten (Lower Austria), has been constrained by dinoflagellate cysts such as *Protoellipsodinium spinacristatum, Chlamydophorella nyei, Cometodinium multispinosum, Subtilisphaera perlucida, Muderongia macwhaei* and *Oligosphaeridium pulcherrimum*. Similarly, the stratigraphic range of the coal-bearing strata of the Khovil-Tugrug subbasin, which is located in central Mongolia, SE of Ulaanbaatar in the Choir-Nyalga basin, has been determined by the presence of various *Pilosisporites notensis, Osmundacidites wellmanii, Aequitriradites spinulosus, Taurocusporites reduncus, Leptolepidites verrucatus, Cicatricosisporites australiensis, Cyathidites australis,* as well as by pollen of Pinaceae (e.g. *Pinuspollenites oralicus, Alisporites* sp.*), Cycadopithes, Araucariadites australis, Taxodiaceaepollenites sp., Classopollis classoides* and *Ginkgo*. Both localities also contain chloranthaceous angiosperms (e.g., *Clavatipollenites*-types, *Asteropollis* only in Mongolia) and unknown angiosperm pollen (*Retimonocolpites*-types in Austria, and coarse reticulate pollen in Mongolia). Monocotyledonous angiosperms (*Liliacidites*-like) and tricolpates (*Platanus*-like) also occur in Mongolia. These findings will be presented with LM and SEM imaging.

P109

EXINE ULTRASTRUCTURE OF FOSSIL GINKGOALEAN POLLEN: THE FIRST DATA FROM AN *IN SITU* MATERIAL

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Up to date, the exine ultrastructure of fossil ginkgoalean pollen has been deduced from the only modern survivor *Ginkgo biloba* L. Some information is available from a pollen assemblage from the Cretaceous of the Russian Far East dominated by monosulcate pollen extracted from a coal-seam composed by exclusively ginkgoalean foliage. The exine ultrastructure was studied in pollen from presumably ginkgoalean dispersed seeds of *Allicospermum budantsevii* Gordenko from the Jurassic of Uzbekistan. Ginkgoalean pollen organs are usually preserved as opened structures, with few pollen grains if any.

We have studied pollen organs of *Sorosaccus gracilis* Harris (=*S. sibiricus* Prynada) from the Middle Jurassic of the Irkutsk basin, Siberia, and managed to extract a sufficient amount of pollen grains for a TEM study. The monosulcate pollen grains vary in size rather significantly, but the exine ultrastructure is uniform. The non-aperture ectexine is composed of a thick solid tectum, a thin infratectum, and a thin foot layer. The infratectum includes a row of small rare alveolae, which are often stretched parallel to the surface. The supposedly poorly preserved endexine is thin and grainy. The structure of the infratectum is distinguishable more easily in areas surrounding the aperture. The ectexine is reduced greatly in the aperture area. There are only homogeneous ectexinal patches over the endexine, which gives a more distinct surface pattern than that of the non-aperture surface.

The striking similarity between the exine ultrastructure of pollen grains of *G. biloba* on the one hand and that of *S. gracilis* and pollen grains from *A. budantsevii* on the other hand proves that the ginkgoalean ultrastructure of the modern type already existed as early as the Jurassic. The exine ultrastructure under study is also similar, though to a lesser degree, to that of the dispersed pollen from the Cretaceous of Far East. The latter pollen grains differ by an infratectum of a row of granules. It is understandable that the diversity of such a long-living group as ginkgoaleans is also reflected in the diversity of their exine ultrastructure. So far, ginkgoalean pollen grains can be differentiated from similar boat-shaped monosulcate pollen by a co-occurrence of these features: the ratio of ectexinal sublayers (a thick homogeneous tectum, a thin infratectum of one row of structural elements, and a thin foot layer) and by a patchy ectexine in the aperture region.

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P110

FINE STRUCTURE OF *WODEHOUSEIA* POLLEN

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Pollen grains of *Wodehouseia spinata* Stanley from the Upper Maastrichtian, Zeya-Bureya Basin, Amur (Heilongjiang) River area, Russian Far East/China were studied by means of light and electron microscopy. They are ellipsoidal, medium-sized, about 25 x 32 µm. Pollen grains have four elongated pori perpendicular to the long axis of the pollen grain, two pori on each side. The exine sculpturing is echinate with echini of three size ranges: large echini around the pori and nearby, small echini on the peripheral region of the compressed pollen and middle-sized echini inbetween. Each porus is bordered with a large echinus. The tectum in SEM is perforate. The exine thickness is unequal throughout the pollen grain, from 0.6 to 1.5 µm; the thin tectum, high and sometimes branched columellae and an inner layer (corresponding to the foot layer or endexine) of an uneven thickness are well-distinguished. There are cavities in lateral regions of the compressed pollen. The echini are solid, and the pori are represented by a break in all exine layers; the pori are located opposite to each other. A comparative analysis has shown that the most logical tetrad type for *Wodehouseia* is tetragonal or rhomboidal one. Echini and microechini occur unevenly in different groups of angiosperms. Choosing from species with porate pollen or pollen with short colpi there are species from Ranunculales, Cucurbitales, Malvales, Caryophyllales, and Dipsacales. The latter is most interesting for the comparison as there are pollen grains with differently sized echini and with echini near the porus; the exine ultrastructure is also similar. Pollen grains with four apertures are not common. If we exclude tetracolpate and tetracolporate pollen, we are left with some species from Bromeliaceae, Betulaceae, Campanulaceae, Haloragaceae, Apocinaceae, and Malpigiaceae. Among them only species from Betulaceae and Campanulaceae have echinate pollen. Campanulaceae species also show the exine ultrastructure similar to that of Wodehouseia. Pollen grains with a complex tectum, branched columellae and uneven thickness of the exine as characterized for *Wodehouseia* are known only in advanced dicotyledons: Apiales, Asterales, and Dipsacales. A comparison with modern angiosperms shows that *Wodehouseia* most probably represents an evolutionary dead end with an over-specialized set of characters of the exine morphology and ultrastructure some of which occur in many unrelated taxa.

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P111

LAMELLATE STRUCTURES IN SPORODERMS OF *ISOETES* MICROSPORES AND ANGIOSPERM POLLEN GRAINS

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Multilamellate zones occur in inner exospores of spores of heterosporous herbaceous lycopsids and are associated with the proximal scar. Lugardon believed them to be a characteristic feature of the microspore ultrastructure of the Pleuromeiaceae and their supposed descendants Isoetales as well as some Selaginellaceae. Recent data from the Devonian show that such structures are probably not restricted to the above groups of lycopsids. Such structures are worth to be studied in terms of their ultrastructure, occurrence in different members of heterosporous lycopsids from geological deposits of different ages, and, especially, their function. To elucidate their function, we have studied microspores of modern *Isoetes echinospora* and compared them with structures associated with apertures in some other groups of the higher plants.

Similar structures occur near apertures in spores of ferns and bryophytes; however, unlike multilamellate zones, they are layered rather than loosely lamellate and do not have distinct outlines. Pollen grains of some angiosperms are more promising for our comparison, since they have a well-developed endexine, rims, or endoapertures. The functions are known for the lamellate lens-shaped body that closes the aperture after callose dissolution: the maintenance of the spheroid shape of the microspore and metabolic exchange between the microspore and anther cavity. In mature pollen, the break in the exine is occupied by a thickened intine; the lamellate body is shifted to the margins of apertures, where various elements of endoapertures appear. The latter structures are only related with the maintenance of the pollen grain shape when it is drying in air.

During the ontogenesis of *Isoetes* microspores, multilamellate zones appear within the inner exospore and do not change their position along the proximal suture until maturation. That means that they do not play an active role during the sporoderm formation. The harmomegatic ability of these zones is incomparable to that of the cavity between the outer and inner exospore. Another possibility is that they can assist during microspore germination. No electron-microscopical data have been available about germination of *Isoetes* or *Selaginella*. Only the intine and pollen tube coat are active during germination of the pollen grain. Only an active functioning of an endospore was shown in germinating spores of *Sphagnum*. Active functioning of multilamellate structures of the inner exospore in *Isoetes* microspores also seems unlikely. However, if they are merely a timid memento of the structure and development of the sporoderm in ancestors, why they did not disappear?

P112

POLLEN MORPHOLOGY OF *GNETUM* IN THAILAND

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The acetolyzed and non– acetolyzed pollen grains of eight *Gnetum* species observed in Thailand, including *Gnetum cuspidatum* Blume, *G. latifolium* Blume var. *funiculare* (Blume) Markgr., *G. leptostachyum* Blume, *G. gnemon* L. var. *tenerum* Markgr., *G. macrostachyum* Hook.f., *G. microcarpum* Blume, *G. montanum* Markgr., and *G. tenuifolium* Ridl. were examined under both LM and SEM. *Gnetum* pollen are generally monad, subspheroidal, inaperturate, microechinate with blunt–ended microechini. In both acetolyzed and non–acetolyzed pollen grains, the psilate surface between microechini is characteristic of the hydrated state, while the raised exine regions as well as the ridge–like folds appear to be representative of the dehydrated state. The appearance of both psilate or ridge between microechini would indicate the harmomegatic function of *Gnetum* pollen. Their continuous tectum supports the validity of the posited molecular relationship within the Asian *Gnetum* clade. This study provides useful information for more accurate identification of fossil pollen from this plant group.

P114

POLLEN IN KARST CAVES PROVIDES NEW INSIGHTS INTO THE ENVIRONMENT BACKGROUND OF FAUNA EVOLUTION IN PLEISTOCENE, GUANGXI, SOUTH CHINA

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The inadequate pollen and spore amounts in the deposits of karst cave limited the development of cave palynology. Nevertheless, it is crucial for understanding the living environments of those inhabitants. In Chongzuo, Guangxi Zhuang Autonomous Region, karst caves are common and lots of mammal fossils were excavated in these caves. Numerous studies in mammal fossils (such as *Gigantopithecus*, *Sinomastodon*, *Elephas*, *Rhinoceros* and *Homo sapiens* etc.) and dating results of eight karst caves in Chongzuo area have set the stage for carrying out the palynological study. Interestingly, the elevations of these caves shows excellent correlation with their formation time, which is, the higher the elevation the older the age of the cave. These eight caves were distributed in different horizons ranging from 174m to 212m above sea level with their ages expanding almost the whole Pleistocene (2.0 Ma to 0.11 Ma), and four of these are Early Pleistocene, one is Middle Pleistocene and three belong to Late Pleistocene. Considering the inadequate pollen grains and furthermore, the high diversity of palynomorphs in South China, the Coexistence Approach (CA) was applied in this study. Based on the seven meteorological parameter intervals reconstructed by CA, the changing trends in Pleistocene were achieved. The Mean Annual Temperature tends to decline from 2.0 Ma to 0.11 Ma (decreased about 4.5 °C) while the MAP shows an increase trend (raised about 120 mm). The climate around 1.0 Ma was warmer than other periods which may be correlated with the intensification of Asian summer monsoon. The vegetation reconstructed from Zhiren Cave (ca. 0.11 Ma) is quite different with the others. It shows an expansion of grassland and the dominant arboreal taxa is *Ulmus* instead of *Pinus* in other caves. The arboreal animals sharply decreased and grassland types were greatly increased. All these signals show an intensification of aridity around 0.11 Ma, and furthermore, *Homo sapiens* can adapt to this deteriorating climate. The MAPs of the mammal fossil-bearing layers were higher than those without mammal fossils while MATs show little differences. Together with the lithology differences, we suggest that when the fossiliferous layers were formed, the fluvial flow is strong enough to carry lots of animal remains into caves. Our study provided important climate information which can help us to get a better understanding of Pleistocene fauna migration and evolution in South China; furthermore, it provides important environmental information during the evolution of *Homo sapiens* in Pleistocene.

P115

SCULPTURES OF *QUERCUS* POLLEN FROM THE LATE MIDDLE PLEISTOCENE OF NORTHEASTERN THAILAND

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Fossil pollen of *Quercus* has been extracted from a sediment layer from a prominent fossil site of Khok Sung, Northeastern Thailand, in the Khorat Plateau, . The deposit was suggested to be an ancient river terrace from 188,000 BP or 213, 000 BP in the late Middle Pleistocene. Habitat reconstruction using high resolution pollen sculpture from SEM images was investigated. The results reveal at least 4 sculpture types of *Quercus* pollen grains. Three sculpture types were assigned to evergreen habitats and one could be either deciduous or evergreen habitats. These suggest existence of wet environment with high humidity in the area during the relatively dry period of the late Middle Pleistocene.

P117

DEVELOPMENT OF RIPARIAN FOREST AND OXBOW LAKE ECOSYSTEMS ALONG THE EARLY HOLOCENE WARMING IN THE SAN RIVER VALLEY (CENTRAL EUROPE): A MULTI-PROXY STUDY

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The warming at the Late Weichselian-Early Holocene transition brought one of the most significant ecosystem alterations during the last 12,000 years in the Northern Hemisphere. However, the responses of several ecosystems, such as oxbow lakes, are poorly recognised in terms of high-resolution approach. The aim of this study was a detailed and multifaceted reconstruction of riparian woodland and oxbow lake ecosystems' development. The selected site is a palaeomeander located in the San River valley (south-eastern Poland), an area devoid of detailed palaeoecological studies. We applied a broad range of analyses: pollen, non-pollen palynomorphs (NPPs), plant macrofossils, microcharcoal (0.01-0.1 mm), Cladocera, Chironomidae, molluscs, stable isotopes from carbonates and organic matter, and geochemistry. In the period of ca. 11,550–11,470 cal. BP a high activity of the river was marked by a low organic matter content, a high share of Glomeromycota and coprophilous fungi spores, and corroded pollen, especially in *Pinus sylvestris* type. The reconstruction of MJT based on Chironomidae revealed the exceptionally high rate of warming during the period of ca. 11,490–11,460 cal. BP, at least 1°C/decade (max. values of 2°C higher than modern ones). During this period, the lake productivity increased and *Betula* woodlands started to spread on the floodplain. The first cooling detected in $MJT_{Chironomidae}$ dated at ca. 11,450–11,250 cal. BP was probably a reflection of the 'Preboreal oscillation'. This cooling initially failed to significantly influence the oxbow lake productivity and spread of *Betula* woodland on the floodplain. However, an enlarged climate instability, manifested by event(s) of increased fluvial activity ca. 11,400–11,330 cal. BP, led to the disruption of *Betula* population on the floodplain and caused a significant decrease in Chironomidae and Nymphaeaceae concentrations. The development of riparian woodlands, initiated by the expansion of *Ulmus* from ca. 11,100 cal. BP, and further spread of *Quercus* and *Fraxinus excelsior* on the floodplain and lower river terraces, as well as the expansion of reed belt communities on the area of the oxbow lake, probably limited the impact of the floods on the lake ecosystem. Nonetheless, ca. 10,010–9880 cal. BP a fluvial activity, indicated by the increase in mineral matter and decline in total organic content, was recorded in the oxbow lake. The research is funded by National Science Centre (Poland) – grant UMO-2012/07/B/ST10/04345.

P118

THREE CENTURIES OF FOREST CHANGES AND PEATLAND DEVELOPMENT ALONG ECONOMICAL AND NATIONAL TURNOVERS CENTRAL IN GREATER POLAND (WESTERN POLAND, CENTRAL EUROPE) – PRELIMINARY RESULTS

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Thanks to multifaceted paleoecological studies of the peatlands and accumulated there organic deposits we can reconstruct human activity and their impact on the wetland ecosystems. In this study, we focus on the Kazanie fen, located in Greater Poland (25 km northwest of the city of Poznań). The aims of our studies were to (i) reconstruct the development of the peatland and surrounding vegetation along with the human impact, (ii) identify intrinsic and extrinsic factors in the peat record, (iii) extract the role of economic and historical turnovers for ecosystems' changes. We analyzed pollen, plant macrofossils, micro- and macrocharcoal, testate amoeba, selected non-pollen palynomorphs (NPPs) analyses, which were supplemented by radiocarbon dating (^{14}C AMS) and historical sources. Preliminary results show very intensive farming before AD 1940 documented by presence e.g. pollen: Cerealia type, *Secale cereale*, and *Centaurea cyanus* in the surrounding mire. A further decline in the share of Cerealia type in pollen spectra was probably related to a decline in agricultural activity during the Second World War. During the last 300 years, rapid trophic changes in the peatland ecosystem were identified. They are notably visible in the results of plant macrofossil and testate amoebae analyses. The transition from vegetation typical of a rich fen to a poor fen took place ca. AD 1982. *Scorpidium cossoni* preferring calcareous environment was replaced by *Sphagnum* mosses (i.a. *Sphagnum fallax*, *S. teres* and *S. fimbriatum*) indicating more acidic habitats. This transition was followed by testate amoebae: *Microchlamys patella*, *Centropyxis aculeata*, and *Arcella vulgaris*. Representatives of *Pyxidicula* ssp. and *Difflugia* ssp., disappeared together with the *Sphagnum* expansion, which provided habitats for *Assulina muscorum*, *Nebela tincta* and representatives of the *Euglypha* spp. occurrence. Simultaneously to this transition *Pinus sylvestris* was replaced by *Alnus* and *Betula* in (local) woodlands. We believe that the results of our research, outlying period well-recognized in historical sources, will contribute to better quantitative understanding the impact of historical land use changes on the functioning of terrestrial and peatland ecosystems.

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P119

A COMPARATIVE STUDY OF THE MODERN POLLEN TAXA OBSERVED IN SURFACE DEPOSITS FROM TRIPURA AND MIZORAM IN NORTHEASTERN INDIA

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The vegetation of Tripura and Mizoram is dominated by the sub-tropical to the tropical forests elements. The latitudinal position and geographical locations of these two remotely located northeastern states make them sensitive to the impact of various environmental factors; such as the monsoon winds from Bay of Bengal, high temperature and precipitation conditions, varied topography and extreme ecological pressure on surface sediments and deposits. The human activities are also ongoing in large magnitudes. These include agricultural activities such as Jhuming or thrash and burn farming, commercial crop plantations such as rubber, oil palm, tea, etc, pastoral activities and others. Thus to understand the impact of all these factors on the modern vegetation and yield of modern pollen taxa in surface deposits such as surface sediments and moss cushions were studied. We analyzed surface sediments in a transect from North to South Tripura and moss cushion samples collected from West to East Mizoram and few sites in north Mizoram; for modern pollen analysis. The yield in the surface sediments from Tripura was limited but few samples did yield various pollen taxa. The moss cushion collected from Mizoram have yielded good amount of pollen taxa. In Tripura the taxa such as Saxifragaceae, Elaeocarpaceae, Theaceae, *Shorea robusta*, *Salix,* Solanaceae, Malvaceae, Rosaceae, Asteraceae, Poaceae etc., were observed. Similar taxa have been observed in the samples from Mizoram with a few exceptions. Based on the ANOVA results our data sets and have been found to give statistically significant results. These preliminary results bring out the significance of the impact of various factors on the pollen yield and preservation in different surface deposits in this region. This is the first such study from these monsoon dominated, Border States of northeastern India. Further quantitative analysis and detailed sampling is required for a broader perspective of the modern vegetation distribution and pollen productivity of the various taxa in Tripura and Mizoram. The modern pollen rain results shall be further applied to interpret fossil pollen assemblages from sediment profiles collected from both Tripura and Mizoram for recovering the history of vegetation and climate changes during the Holocene in the region.

P120

HIGH-RESOLUTION PALAEOECOLOGICAL ANALYSES OF THE SMALL ALPINE PEATLAND "BLACKENALP-OBERES MOOR" (CANTON URI, SWITZERLAND) REVEALED POSSIBLE ARTIFICIAL CREATION OF A POND AS WATERING PLACE FOR LIVESTOCK AROUND AD 1575

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Palynological and plant macrofossil analyses performed on a 82 cm long silty peat stratigraphy at 1820 m a.s.l. in the Central Swiss Alps allowed the reconstruction of the past local flora, vegetation and landscape development on a ca. 20 year-resolution. Sedimentation started around AD 1575 during the Little Ice Age with a dominance of herb pollen, fern spores, and micro-charcoal particles, all revealing their deposition in a treeless, open pastoral landscape. During a second phase from ca. AD 1750–1900 the pond was dominated by aquatics such as *Sparganium/Typha angustifolia*, whereas the nearby valleys (Engelbergertal in the West and Reusstal in the East) were likely used for the cultivation and agricultural production of cereals (incl. rye – *Secale cereale*) and *Cannabis*. The presence of pollen from the neophyte *Ambrosia* as well as of pollen from corn (*Zea mays*) does characterize the last phase since AD 1900, and correlates very well with written sources on the intentional and non-intentional introduction of these plants. Given this pastoral area to have been in a region with very few watering places for livestock (cows, sheep, goat), and given that archaeological studies on local former pastoral huts have revealed changes in agricultural and pastoral sustainability systems after the Medieval climate optimum, we hereby propose a strong "landnam" or terra-forming phase to have been responsible for an artificial creation of our small pond basin studied.

P121

FROM BOG TO FEN - PALAEOECOLOGICAL DEVELOPMENT OF A CALCAREOUS SPRING FEN IN SAAREMAA, ESTONIA

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Despite the fact that biotopes of Calcareous spring fens are highly endangered, very little is known about their actual development and dynamics of vegetation diversity throughout the Holocene. This study from Vesiku calcareous spring fen in Saaremaa island (Estonia) traces the history of a fen development over the last 9000 years. Detailed pollen analysis, including spores, non-pollen palynomorphs (NPP's) and macrofossil analysis, were carried out from a sediment core to reconstruct vegetation development, environmental changes and human impact. Existing pollen data from a nearby large Vedruka bog was used to reconstruct regional vegetation with the help of REVEALS model and the reconstructions were used for comparison with Vesiku fen site data with more local pollen signal. Sediment accumulation in Vesiku spring fen started approx 9000 y BP, during the time of Litorina Sea regression. Vegetation and NPP composition at the earliest stage from 9000 to 6000 years BC indicate that the fen was acidic and developed as a bog, which is opposite to the typical mire autogenic succession from groundwater-fed to predominantly rainwater-fed. According to the REVEALS model, the dominant vegetation composition in the landscape consisted of low-growing perennial shrubs *Calluna vulgaris* and Ericaceae, with the admixture of pine. Spring fen characteristics developed about 6000/5000 years BP when regional vegetation composition indicates warmer climatic conditions. Our results suggest that further regression of the sea level led to a flow of calcareous mineral-rich groundwater through Vesiku site, initiating the development of calcareous fen with different calciphilous plants such as *Primula, Linum, Potentilla, Parnassia*. Palynological richness increased considerably in the beginning of the fen stage (23–37 taxa) for the next 4000 years. However, during the last 2000 years, the richness decreased – a contrasting trend to the overall increase in the surrounding sites. The comparison with REVEALS model reconstruction from Vedruka bog indicated that the fen began overgrowing with Cyperaceae ca 2000 years BP. Grazing and trampling directly on the fen might be one of the reasons behind the richness decrease. At the same time, the overall drainage and eutrophication of the landscape have led to declining of the water table causing strong humification and pollen archive decomposition. Pollen data from traps and moss polsters will help to clarify the reasons behind the diversity decline during the last 2000 years. We believe our findings provide a deeper understanding that will help to create future strategies for calcareous spring fen conservation and management.

P123

THE RELATIONSHIP OF POLLEN-FLORISTIC DIVERSITY IN POOR-SPECIES AND RICH-SPECIES REGIONS OF CZECH REPUBLIC

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We explored the relationship between pollen and floristic diversity in two areas with a steep diversity gradient: White Carpatians – a biodiversity hotspot of termophillous vegetation comprising dry grasslands and broadleaved forests, and Bohemian-Moravian Highland – spruce dominated forest with meadows and wetlands. Each region was sampled by 20 forest sites and 20 sites in open habitats. A detailed florisic survey in radii of 10 and 100 m and in two transects of 1 km revealed more than 1200 vascular plant species. More than 180 taxa were found in the pollen assemalges. Changing the floristic diversity in the taxonomy of pollen types has no effect on the strength of the diversity relationship. Considering the other biases of pollen ananalysis, especially pollen productivity, we based our comaparision of the floristic diversity with pollen diveristy on: i) standard pollen sum, ii) modified sum by pollen productivities and iii) representation factors.

Pollen productivities (PPE) and representation factors (RF) calculated from the same pollen-vegetation dataset do not improve the diversity relationship; possibly because, pollen productivities of the main taxa in White Carpathians (Poaceae and *Quercus*) are relatively similar. The most optimal RFs calculated directly from the pollen-floristic relationship are also, almost all, equal to 1. Both regions showed that the main factor influencing the relationship of the pollen-floristic diversity resides in the dispersal-deposition bias. Forested sites have higher proportion of the regional pollen component (*Ambrosia*, *Artemisia*, Chenopodiaceae) than the open sites. Pollen is trapped on the larger leaf area of the trees and subsequently washed to a moss polster.

Work was supported by Czech Science Foundation (project no. 16-10100S).

P124

SMALL SCALE STUDIES OF POLLEN PRODUCTIVITY BASED ON MOSS SAMPLES FROM CALCAREOUS MEADOWS IN ESTONIA – SPECIAL ATTENTION TO *HELIANTHEMUM*

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Helianthemum pollen is commonly found in Late Glacial sediments, also outside its present distribution area, where it is supposed to have been growing in light demanding communities. In Norway, *Helianthemum* is found in sediments from the Late Glacial and again in pollen samples from layers deposited within the medieval town of Bergen during this time period. To help interpretation of Late Glacial vegetation and source of pollen grains found in medieval refuse layers, as well as of pollen assemblages with *Helianthemum* in general, increased knowledge of dispersal distances of *Helianthemum* is needed. As it can be one of the good indicators of landscape openness it will also be important to have pollen productivity estimates for this pollen type. The present investigation aims to get knew data on pollen dispersal and production of *Helianthemum nummularium*. Nowadays *H. nummularium* is growing on calcareous and wooded meadows, on alvars and alvar pine forests, in Estonia. It grows in small groups and patches, is light demanding and is most frequent in northern Estonia and western islands, rarely on sandy plains.

Pollen surface samples of moss and vegetation data were obtained in two study sites in Estonia. One is situated in Rebala Heritage Reserve in North Estonia. We selected one ancient burial ground dated to the Bronze Age (8th-7th century BC). Another site is situated in the Muhu Island, close to Nõmmküla on pasture land. In both sites the vegetation was described in detail and moss samples collected, following the methodology developed in the Cracles project (Bunting et al. 2013). The preliminary results show a clear connection between presence of *Helianthemum* in the vegetation and in the pollen samples. Dispersal and pollen production of *H. nummularium* and other open-land taxa will be presented and discussed.

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P125

ENVIRONMENTAL HISTORY AND VEGETATION DYNAMICS IN THE AREA OF CENTRAL CROATIA

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In the sediment of the Blatuša peatland (central Croatia) qualitative and quantitative analyses of pollen and non-pollen palynomorphs, together with charcoal particles were performed. Based on the accumulated palynological taxa, the following zones were identified: *Pinus* - *Fagus* - (*Ulmus*) (Zone 1, depth 210 - 175 cm), *Fagus* - *Alnus* (Zone 2, depth 175 - 85 cm), Poaceae - *Fagus* - (*Quercus*) (Zone 3a, depth 85 - 45 cm) and Poaceae - *Carpinus* (*Quercus* - *Fagus*) (Zone 3b, depth 45 - 5 cm). According to the results of ^{14}C AMS dating, deepest section of the core belongs to the late Subboreal period. The composition of the local palynological taxa and the ecologically indicative non-pollen palynomorphs indicates the dynamics of the hydrological regime as well as the trophic conditions on the habitat, with occasional domination of species from the family Cyperaceae, ferns Polypodiales or peat moss - *Sphagnum*. Based on accumulated non-pollen palynomorphs four zones were identified: HdV-179 - *Spirogyra* (EINPP1, depth 210 - 165 cm), *Glomus* - *Spirogyra* (EINPP2, depth 165 - 100 cm), *Byssothecium circinans* (EINPP3, depth 100 - 25 cm) and *Assulina* (EINPP4, depth 25-5cm). During the Zone 1 and 3b, the researched area was a mosaic of wetland vegetation and wet meadows, with partially developed peatland vegetation. Zone 2 is characterized by the relative local domination of the ferns, and Zone 3a by the relative dominance of the peat moss. The shares of arboreal pollen, anthropogenic indicators, charcoal particles and palynological richness point to the different intensity of anthropogenic pressure, which is mostly pronounced in the period from the developed Middle Ages to the present. Charcoal particles are evidence of regional and local fires as essential factors in succession processes. The quantity and quality of the analysed palynomorphs enable us to apply the results of the reconstruction of Holocene postglacial vegetation changes for the same period for a narrower area of this site located at the southern border of the southern part of Central Europe.

P127

VEGETATION DYNAMICS AND HUMAN ACTIVITY IN THE MIDDLE OKA RIVER BASIN (EUROPEAN RUSSIA) DURING THE MIDDLE AND LATE HOLOCENE

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The new results from paleoecological studies of vegetation and fire history over the last 8700 years in the Middle Oka River Basin at the south-eastern boundary of the Meshchera Lowlands (Ryazan' region, European Russia) based on radiocarbon dating, pollen and micro-charcoal records from peat profile are presented. The studied peatland is small forest mesotrophic mire called "Kapelka" (the "Droplet" in English) due to similar form. The obtained results showed that most of the changes in the regional vegetation during the Mid- and Late Holocene were mainly influenced by the climate changes and human impact. Since 8700 cal yr BP, the vegetation history represented a series of consecutive phases of birch-pine and pine-broadleaf forests with participation of spruce after 2500 cal yr BP. The maximal abundance of broadleaf tree species was detected for the period of 4700-2000 cal yr BP. Signals of anthropogenic changes in vegetation is marked in the pollen spectra since the Neolithic (the Middle Holocene), however only since 2000 cal yr BP (the Early Iron Age), vegetation dynamics were strongly influenced by anthropogenic activity and human-induced fires. Large-scale landscape changes and the degradation of natural vegetation became conspicuous over the past three centuries. The present-day state of plant communities in the Middle Oka River Basin is totally controlled by anthropogenic factors.

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P128

CONIFEROUS SPECIES OF AZERBAIJAN AND THEIR ROLE IN FORMING HOLOCENE LANDSCAPE

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Palynological material accumulated through study of archaeological camps of the ancient people indicated that spreading of conifer species during Holocene (10-2 thousand years ago) extended far beyond the boundaries of their contemporary areal. The highest dynamics of boundaries of the areal had pine, spruce and fir tree.

Spruce and fir trees are not growing in Azerbaijan nowadays.

In the second half of the Atlantic period, IV thousand B.C. (6-5 thousand years ago) according to the spore-pollen spectra of the sections of the settlements located in the Kura-Araz depression (Arukhlo, Leylatapa, Soyug-Bulag) in the conditions of the contemporary semi-deserts, the climate humidity was high. Up to 10% of the pollen of *Picea orientalis* and single cases of *Abies nordmanniana* pollen were observed in the spectra of the most western settlement of Soyug-Bulag. At present the Caucasian areal of spruce and fir trees coincide. The eastward spreading of the spruce is precluded by lack of humidity as well as high summer temperatures and warm winters. In the second half of the Atlantic period the areal of spruce and fir trees over 100 km further eastward. The eastward expansion in the area of spruce tree forests in the mountains of Lesser Caucasus indicates that humidity level then significantly exceeded the contemporary parameter.

High content (40-90%) of the pollen *Picea eldarica* in the spectra evidences of spreading of pine tree light forests around the settlements. Contemporary areal of *Picea eldarica* is endemic of Azerbaijan and constitutes 400 hectares in the slopes of Ellyaryugu ridge in the vicinity of border with Georgia. In the past according to the palynological data the areal extended from Ellyayugu ridge southward to the ridge of Bozdag and then further to the plain of Mughan towards Talysh Mountains, as well as in the north-western direction toward the Garayaz plain and further to Georgia. After that in the first half of sub Boreal period, III millennium B.C. (5-4 thousand years ago), with sustained sufficient climate humidity the content of spruce tree pollen in the spectra of settlements (Leylatepe, Uchoghlan, Alkhantepe) is reduced. This fact was related to the logging of pine trees by inhabitants of the settlements. Invention of a potter's wheel during that period and production of ceramic ware required good fuel for potter's furnace. The increasing aridization of climate also significantly contributed to this.

P129

THE POLLEN MONITORING PROGRAMME; THE FIRST TWO DECADES

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The Pollen Monitoring Programme (PMP) was founded in 1996 by Dr Sheila Hicks. The aspirations and development of the PMP over the last 20 years are described.

The PMP aims to investigate modern pollen deposition, to gain insights into the pollen-vegetation relationship and factors influencing production, dispersal and deposition. The PMP employs modified Tauber traps to provide absolute estimates of pollen deposition for each taxon. The trap data also provide a basis for comparison with other sampling media including lake sediments and soil samples. The ultimate goal is to improve the interpretation of past pollen records.

The PMP is essentially a group of collaborating palynologists, managing a network of modern pollen monitoring sites. At many sites, including Finland, Poland, Switzerland, Bulgaria, Georgia and Wales, modern pollen deposition has been monitored annually for over 20 years, producing invaluable long records (see Giesecke *et al*. 2010).

The PMP database includes almost 2000 samples from 14 countries. The intention is to incorporate these data into the multi-proxy database Neotoma (www.neotomadb.org). PMP data have been employed to answer a variety of questions and over 70 papers have been published. For example, van der Knaap *et al*. (2010) examined the relationship between surface pollen deposition and climate. Abraham *et al*. are using PMP data to reconstruct past vegetation. There is great potential to use this data for modelling vegetation-climate interactions and to improve our understanding of the pollen-vegetation relationship.

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P130

POLLEN PRODUCTIVITY ESTIMATES OF MEDITERRANEAN TAXA – FIRST RESULTS FROM SOUTHERN FRANCE

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Pollen-based reconstructions of past land cover, inferred from modelling approaches (Landscape Reconstruction Algorithm - LRA, Sugita 2007a,b) are necessary to evaluate objectively the past changes in plant cover across the spatial scales. Applications of the LRA approach for quantitative reconstructions of plant cover are spatially limited due to the unavailability of relative pollen productivity (RPP) in large parts of the world. While RPP – one of the important parameters for LRA - have already been obtained for the major pollen types in northern European (e.g., Broström et al., 2008; Mazier et al., 2012), RPPs for pollen/plant types characteristic to the Mediterranean region are still unavailable. This study provides the first set of RPPs from the Montpellier area (southern France) for the important Mediterranean taxa. Pollen counts from randomly-selected twenty-four sites and the survey data around individual sites were used for the Extended R-value (ERV) model to estimate the relevant source area of pollen (RSAP) and RPPs of eleven major plant taxa (7 trees/shrubs and 4 herbs). The extent to which dispersal model selection affects the estimates of RSAP and RPPs was evaluated using the Lagrangian Stochastic Model (LSM) and Gaussian Plume Model (GPM) in the ERV analysis. Estimates of RPPs for *Buxus*, *Castanea*, Ericaceae (including *Erica arborea* and *Arbutus unedo*), *Phillyrea*, *Pistacia*, *Quercus* evergreen, and Lamiaceae) are the first in Europe. RPPs obtained for *Corylus*, Cichorideae, Poaceae and Ranunculaceae) were compared with those previously available in Europe. RPPs obtained in this study will be applied for pollen-based reconstructions of past land cover in the Mediterranean area. This study is part of the PAGES working group LandCover 6k (http://www.pages-igbp.org/ini/wg/landcover6k/intro)

Broström et al, 2008, Vegetation History and Archeobotany 17, 461-478; Mazier et al, 2012, Review of paleobotany and palynology, 187: 38-49; Sugita, 2007a & b, The Holocene 17 (2), 229-241 and 17(2), 243-257.

P131

FILAMENTOUS CYANOBACTERIA IN JURASSIC GEOTHERMAL PALEOENVIRONMENTS FROM PATAGONIA, ARGENTINA

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Structurally preserved, filamentous cyanobacteria occur in Middle-Upper Jurassic siliceous cherts from the La Matilde Formation (Bahia Laura Group) in the Deseado Massif, Santa Cruz, Patagonia, Argentina. Specimens consist of colonies of densely spaced, heteropolar, uniseriate trichomes (> 300 µm long) that occur firmly attached to different substrates, commonly on partially degraded land plant parts. Based on the size and morphology of the cyanobacteria and habit characteristics, the fossils closely resemble certain extant members in the family Rivulariaceae (Oscillatoriales), such as *Gloeotrichia, Homeothrix* and *Rivularia*. The presence of Rivulariaceae in the La Matilde Fm geothermal deposits is suggestive of calcareous aquatic settings with periodically variable concentrations of available phosphate and fluctuating anoxia on lake floors, much like the settings of some lacustrine-associated modern hot-spring environments where representatives of this family of cyanobacteria also are common. Affiliated with many of the cyanobacterial colonies are spheroidal to ovoid vesicles, up to 45 µm in diameter, which occur singly or in small clusters (coenobia?), and typically are located near the bases of the cyanobacterial filaments. The vesicles resemble certain present-day lower fungi, algae, and cyanobacteria, but their systematic affinities remain unresolved. Nevertheless, their co-occurrence with the filamentous cyanobacteria suggests that the cyanobacterial overgrowths from the La Matilde Fm were not monospecific, but rather consisted of several different organisms that perhaps even interacted with each other. For example, the fossil association is reminiscent of associations between present-day Rivulariaceae and certain other cyanobacteria in modern hot-spring environments, which are effective in warding off cyanobacterivorous microinvertebrates.

P132

A FIRE REGIME FRAMEWORK FOR UNDERSTANDING PALEOWILDFIRE IN HYPEROXIC TIMES: COMBUSTION, SIMULATIONS, AND PALEOENVIRONMENTAL RECONSTRUCTIONS

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The Pennsylvanian is well known for its rich plant fossil record in the equatorial tropics, which captures numerous *in situ* T_0 assemblages that allow for detailed landscape reconstructions. Among the many interesting paleoecological aspects of this subperiod is the importance of fire in Pennsylvanian landscapes, based on charcoal and other proxy evidence. Atmospheric oxygen levels during this time interval were probably elevated compared to the Present Atmospheric Level (~21%). The behavior of wildfire under such "hyperoxic" conditions and the combustion characteristics of fuel sources in Pennsylvanian landscapes are at best partially understood. My research is aimed at understanding the function of paleowildfire as one of the agents shaping wetland and seasonally dry ecosystems of Pennsylvanian Euramerica, as well as developing methods for studying paleowildfire and fire regimes that can be applied to other terrestrial ecosystems and time periods.

Here I present my methodology and preliminary results of combining physics-based fire simulations, charcoal-based paleowildfire reconstruction, and experimental hyperoxic combustion work. This information is used to better describe not only individual fires in the Pennsylvanian, but the characteristics that define a fire regime: mean fire frequency, extent, intensity, season, and ecosystem impact. I use spatially explicit, *in situ* T_0 fossil assemblages to build computer model landscapes and incorporate them in the physics-based fire simulation program Wildland Fire Dynamics Simulator to characterize the spread of fire and its impact. In addition, I analyze charcoal abundance and physical characteristics in contemporaneous coal ball samples as a parallel method of understanding individual fire events. This includes analyzing which taxa burned and which plant organs, and what the distribution of charcoal size indicates about fire intensity. Using data from various coal sequences, I intend to scale up temporally to try to understand fire frequency and average extent. The updated understanding afforded by combining fire simulation and coal ball data will allow me to better make assertions as to what sort of fire regimes may have existed during Pennsylvanian. Finally, I plan to study the combustion of various paleofuel analogs under a variety of atmospheric oxygen levels and characterize fire spread rate, fuel consumption rate, and burn intensity. These empirical data will be used to validate simulation results as well as directly add to the limited amount of information on the the effect of oxygen levels on fire behavior.

P133

A CHEMICAL AND MORPHOLOGICAL STUDY OF *NITRARIA* (NITRARIACEAE) POLLEN, WITH IMPLICATIONS FOR HISTORICAL BIOGEOGRAPHY

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The steppe-desert taxon *Nitraria* (Nitrariaceae) is thought to have originated in the Tibetan highlands in the Paleogene, from where it dispersed to coastal regions in the Mediterranean, Middle East and Southern Australia. *Nitraria* is an ideal genus for inferring the historical Tibetan steppe development, yet much of its evolution remains unknown. We investigated whether pollen morphology and chemical composition of the exine are useful in separating species and informing on the historical biogeography of *Nitraria*. We also tested whether pollen characteristics relate to a particular geographic region. To achieve these goals we used a novel approach consisting of a combination of classical pollen morphological analysis with Light Microscopy (LM) and Scanning Electron Microscopy (SEM), Fourier Transformed Infrared spectroscopy (FTIR) and molecular phylogenetics. We found that this integration of data types provides a powerful tool for exploring the evolutionary history of *Nitraria*. Multivariate approaches could be useful for assigning fossil specimens to modern taxa. These results will now be used to reconstruct the historical biogeography of *Nitraria*.

P134

GUARD CELL REGULATION IN PLANTS: ABSCISIC ACID SENSING IN STOMATA DERIVED BY THE LATE PALEOZOIC?

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Water balance is a key factor of plant homeostatic strategies. Stomatal response to changes in water supply (soil moisture) mediates plant water homeostasis. Stomatal response to soil moisture is either directly hydraulic or hormonal-hydraulic. The hormone ABA signals stomatal closure in response to drought in some taxa. Drought tolerance was likely important for the continuity of some taxa through Carboniferous Permian Transition (CPT) characterized by global aridity [1]. Previous studies of extant taxa suggest that ABA cause stomatal closure in spermatophytes, but not in vascular non-spermatophytes [2]. Therefore, ABA stomatal closure may have appeared in the ancestor to spermatophytes. However, many groups remain untested. We tested extant relatives of CPT taxa that are uncharacterized for stomatal response to ABA dosing. We used cuttings of non-seed bearing vascular plants (pteridophytes: *Lycopodiella, Psilotum, Osmunda, Nephrolepis*), gymnosperms (*Zamia, Ginkgo, Gnetum, Picea, Pinus, Pseudotsuga, Podocarp, Araucaria*). To confirm uniform angiosperm response, we used a putative basal angiosperm (*Amborella*) and two core angiosperms (*Acorus, Brassica*). We measured foliar ABA level, and stomatal water vapor conductace (g_s) directly and using the Franks Model estimated from light micrographs [3]. Model estimates corroborated by porometry conductance for each taxon. As expected, seed-bearing vascular plants reduced g_s by closing stomata following ABA treatment, and pteridophytes did not. Seed plants all showed a similar percentage of reduction in g_s relative to maximum g_s. Gymnosperm responses (conifers, their sister group *Ginko,* and cycad *Zamia*) took two to four times as long as angiosperms. The putative basal angiosperm *Amborella* and basal monocot *Acorus* showed similar response as the eudicot. These results support the hypothesis that ancestors of extant gymnosperms closed stomata in response to ABA signaling. Therefore, ABA sensing may have contributed to differential drought tolerance with potential effect on community composition changes in the CPT. The response in basal seed plants suggests that pteridosperms may have used ABA to close stomata and their disappearance was due to other factors. Future work should corroborate this result in unstudied taxa, and from alternative perspectives to include genetics.

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P135

PLANT-ANIMAL INTERACTIONS IN THE CARNIAN (UPPER TRIASSIC) OF NORTHERN ITALY (CORTINA D'AMPEZZO, BELLUNO PROVINCE)

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Plant-amber associations from Carnian (Upper Triassic) levels of Heiligkreuz Formation in the Dolomites (Northeastern Italy) are reported since the early 20th centuries. However, only in the last few years revealed some of the amber droplets inclusions of soft-body microorganisms like bacteria, fungi, algae, protozoans and different types of arthropods. The discovery of insects (e.g. head capsule of a Nematoceran fly) and gall mites (e.g. *Ampezzoa triassica*, *Triasacarus fedelei*) enabled not only to study the evolution and paleoecology of the Upper Triassic microbial life but also to draw hypothesis on plant-animal interactions. In association with the amber droplets, in the sandstones and paleosols of the Heiligkreuz Formation, were found also shoot axes and dispersed leaves with well-preserved cuticles. These leaves were putatively attributed to the conifer family Cheirolepidiaceae, confirmed also by the palynological record, i.e. the presence of *Classopollis* Pflug. The dispersed leaves were studied in detail giving particular attention to breaks or holes in the cuticular structure. The association of cuticles and amber in the same horizons made us consider, among others, also the role of the amber in cuticles damages. Actually, 17% of the studied leaves show disruptures in the cuticle that can be attributed to the presence of amber. Only 1% of the plant evidenced damages that could not be imputated to natural ruptures or damage due to the presence of amber droplets. We have identified: (1) marginal feeding; (2) small circular traces of piercing-sucking; and (3) damages of unknown origin. Damage types such as galling or oviposition was expected due to the presence of mites in the amber droplets, but were so far not identified. Peculiar about the damages is the fact that the damages are of very variable scale, some at very small size that resemble the dimension of the mites of the Tetrapodili lineage.

P136

MIDDLE TRIASSIC AMBER FROM THE SOUTHERN ALPS OF ITALY

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Amber from six Triassic outcrops localities of the Southern Alps of Italy represents one of the most ancient and quantitatively substantial Triassic fossil resin records in the world.

The most famous is the Carnian (Upper Triassic) amber record of the Dolomites and Julian Alps, consisting of both dispersed grains and amber closely associated with resin-producing plant remains. Such characteristic Carnian amber-bearing interval has been linked to the climatic perturbation known as "Carnian Pluvial Event (CPE)".

Older Triassic amber records, however, were recently reported from the Middle Triassic of the Venetian Prealps and from the Dolomites. Amber associated to coniferalean *Voltzia* from the famous Anisian macroflora of Recoaro (Vicenza, Venetian Prealps) was found in historical collections housed in Venice and Verona Museums. Also Voltziales from the Ladinian "Wengener Schichten" of the Dolomites, housed in the Collections of Natural History Museum of Vienna, yielded amber associated with conifer shoots.

All these findings represent the oldest known Triassic fossil resins, demonstrating that the preservation of amber is not restricted to the sediments deposited during the Carnian, as previously suggested. These discoveries contribute to partially fill the gap in the amber record between the Carboniferous and Upper Triassic.

P137

NEW STRATIGRAPHICAL DATA ON AMBER FROM NORTHERN APENNINES (ITALY)

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Occurrence of amber in the northern Apennines (Italy) has been known since the 17th century near the city of Bologna (Masini, 1650; Boccone, 1684). In 1886 Strobel also reported amber from Sassuolo in the province of Modena. Based on lithostratigraphic correlations, such amber was tentatively assigned to the lower Oligocene (Skalski & Veggiani, 1990), but its precise age remained elusive because this fossil resin was never found *in situ*. Angelini & Bellintani (2005) by means of spectroscopic analysis found that ambers of Scanello Bolognese (Bologna) and Castelvecchio di Prignano (Modena) present a marked difference. Moreover, the attribution of the amber of Castelvecchio to the Oligocene is merely based on lithological similarity between the amber-bearing beds and those of the Ranzano Formation (Skalski & Veggiani, 1990).

An outcrop containing amber has recently been located near Castelvecchio and includes about 5 m of succession, consisting of more or less calcareous sandstones intercalated with silty and variously bioturbated clayey levels. Within the arenitic levels (usually in the upper part) there are levels rich in vegetal debris, containing amber and pieces of coal. Amber occurs as fragments and drops, ranging from 0.5 cm to over 6-7 cm, usually very dark red in color. To date, no animal inclusions have been observed, only a few tiny carbonaceous fragments that make the color of the fossil resin dark. Fourier transform infrared (FTIR) analysis was performed on the amber and compared with spectra of other known fossil resins.

To clarify the stratigraphic context of the fossil resin of Castelvecchio, samples were collected for the study of calcareous plankton, which permitted to attribute the fossiliferous levels to the uppermost part of the Maastrichtian. This result allowed, for the first time, to assign amber from the northern Apennines to the Cretaceous, differently from what has been reported so far in the literature.

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P138

PLANT CUTICLES FROM THE ALBIAN OF EL SOPLAO, CANTABRIA, NORTHERN SPAIN

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The amber deposit of El Soplao corresponds to the maximum regressive episodes of the non-marine to transitional marine siliclastic Las Peñosas Formation, which represents the regressive stage of a major regressive-transgressive, carbonate-dominated lower Aptian-upper Abian marine sequence (Najarro et al., 2009, 2010). Well-preserved plant cuticles of the conifers *Arctopitys*, *Brachyphyllum, Alvinia* and *Frenelopsis* and the ginkgoes *Nehvizdya, Nehvizdyella* and *Pseudotorellia* have been reported. Cuticles of these taxa are studied in detail, and taxonomy and systematics are compared with the plant assemblages from other Lower Cretaceous Iberian localities such as Las Hoyas, Rubielos de Mora, and San Just. A particular attention is paid to the relationship between amber and plants.

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P139

ORIGINATION OF THE SACRED LOTUS FAMILY: PRELIMINARY PHYLOGENETIC PLACEMENT OF THE NELUMBONACEAE, WITH NEW *NELUMBO*-LIKE LEAVES FROM THE LATE OLIGOCENE FOSSILLAGERSTÄTTE OF ROTT NEAR BONN, GERMANY

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Although the Sacred lotus is a culturally and economically important water plant, *Nelumbo* is not a true water lily, but is distantly related to the Nymphaeaceae. Instead, it is separated into its own family, the Nelumbonaceae, which consists of a monotypical genus with two species. Recent molecular phylogenetic analyses suggest that the Nelumbonaceae is one of the disparate families of the order Proteales, which also include the Sabiaceae, Platanaceae, and Proteaceae. To understand the phylogenetic position of the *Nelumbo* clade in the past and present, the leaf architectural characters in the order Nelumbonales and closely related outgroups were studied. To this end, we developed a character list of 66 vegetative and leaf architectural characters and coded the leaves of over a dozen species of living plants. We initially added the best preserved three specimens of a fossil leaf morphotype previously described in part as *Nymphaea lignitica* WESSEL et WEBER 1855 from the late Oligocene lake at Rott near Bonn, Germany. An extensive series of phylogenetic analyses were implemented using PAUP. The results confirm that there is much variation within families and among families of the order Proteales. Within the Nelumbonaceae, key features include an aquatic is implied in the leaf by a lack of agrophic veins, large leaf size, obicular leaf shape, centrally peltate insertion of the petiole, and clearly actinodromous basal venation with multiple primary veins. With regard to the new morphotype from Rott, the fossil leaf differs from those of living *Nelumbo* spp. in having a more proximally placed peltate insertion of the petiole and secondary veins along the entirely of the medial primary vein. Living *N. nucifera* and *N. lutea* have a more centrally placed petiole, and few secondary veins arising from only the distal half of the medial primary vein or lack secondaries. These characteristics are not found within the variation of living *Nelumbo*, suggesting the species belongs in an extinct genus. In addition, we have added several other well-preserved fossil species to study the diversification of the Nelumbonaceae. This first phylogenetic analysis of living *Nelumbo* and of *Nelumbo*-related fossils will lead to a better understand of the dynamics of extinction and origination of members of the clade, an important member of the global flora since the mid-Cretaceous.

P141

PHOENICOPSIS (LEPTOSTROBALES) AND *PSEUDOTORELLIA* (GINKGOALES) IN THE CRETACEOUS OF NORTH ASIA

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Detached leaves and their fragments belonging to *Phoenicopsis*, *Torellia* and *Pseudotorellia* have similar morphological but different epidermal features. *Torellia* Heer, 1870 was established for linear leaves from the Paleogene of Spitsbergen. Later, some Mesozoic and Cenozoic plants were attributed to this genus. Based on the epidermal leaf patterns, Florin, 1936 transferred the Mesozoic species of *Torellia* to *Pseudotorellia.* Besides *T. rigida* (type species) from the Paleogene of Spitsbergen, the epidermal structure was also described for *Torellia* sp. (Sveshnikova, Budantsev, 1969) from the Upper Cretaceous of New Siberia Island, Russia. We re-evaluated the epidermal features of the Late Cretaceous leaves and found that they are identical to those of *Phoenicopsis papulosa* from the Upper Cretaceous of northeastern Russia. This is the northernmost occurrence of *Phoenicopsis* in Asia.

Phoenicopsis and *Pseudotorellia* were common elements of the Mesozoic floras in North Asia. Nine Early Cretaceous species of *Phoenicopsis* with studied epidermal structure were described from Transbaikalia, the Russian Far East and the north of Eastern Siberia, and one more species was reported in the Urals. Only three Late Cretaceous species with studied epidermal structure are known, all of them are from the northeastern Russia. Besides this, bundles of *Phoenicopsis* leaves lacking preserved cuticle were reported from the Maastrichtian–Danian of Chukotka.

Unlike *Phoenicopsis*, occurrence of *Pseudotorellia* is known in the Lower Cretaceous of Western Siberia. Leaves of *Pseudotorellia* dominated in paludal plant communities in Transbaikalia and Russian Far East in this time. Unlike these southern regions of North Asia, *Pseudotorellia* leaves rarely occur in northern regions. Now four *Pseudotorellia* species are known from the Lower Cretaceous of Yakutia, including a new occurrence of the *Pseudotorellia* (*P. parvifolia,* sp. nov., in press.) in the Lena Basin. Previously, only two *Pseudotorellia* species were reported from the Upper Cretaceous: both from northeastern Russia. Recently, we have found *Pseudotorellia* leaves (*P. kiensis,* sp. nov., in press.) in the Cenomanian of the south of Western Siberia.

In the whole, remains of the *Phoenicopsis* leaves are unknown in the Cretaceous of Western Siberia and they are not as abundant in the Lower Cretaceous of the southern regions of North Asia as *Pseudotorellia* leaves*,* which dominated in some plant assemblages in the latter in this time. On the contrary, remains of the *Pseudotorellia* leaves are sporadic in the Lower Cretaceous of the northeastern Asia, while bundles of the *Phoenicopsis* leaves are numerous.

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P142

THE BLETTERBACH BIOTA AND THE LOPINGIAN (LATE PERMIAN) ECOSYSTEMS

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Integrated sedimentological and palaeontological studies in the Bletterbach gorge (Dolomites, N-Italy) allowed us to reconstruct a well-structured Wuchiapingian (Lopingian, late Permian) ecosystem in a distal floodplain environment characterised by a complex trophic network. The flora (> 30 taxa) is dominated by ginkgophytes and conifers, whereas seed ferns, taeniopterids and sphenophytes are rare elements. Plantδinsect associations indicate a modest diversity and level of herbivory and host specialization. Tetrapods (13 ichnotaxa) are represented, in order of abundance, by parareptiles (pareiasaurs), neodiapsids ("lacertiforms"), various groups of therapsids, capthorinids and other, undetermined amniotes.

A comparison with the 14 best-documented Lopingian terrestrial ecosystems included a quantitative characterization of the fauna (body fossil and ichnofossil records), the relative abundances of floral groups, and climatic and palaeolatitudinal settings. Both floral and faunal bioprovinces were strongly affected by the distribution of climate regimes, and palaeolatitude was a predictor of ecosystem compositional affinity. The Bletterbach biota, together with ecosystems from Morocco and Niger, provides a unique window on equatorial to low latitude life and yields evidence that the most diverse assemblages at high taxonomic levels are those at mid to low latitudes. Although fossil-rich, higher latitudes ecosystems (e.g., Junggar and Karoo) are much less diverse at high taxonomic levels. Climatic constraint appears crucial in shaping the distribution of the three main herbivorous groups. Dicynodonts were best adapted to cool temperate climates with glossopterid/coni-

fer-dominated woodlands. Pareiasaur distribution best correlates with conifer- and ginkgophyte-rich woodlands that developed in the warm temperate climate of equatorial to sub-equatorial Pangaea. Captorhinid distribution is consistent with the semi-arid to arid conditions of the tropical summerwet biome, where they might have fed on "pteridosperms" and conifers. Climate, latitude and tectonic history controlled the affinity of the different ecosystems. North Gondwanan ecosystems had closer affinities with Euramerican than with south Gondwanan ecosystems. The Laotian ecosystem shows affinity with Karoo-type ecosystems, likely inherited before the northward migration of SE-Asian continental blocks. The Lopingian latitudinal gradient shows a poleward decline in tetrapod richness. Tropical assemblages include a mixture of holdovers from the early Permian (e.g., temnospondyls, captorhinids), early members of clades best known in the Triassic (e.g., Archosauriformes), and contemporary taxa that also are present at higher latitudes (e.g., therapsids, pareiasaurs), suggesting that the tropics acted as both a cradle (i.e., an area with elevated origination rates) and a museum (i.e., an area with low extinction rates) for biodiversity.

P143

WHOLE-PLANT RECONSTRUCTION, UPDATED PHYLOGENY AND POLLINATION MECHANISM OF *AUSTROHAMIA ACANTHOBRACTEA* (CUPRESSACEAE) FROM THE MIDDLE JURASSIC OF NE CHINA

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The recent discovery of abundant impressions and compressions of leafy twigs, pollen cones, and seed cones of **Austrohamia acanthobractea** in certain fossiliferous beds of the Middle Jurassic Daohugou Lagerstätte in Inner Mongolia, NE China provides detailed morphological features, permitting whole-plant and pollination reconstruction, and a more accurate evaluation of the relationship between this extinct plant and extant or fossil basal Cupressaceae conifers. The fossil species consists of helically arranged linear leaves with two narrow stomatal bands on the abaxial surface. Pollen cones are borne in clusters of four, and attached sub-terminally. The pollen cone is borne in the axial of a lanceolate bract and microsporophylls are peltate. Seed cones are less than 1 cm, borne solitarily or in pair, terminally or laterally attached, and bear numerous spirally arranged bract-scale complexes. The bract-scale complex is apparently absent a free ovuliferous scale. Two ovules are present on the proximal end of the bract adaxial surface. Ovules are flask-shaped and inverted. Seeds are obovate, and possess two narrow resemblance to modern **Taiwania** than to **Cunninghamia**. A morphological cladistics analysis resolved **Austrohamia** is the outgroup taxa to Cunninghamiodeae, and they together composed a clade which is a sister group to living **Taiwania**, **Athrotaxis**, fossil **Stutzeliastrobus**. Furthermore, germinating pollen grains, geminated pollen and associated pollen tubes, archegonia, and germinating pollen grains, as well as an entire flask-shaped ovule undergoing the pollination process, were observed in the bract-scale complexes after maceration. These information apply to the pollination prior to fossilization. Here the complete pollination process of **Austrohamia** is reconstructed based on the mechanism of pollination. The reconstructed results show that the pollination process observed in the present species falls in between those of modern Cupressaceae and those of modern Pinaceae and Podocarpaceae.

Key words: Cupressaceae, **Austrohamia**, Middle Jurassic, Daohugou Lagerstätte, phylogeny, pollination mechanism

P144

PALYNOFLORAL EVOLUTION ON THE NORTHERN MARGIN OF THE INDIAN PLATE, SOUTHERN QINGHAI-XIZANG PLATEAU, CHINA DURING THE CRETACEOUS PERIOD

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The Qinghai-Xizang Plateau has undergone globally dramatic changes in plant evolution in the past. Each of its compositional blocks, which used to be separated hundreds of million years ago, experienced a unique evolutionary history. The southern Xizang (Tibet) block, for example, changed from having a Gondwanan affiliation during the Palaeozoic Era to being a Himalayan Province today, the youngest major floral province in the world. This block, as a constituent part of the Indian plate, separated from Gondwana during the Cretaceous Period and drifted northwards until it collided with Eurasia at the end of Cretaceous or in the early Cenozoic. Its continuous convergence with Eurasia led to the development of the high Qinghai-Xizang Plateau in the late Cenozoic. The tectonic activity associated with the movement of the Indian plate undoubtedly brought about profound environmental changes that further affected the earth's ecosystem and hence the composition of regional biotas, both terrestrial and marine. Our palynological analysis of a Cretaceous sedimentary succession in Gamba County, southern Xizang, reveals in detail how the region-

al palynoflora changed during this continental rearrangement. Comparison between the main components and endemic taxa of coeval palynofloras in southern Xizang, Australia and Africa shows that the terrestrial floras of the Gamba region of southern Xizang clearly changed from having connections with Gondwana during the Early Cretaceous to North Africa during the Late Cretaceous. Changes in climate and geographic isolation were key factors in the diversification of the vegetation in the vicinity of Gamba and in adjacent continental blocks. Increases in inceptions of new taxa in both this region and Australia coincide with tectonically active periods on the two continents, implying the break-up of Gondwana, the fundamental driving force behind the palynofloristic changes in the Tethyan region for the Cretaceous Period.

P145

EARLY PERMIAN PALYNOMORPHS AND THEIR PALAEOCLIMATIC IMPLICATION: A CASE STUDY FROM RAJMAHAL BASIN, INDIA

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Rajmahal Basin is one of the important basins in India for palynological study of Mesozoic succession. The basal unit in the stratigraphy of Rajmahal Basin is the Archean granitic complex; which is unconformably overlain by the Permian and Mesozoic sequences. The Upper Gondwana sequences in the Rajmahal Basin are represented by Dubrajpur and Rajmahal formations (Triassic to early Cretaceous). The Rajmahal Formation constitutes traps and Intertrappean sequences. Lower Gondwana sequences represent Permian strata comprising Talchir and Barakar formations.

The borehole BRS-2 was drilled in Salbadra-Gomarpahari sector, which is located at south of Brahmani Coalfield of Rajmahal Basin. The sector lies between latitudes 24º07'28" to 24º08'56"N, and longitudes 87°35'02" to 87°37'55"E and covers an area of 12.266 sq kms. The borehole BRS-2 intersected through coal forming Barakar Formation (Artinskian) and the Talchir Formation (Asselian-Sakmarian). Palynological analysis of six samples collected from Talchir sequences has revealed one palynoassemblage namely **Parasaccites korbaensis** Assemblage zone which is designated as earliest Permian in age. The palynoassemblage includes **Parasaccites** spp., **Plicatipollenites** spp., **Jayantisporites** spp., **Divarisaccus lelei**, **Caheniasaccites** sp., **Sahnites barelensis**, **Tuberisaccites indicus**, **Microbaculispora** sp., **Microfoveolatispora** sp. and **Callumispora gretensis**.

Spheroidal inclusions are infrequently encountered in monosaccate gymnosperm pollen grains Viz. **Parasaccites** and **Plicatipollenites** are also recorded. These structures occur solitary or in cluster of one to seven in the corpus of the monosaccate pollen grain. Probably these inclusions are perhaps the endobiotic zoosporangia of a chytrid or member in the Hyphochytridiomycota. These are useful in expanding our knowledge about fungal interactions in ancient ecosystems.

The palynoassemblage has also represented by many permanent, naked, tetrahedral and decussate forms of fossil spore tetrads assignable to the dispersed microspore genera **Microbaculispora, Microfoveolatispora, Jayantisporites**, **Didecitriletes** and **Horriditriletes.** Except **Jayantisporites** other genera are reported for the first time from the earliest Permian stratum (Talchir Formation). The presence of a trilete mark in the spores of the tetrads reveals their alliance with the pteridophytic group of plants. The occurrence of these fossil spore tetrads and dyads from earliest Permian suggests the prevalence of extreme cold conditions during the deposition of the Talchir Formation as a consequence of Carboniferous glaciations followed by deglaciation at the beginning of the Permian period.

Key words: Permian, Rajmahal Basin, Palynomorphs, spore tetrads, chitrids and palaeoclimate

P146

WILDFIRES ARE NOT ONLY IMPORTANT FOR LAND ECOSYSTEMS BUT MAY PROVIDE ESSENTIAL REGULATION OF OCEAN HABITAT CONDITIONS

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The modern ocean is 'on the edge of anoxia', with an increasing number of dead zones around the world expanding. This is because the amount of oxygen reaching the deep ocean from the atmosphere and downward ocean mixing is almost equal to the amount of dead organic matter (food), sinking to the deep ocean. As the organic matter is consumed, respiration takes place, using up almost all of the oxygen present in the deep ocean.

Throughout Earth's past, there have been many periods where the oceans have become anoxic. These are termed Oceanic Anoxic Events (OAEs), and represent periods of major disruption to the global carbon cycle. During an OAE, increased organic carbon burial and preservation occurs. Numerical models predict that increased organic carbon burial across an OAE could drive a rise in atmospheric oxygen which may be capable of ultimately terminating ocean anoxia after ~1 million years. However, such model estimates remain untested. Wildfire is highly responsive to changes in atmospheric oxygen therefore we would anticipate that fire activity should vary across an OAE. We test this hypothesis by tracing variations in the abundance of fossil charcoal across the Toarcian OAE (T-OAE), occurring ~183 Ma. Our results reveal a sustained ~800 kyr enhancement of fire activity beginning ~1 Myr af-

ter the onset of the T-OAE and which peaks during its termination. We hypothesize that this major enhancement of fire, was primarily driven by increased atmospheric oxygen and therefore provide the first fossil based evidence suggesting OAEs are terminated by fire-feedbacks to rising atmospheric oxygen.

P147

MILANKOVITCH FORCING OF EARLY JURASSIC WILDFIRES

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The Early Jurassic was characterized by major climatic and environmental perturbations which can be seen preserved at high resolution on orbital timescales. The Early Jurassic is a period of overall global warmth and therefore serves as a suitable modern day analogue to understand changes in the Earth System. Presently, Earth's climate is warming and the frequency of large wildfires appears to be increasing. Recent research has indicated that Quaternary deposits reveal the wildfires respond to orbital forcings, however, to date no such study has been able to test whether wildfire activity corresponds to changes over Milankovitch timescales in the deep past.

An excellent high resolution astrochronology exists for the Upper Pliensbachian in the Mochras borehole (NW Wales). Ruhl et al. (2016) shows that elemental concentration recorded by handheld X-ray fluorescence (XRF) changes mainly at periodicities of ~21,000 year, ~100,000 year and ~400,000 year, which is coupled to changes in sedimentary bundles.

We have quantified the abundance of fossil charcoal at a high resolution (10-15 cm) to test the hypothesis, that these well preserved climatic cycles influenced fire activity throughout this globally warm period. Our preliminary results suggest that variations in charcoal abundance appear to be coupled to Milankovitch forcings over periods of ~21,000 and ~100,000 years. We suggest that these changes in fire relate to changes in seasonality and monsoonal activity that drove changes in vegetation that are linked to variations in the orbital forcing.

P148

ENVIRONMENTAL INFLUENCES ON ANCIENT MAYA LAND-USE IN BELIZE

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Understanding past human-environmental interactions during periods of climate change can help shape future management strategies in tropical regions. The Classic Maya civilisation (250-1000 AD) of Mesoamerica is known to have caused large-scale environmental impacts against a backdrop of climate instability. Existing palaeoecological research highlights large declines in forest pollen that are attributed to past deforestation and maize agriculture. Many of these studies focus around large ceremonial centres, which may reflect the intensive agriculture that was required to support high population densities. Palaeoecological investigations from medium to low-density sites provides an opportunity to investigate how the Ancient Maya managed their landscapes using alternative strategies, such as agroforestry, and the resilience of these strategies under changing climate conditions.

This research will investigate Ancient Maya environmental interactions in Belize during periods of known climate instability. Site selection was based on three criteria: (1) a diverse range of ecosystems is represented; (2) all sites are not located near large ceremonial centres; (3) all sites were continuously occupied during the Ancient Maya period. Island (coastal) and mainland sites were compared to investigate ancient Maya land-use strategies in these different environments. Peat cores were extracted from Marco Gonzalez (189cm) and Basil Jones (350cm), located within mangrove and dry forest ecosystems, respectively, on the island of Ambergris Caye. On the mainland, a short lake sediment core was extracted from Laguna Aguacate (Spanish Lookout). The site is situated amongst large maize fields and patches of degraded broadleaf deciduous forest, which provides a modern analogue for agriculture during the Ancient Maya period. High-resolution pollen and charcoal analyses will determine past land-use strategies, such as forest clearance, permaculture and swidden agriculture. Key pollen indicators of landscape modification, such as crops (*Zea mays*) and economically important taxa (e.g. palm) will show the land-use strategies of the Ancient Maya; while changes in the abundance of forest pollen will determine the extent to which deforestation occurred around medium-density sites. By comparing these environmental reconstructions to existing palaeoclimate records, this study could shed light on the resilience of different land-use strategies under future climate scenarios.

P149

ANOTHER MAAR LAKE, ANOTHER STORY: PALYNOLOGICAL STUDY OF EOCENE LACUSTRINE SEDIMENTS AT GROSS ZIMMERN (HESSE, SOUTHWEST GERMANY)

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The lacustrine succession at Groß Zimmern, 10 km east of Darmstadt (Hesse, SW-Germany), represents one of half a dozen of isolated Paleogene deposits scattered across the Sprendlinger Horst, the northern extension of the Hercynian Odenwald basement in Southwest Germany flanking the Upper Rhine Graben to the northeast. Scientific drilling in the center of the structure recently revealed a reference core, including 80 m of a volcanoclastic breccia overlain by 30 m of a lacustrine succession of clastic sediments and finely laminated bituminous shale. However, the whole lacustrine succession shows signs of slumping, redeposition or in-situ deformation. The discovery of massive volcanoclastic deposits proved that the overlying lake sediments have been deposited within a small maar structure with a diameter of 250 to 400 m. A first palynological analysis now suggests that the lake sediments were of Middle Eocene age. This age is consistent with the age of other Paleogene deposits on the Sprendlinger Horst, such as, e.g., the nearby maar lake of Messel.

Our quantitative palynological study revealed different pollen and spore assemblages. In the lower part of the succession aquatic plants and swamp elements, such as Hydrocharitaceae and Taxodiaceae, as well as marsh elements, such as Restionaceae, dominated indicating a relatively high lake level causing flooded habitats in the crater area. In the upper part of the record these elements decreased significantly or disappeared completely. This can be interpreted by a change to less humid conditions accompanied by falling lake level. Changes in the pollen assemblages are mainly restricted to plants living at the lake shore. However, the dominating elements of the surrounding (para) tropical forest, such as *Plicatopollis* spp. (Juglandaceae) and *Tricolporopollenites cingulum* (Fagaceae) are characterized by cyclic frequency fluctuations. Since the lacustrine sediments are completely disturbed, probably due to seismic activity or rapid subsidence within the crater, the interpretation of palynological assemblages in terms of paleoenvironmental trends has to be treated with caution. However, the general trend obviously follows a pattern common to the lacustrine filling of other nearby maar structures which indicates that the succession was not completely mixed up by disturbance.

P150

REFINING PLANT CUTICLE-BASED LEAF MASS PER AREA PROXIES TO UNLOCK PLANT RESPONSES TO CLIMATE CHANGE IN THE PAST AND THE FUTURE

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Inferring palaeoclimates from the plant fossil record provides an in-depth understanding of the past environmental and atmospheric changes that have defined the current climate. Observing how species adapted to the rapid environmental changes that occurred throughout geologic time, gives a greater understanding to how their extant relatives may react to the future projections for the Earths' climate system. Due to the correlation between specific plant traits and local environment and climate, the sensitivity of different leaf traits to changes in the climate system has great importance when inferring past climates. This investigation focused on refining the previously described epidermal cell density proxy for leaf mass per area. The method has only been described for Ginkgophytes and this project aimed to determine if the method can be robustly applied across species and family to broaden its applicability. Leaf mass per area and leaf cuticle thickness were also investigated with the aim of establishing a relationship between changing levels of atmospheric CO_2 and other environmental factors. The initial findings support that this method can be more broadly applied across plant functional groups. The use of a range of extant species, mainly Angiosperms and Gymnosperms, enables us to compare the results generated to the fossil record to establish the functioning of past plant communities. This method may prove useful for investigating plant responses to rapid climate change in the past and to predicting likely plant responses to near-term future climate change.

P151

PALAEOENVIRONMENTS, 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 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. Previously, all occurrences of the Kenslow Member were assumed to be contemporary, howeverpalynostratigraphy suggests this is not the case. This new interpretation implies that a sequence of fossiliferous horizons is present in the Brassington Formation, rather than single layer. Using this revised chronology, a new vegetation and climate record for the Atlantic margins of northwest Europe has been produced. We report that the Bees Nest Member, which underlies the Kenslow Member, is not barren as had been previously thought and has produced a pollen assemblage. Overall, the palynology shows that 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).

P152

FOSSIL EVIDENCE FOR THE DIVERSIFICATION OF CROWN-GROUP CUNONIACEAE FROM THE EARLY PALEOCENE (DANIAN) OF PATAGONIA, ARGENTINA

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Fossil flowers from the early Paleocene of Patagonia, Argentina attributable to Cunoniaceae provide an exceptional opportunity to evaluate the timing of diversification and the biogeographic history of an iconic Southern Hemisphere family. Two fossil species known from fossil flowers, *Lacinipetalum spectabilum* and another unnamed one, were collected from sediments of the Danian Salamanca Formation which crops out in Chubut. We explored the relationships between the fossil species and extant Cunoniaceae using Maximum Parsimony and Bayesian Inference. The fossils were included in a matrix of combined morphological and cpDNA sequence data (*rbcL*, *trnL-F*, *matK*). The two methods yield similar results. A close relationship between *Lacinipetalum* and extant Schizomerieae is confirmed and the position of the unnamed fossil is nested within the Cunoniaceae crown-group, but it does not conform to any extant genus or tribe. Older fossils attributable to the family include dispersed pollen and wood from the Upper Cretaceous of Argentina and the Antarctic Peninsula, but the phylogenetic position of those fossils is still uncertain; thus, the Salamanca flowers are the oldest macrofossil evidence of crown-group Cunoniaceae worldwide. Their discovery in the Salamanca Formation strengthens the hypothesis that the diversification of crown-group Cunoniaceae was underway at the beginning of the Cenozoic. Although Australasia is currently the center of diversity for the family, the emerging record from South America indicates that west Gondwana played a more important role in the diversification of Cunoniaceae than previously thought.

P153

CYCLIC CHANGES IN PLANT DIVERSITY AND PALEOECOLOGICAL CHARACTERISTICS DURING THE MIDDLE MIOCENE IN CARPATHIAN FOREDEEP AND CENTRAL PARATETHYS (CZECH AND SLOVAK REPUBLICS).

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The study area covers slopes of the tectonically stable European platform and foreland of the tectonically active Carpathian mountain chain. The research of pollen spectra mirrors the evolution of landscape and climatic changes in the Central Paratethys domain during the Karpatian and Badenian (late Burdigalian to early Serravalian according to the standart chronostratigraphy; MNN4-MNN6). This interval includes the final phase of the **Mid-Miocene Climatic Optimum** and the **Middle Miocene Climatic Transition** at 14.8-12.0 Ma. The **l**andscape evolution, conditioned by uplift of the Carpathian mountain chain and subsidence of adjacent lowlands, led to the formation of a disting relief. The application of the PFT technique (26 PFT system and an additional aquatic PFT) reveals changes in the proportion of vegetational components. All in all the ecospectra obtained for

the studied microfloras indicate that during the time-span regarded a diverse, thermophilous mixed mesophytic forest vegetation persisted in the neighboring continental parts of the study area. This observation contradicts the presence of dry climatic phases as have been reported from coeval records elsewhere. The almost continuous presence of a PFT including swamp trees (2-5 % of total diversity) indicates that swamp forest thrived in coastal areas throughout the studied period.

The studied ecospectra show shorter-term cyclic changes in plant diversity. These changes are best traced when studying various indices. When using the propotion of broadleaved evergreen vs. broadleved deciduous tree diversity as indicator for temperature changes short-term alternations of warmer and cooler phases are obvious from the record. The ratio of xeric herbs and shrubs is used here as an indicator for dryer and wetter climatic phases. The record of this wet/dry index also shows short-term shifts. Both, evergreen and xeric index have a significant co-variability, however, it is shown that the dry peaks pre- or post-data in each case the warm peaks in the record. Possible reasons for the mechanism behind still have to be discussed. For coeval series of the Lower Rhine Basin (northwestern Germany) it has been demonstrated that warm intervals were particularly wet while in the present Paratethys record it seems that warmer phases were dryer, at the same time.

P154

PALYNOMORPHS FROM NEOGENE SEDIMENTS OF THE BANATSKO ARANĐELOVO LOCAL DEPRESSION (SERBIA)

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Within the framework of the palynological research, samples of Neogene sediments were collected from the drillholes in Banatsko Aranđelovo local depression, which is located in the northeast Vojvodina within Banat depression. Total of 30 samples were taken from 9 wells. The samples originate from the Panonian and Pontian sediments. They are mainly marl and siltstone.

The palynospectral analysis found that two complexes of palynomorphs can be distinguished:

(a) complex dominated by bisaccate pollen grains of conifers, represented by large number of usual species occurring in Neogene (*Abiespollenites absolutus*, *A. maximus*, *Pinuspollenites macroinsignis*, *Pinuspollenites labdacus*). A significant percentage of arcto tertiar (mostly moderately warm) elements, *Tsuga* and *Larix*, with pollen *Abies* represents a permanent arcto tertiar elements in Badenian and Sarmatian. *Taxodiaceae* and *Cupressaceae* are in some samples abundant and, along with *Laevigatosporites haardti* and *Myrica* pollen, indicate marshy areas.

Biostratigraphic analysis of palinospectras shows Badenian age of sediments and palaeoecological analysis proved a sub-tropical climate with influence of arcto tertiar elements.

(b) complex in which angiosperms (*Carya*, *Pterocarya*, *Alnus*, *Juglans*, *Tricolpopollenites*, *Sciadopityspollenites*) and gymnosperms (*Abiespollenites absolutus*, *A. maximus*, *Pinuspollenites macroinsignis*, *Pinuspollenites labdacus*, *Podocarpidites* with several types, with several types of *Zonalapollenites*) are relatively equally presented. Among the angiosperms, there is noticeable presence of *Gramminaea*, and in some spectra of *Chenopodiaceae*.

Based on the characteristics of palinospectras, age of the sediment was determined as Sarmatian (presence of *Sciadopityspollenites*, which occurs only in Sarmatian, and the presence of *Graminidites*).

Climate during Sarmatian was warm and mild. Sarmatian paleopalinological complex contain species of xerophilic families such as *Chenopodiaceae* and *Gramminaea*, most probably due to the dry climate, and that is the only difference between Sarmatian and Badenian microflora.

Key Words: Palynomorphs, Biostratigraphy, Paleoecology, Neogene, Banatsko Aranđelovo.

P155

DIVERSITY PATTERNS IN MICROFLORAS RECOVERED FROM MIOCENE BROWN COALS OF THE LOWER RHINE BASIN REVEAL DISTINCT COUPLING OF THE STRUCTURE OF THE PEAT-FORMING VEGETATION AND CONTINENTAL CLIMATE VARIABILITY

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Brown coal deposits of the Lower Rhine Basin, northwest Germany, covering the time-span from the late Aquitanian to Serravallian and most of the Tortonian allow for studying vegetation dynamics during the Mid-Miocene Climatic Optimum and Late Miocene Cooling. Based on a total of 400 microfloras sampled from brown coal seams exposed in the Hambach and Inden open cast mines structural changes in the vegetation can be studied under the comparatively stable environmental conditions of persisting coastal mires. In order to minimize the impact of local edaphic conditions in the peat bog such as oscillations of the groundwater level, the palynomorph record is interpreted at the level of diversity of plant functional types (PFTs). The pollen and spores recovered from the samples are assigned to a total of 26 herbaceous to arboreal PFTs, based on their botanical affinity.

The PFT diversity spectra obtained from the microfloras reveal a

variable proportion of herbaceous to shrubby functional types attaining ca. 30 % at a mean, in both the middle and late Miocene sample sets. With ca. 70 % of the total diversity attributable to arboreal functional types the peat-forming vegetation of the studied Miocene strata basically represented a swamp forest. This interpretation is in line with earlier reconstruction based on the study of fossil woods. When regarding the composition of the arboreal fraction in the diversity spectra it is shown that the proportion of the dominantly thermophilous evergreen types among broadleaved PFTs shows long-term trends that follow the overall climate evolution throughout the studied time-span, as e.g. known from marine archives. Conifers became more diverse during the Langhian (ca. 15 %, at a mean), and were at a high level (ca. 20 % at a mean of the total PFT diversity) in the Tortonian. Both, the diversity proportions of conifer PFTs among other arboreal components, and the composition of the broadleaved angiosperm PFT fraction display a pointed short-term variability that probably can be related to eccentricity cycles when considering the available independent stratigraphic framework. Our results suggest a distinct coupling of the structure of the peat-forming vegetation and continental climate variability in the study area.

P156

THE LATE OLIGOCENE FLORA FROM WESTERN SERBIA (THE ZAPADNA MORAVA GRABEN)

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Palaeofloras of Paleogene in Serbia are relatively rare, especially comparing them with floras from Neogene sediments. Most Paleogene phytoassociations from the territory of Serbia existed in dry and warm climate. The youngest Paleogene phytosociation originates from the "Pranjani Basin" (western Serbia), locality Kamenica. Age of this paleoflora is determined as Late Oligocene. This fossil plant assemblage is different from other phytoassociations of Paleogene. Pranjani Basin is part of the Zapadna Morava graben. The Zapadna Morava graben is the largest Intradinaric depression extending NW-SE. This Graben is characterized with large subsidence of the Ottnangian-Karpatian. The central graben sank deepest down, more than 2000 metres.

Fossil plants are collected from the locality Kamenica river (left bank) in village Kamenica. Leaf imprints presently studied originate from from a dark-gray, very compact marls which lies across the serpentine. These sediments are characterized with large thickness.

Leaf imprints are well preserved and it suggest on relatively proximity of paleovegetation to deposition basin. In sediments with fossil plants are found fish remains (Hiodontidae). More than fifty plant taxons are determined.

Palaeophytoassocioation from the Kamenica is characterized with leaf imprints larger than in other Paleogene fossil floras. Also, it differs in taxonomical composition. Prevailing forms are representatives of broad-leaved evergreen forests. In older Paleogene sediments these forms are extremely rare.

In this paleofitoassociotion dominate the conifers, especially Pinus paleostrobus, Sequoia, Libocedrus. Representatives of the broadleavs evergreen forests of are presented with Laurus, Quercus, Ficus et. al.

In Serbia Paleogoene fossil flora predominantly suggests to warm and dry paleoclimate. Fossil remains from Kamenica locality is different. According on CLAMP analysis it suggest on humid and warm climate. Also paleoflora from this locality is youngest among Paleogene floras in Serbia.

Palaeoclimate estimates derived from the woody dicotyledonous angiosperm from the Kamenica locality indicate the climate was warm and humid, subtropical-tropical.

Such favorable environmental and climate conditions were reflected in the vigor of vegetation in Late Oligocene.

P157

PALYNOLOGICAL ANALYSIS OF THE MIDDLE MIOCENE IN THE E8-X CORE IN THE NORTH SEA

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The content of palynomorphs, primarily dinoflagellate cysts, is analysed in samples from the middle Miocene in the E-8X core (supplemented with cutting samples), from the Danish part of the North Sea, southeast of the Tyra Field.

Lithostratigraphically the studied succession comprises the uppermost Lark Formation of the Hordaland Group and the lowermost Nordland Group. Parts of the succession are very rich in biogenic silica.

The interval spans the change from the global Mid-Miocene Climatic Optimum (late Burdigalian to Langhian) to a cooler climate in late Langhian/Serravallian. Yet, the palynomorph assemblages in the palaeo-North Sea Basin, as it was relatively restricted, may also have been prone to regional controls.

The cooling in the Langhian resulted in a global eustatic sea-level fall. However, due to subsidence of the North Sea Basin a transgression occurred. The presented project aims at documenting the changes in the dinoflagellate cyst assemblages and in the assemblages of sedimentary organic particles during these environmental changes.

The dinoflagellate cyst stratigraphy is based on the zonation by Dybkjær & Piasecki (2010), and the palynomorph assemblage is analysed for palaeo-environmental changes, such as salinity, temperature, productivity and distance to land.

P158

CLIMATE AND VEGETATION DYNAMICS DURING THE EOCENE GREENHOUSE OF CENTRAL EUROPE: PALYNOLOGICAL INVESTIGATION OF LACUSTRINE SEDIMENTS FROM LAKE "PRINZ VON HESSEN" (SOUTHWEST GERMANY)

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Lacustrine sediments of a small pull-apart basin at Grube Prinz von Hessen, 5 km NE of Darmstadt (Southwest Germany), have been analyzed palynologically in order to reveal long- and short-term interaction of climate and environment across the last natural greenhouse system in Central Europe. The lacustrine succession includes 34 m of clastic sediments which are overlain by 54 m of finely laminated bituminous claystone and lignite. In a first step the complete section has been covered by samples in 2 m intervals. Based on palynological index fossils it can now be proven that the lake basin must have persisted for some millions of years from the latest Early Eocene into the Middle to Late Eocene. Statistical analyses of the diverse and well-preserved palynoflora reveal 5 distinct associations throughout the sedimentary record. There is a strong correlation between major changes in vegetation and lithology which was controlled by factors such as tectonics and climate. In a second high resolution study palynological data from a *c*. 13 m thick part of the succession which is characterized by a regular alternation of lignite layers and mudstones have been analysed. The results show a correlation to lake level fluctuations including short time establishment of an open lake. Nevertheless, since no rooting structures have been observed below the lignites and some of them show erosional structures at their base, an allochthonous origin for the organic material in the lignite layers is suggested. It has been redeposited from material which was eroded around the lake, probably due to tectonic activity. Therefore, an orbital control of lake level fluctuations responsible for the regular occurrence of lignites cannot be proven. Nevertheless, cyclic abundance fluctuations of palynomorphs indicate an orbital influence and therefore a climate control on vegetation changes independently of lake level fluctuations.

P159

EFFICACY OF GRASS PHYTOLITHS IN DISCRIMINATING DELTAIC SUB-ENVIRONMENTS OF INDIAN SUNDERBANS: IMPLICATIONS IN LATE QUATERNARY ENVIRONMENT RECONSTRUCTION

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The efficacy of modern grass phytolith morphometry and frequency data for distinguishing deltaic sub-environments has been examined on 40 surface soil samples collected from different eco-successional zones of the Sunderbans delta, West Bengal, India. The representation of diverse grass phytolith mophotypes and their frequency of occurrence in the surface soil samples have helped in discriminating different deltaic sub-environments particularly the true mangrove zones from mangrove associated and the non-mangrove zones. Among the 40 surface soil samples, 19 samples from true mangrove zone yield high frequencies of ellipsoid rondel, spool/horned tower, flat tower and four horned rondel morphotypes. Twenty one surface soil samples collected from the mangrove associated and non-mangrove zones display dominance of lobates (bilobate, polylobate), cross, short saddle, plateau saddle, long saddle, collapsed saddle and keeled rondel morphotypes. Furthermore, two eco-successional zones under true mangrove environments (Swampy mangroves or intertidal mangrove zone and tidal mangrove zone) and three zones under mangrove associated and non-mangrove environments (True Mangrove decline zone, zone of colonization of non-littoral species and xerophytic non mangrove & dry-evergreen forest zone) could also be differentiated with little overlapping. These phytolith data are further subjected to Discriminant Function Analysis (DCA) which successfully distinguished the respective deltaic sub-environments. Two late Quaternary sub-surface sedimentary profiles from this region were further studied to reconstruct past depositional environment. Depending on the fossil grass phytolith assemblages two depositional environments comparable to the present day eco-successional zones of the Sunderbans delta have been identified in the Suryapur subsurface profile (22°18'35''N; 88°27'41''E). Environment of deposition at zone II (depth 290 cm – 0 cm; age 4290 cal a BP to recent) corresponds with the mangrove associated and non-mangrove zones whereas zone I (depth 390 cm – 300 cm; age 4750 cal a BP – 4290 cal a BP) is comparable to the true mangrove environments. The sub-surface sediment from Mollar Chawk profile (22°5'20.05''N; 88°15'55.67''E) reveals that zone I and zone II (depth 620 cm – 370 cm; age 13677 cal a BP – 3788 cal a BP) exhibiting fossil grass phytolith assemblages represent a true mangrove environment with discernable tidal influence whereas zone III (depth 360 cm – 0 cm, 3788 cal a BP to recent) indicates a mangrove associated and non-mangrove environment with little or no tidal influence.

P160

HISTORY OF SAMI SOCIETY AND REINDEER HERDING IN NORTHERN FENNOSCANDIA IN LIGHT OF THE COPROPHILOUS FUNGAL SPORES

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Reindeer (*Rangifer tarandus*) is the most dominant large herbivore affecting the vegetation of the northern Fennoscandia. The combined human-animal agency e.g. concentrated grazing and trampling by semi-domesticated reindeer herds, has changed the vegetation by creating graminoid-dominated green patches throughout the Arctic, especially in Fennoscandia and northern Russia. The effect of these activities on local vegetation may persist for centuries.

Suollagavallda site is located in the Scandinavian Alpine area in northern Sweden. The study area is in a mountain valley with numerous ancient dwelling sites indicated by several Stallo foundations and stone hearths. The discussion in recent decades have been whether these settlements are remains of the camp sites of wild reindeer hunters or represent an early phase of reindeer herding and pastoralism with settlement, even during winter. The site has been chosen for a high-resolution pollen and coprophilous fungal spore analysis, because the archaeology itself does not reveal much about the history of activities on site during the late Iron Age and Early Medieval Period. Our hypothesis is, that Sami have also practiced reindeer milking in the area during the summer months, and the animals have been kept on site for several weeks at the time, year after year repeatedly over several generations, which has had its effect on the vegetation structure, cover, and composition.

The abandoned milking sites can usually be spotted from the surrounding areas because of their rich herb flora. The vegetation change can be very persistent. Several ecological mechanisms contribute to the long-term stability of the historical milking grounds. Recent studies from the Netherlands also show that there is a significant relationship between the coprophilous fungal spore abundance and local biomass densities of herbivores that can be used in the calibration of fossil records.

The results from Suollagavallda profile show a peak of coprophilous fungal spore *Sporormiella* along with a decline in the percentages of *Betula* and *Salix* pollen, and an increase in *Juniperus* and *Rumex* which are good palynological indicators of grazing in the area. The pattern is very similar to some earlier observations from other reindeer herding sites in Sweden. The high percentage of coprophilous fungal spores in the analyzed samples suggests that the method can be used to date the timing and duration of reindeer milking in the Suollagavallda valley.

P161

WEST AFRICAN HYDROLOGICAL VARIABILITY OVER THE PAST 150,000 YEARS INFERRED FROM A MARINE NON-POLLEN PALYNOMORPH RECORD

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Non-pollen palynomorphs (NPPs) are highly valuable ecological indicators, however their application within African palaeoclimate studies is, to date, extremely limited. Previous studies have investigated their application in lacustrine studies, but not before in a marine setting. Here we present a record of West African monsoon positioning and hydrological variability from a 150,000 year marine core from the Ogooué Fan, offshore Gabon, inferred from NPP data. Algal morphotypes are interpreted as indicating terrestrial surface water extent reach a maximum during the mid-Holocene African Humid Period. Algal prominence co-varies with fungal morphotype incidence; a fungal maximum during Marine Isotope Stage (MIS) 5b indicates maximum precipitation. Aquatic NPPs, representative of larger water bodies, do not appear in the record until mid MIS 5 and in conjunction with a dominance of lowland rainforest within the corresponding palynological record, are interpreted as an indicator of increased precipitation in conjunction with eccentricity maxima.

P162

NON-POLLEN PALYNOMORPHS FROM DRAINED AND REWETTED FENS

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The interdisciplinary WETSCAPES project studies turnover processes in drained and rewetted peatlands in North Eastern Germany to support climate and water protection, and as a basis for sustainable (wet) peatland cultivation. The main objective of the project is to understand the development and functioning of drained peatlands after rewetting.

For high resolution analyses we sampled peat monoliths from pairs of drained and rewetted sites in a percolation mire, in a coastal wetland, and in two adjacent alder carrs. The monoliths were cut into 0.5 cm contiguous slices which were subsampled for a set of analyses: micro fossils (palynomorphs), macro fossils, microbial DNA (methanogens, [de]nitrifiers) and soil chemistry (elements, carbon species).

Here we present the results from a percolation mire that was drained for agriculture in the late 1960s. The site was rewetted in 1997. It is now water-logged during the whole year. Vegetation is dominated by sedges (*Carex* spec.). The monolith of 55 cm includes about 10 cm of newly formed plant material (litter, roots and radicels) underlain by a 25 cm thick layer of compacted and highly decomposed, amorphous peat material (the former cultivated grassland soil). Below lies a well preserved original peat. Recent roots and radicels are found throughout the profile.

We describe the non-pollen palynomorph assemblages in order to characterise different decomposition stages to trace i) the decay of the original peat caused by the former drainage and ii) the aging of recently deposited material on its way to form new peat.

The combination of different analyses will hopefully provide new insights into the identity and indicator value of NPP types.

P163

THE PHENOMENON OF KUNGUR FOREST-STEPPE (PRE-URALS): IMPLEMENTATION OF POLLEN AND NON-POLLEN PALYNOMORPHS

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The Kungur forest-steppe is the most northern outpost of the European forest-steppe zone, the ecotone biome between woodlands and open landscapes stretching from the Carpathians to the Ural Mountains. The Kungur forest-steppe is located in the SE Perm region (Russia) within the zone of the pre-Uralian belt of hemiboreal spruce and fir-spruce forests with intermixed broadleaf trees. Due to the co-existence of boreal, temperate and steppe species, this island is characterized by high plant diversity and represents an important biodiversity hot-spot in the boreal zone. Intensive agriculture, pasture, and lumbering are leading to the loss of this unique steppe ecosystems. For sustainable protection management, a background in vegetation history is a necessary requirement. Several driving factors for the origin of the Kungur forest-steppe were proposed by botanists and geographers: geology, the climate of the past, or humans. However, no palaeoecological studies were implemented in order to understand its history. The project aims to understand the phenomenon of the Kungur forest-steppe in terms of its formation and dynamic within the hemiboreal zone of the pre-Urals. For this, peats and lacustrine sediments from Kungur forest-steppe are being studied in comparison to those from

the typical hemiboreal forests. Studies on pollen and non-pollen palynomorphs (NPP) provide a basis for the reconstruction of vegetation and environmental history of both regions. While pollen is used for reconstructions of the vegetation history, NPP indicate other important processes for the landscape dynamic such as pasture, erosion intensity or eutrophication. Since just few pollen studies and no NPP studies are known from the entire Perm region, in this work I would like to present the first results of the project with a special emphasis on NPP implementation and interpretation.

P164

TESTATE AMOEBAE AS A PROXY FOR RECONSTRUCTION OF PALAEO-HYDROLOGICAL REGIME IN PEATLANDS: A CASE STUDY FROM THE EASTERN-EUROPEAN PLAIN

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Testate amoeba transfer functions are widely used for reconstruction of palaeo-hydrological regime in peatlands. We investigated the effect of water table depth on the species structure of testate amoeba assemblages in peatland ecosystems of European Russia. A transfer function for quantitative palaeo-reconstructions has been developed. This involved the establishment of a training dataset, construction of models, and testing of their performance. The model constructed by weighted averaging regression was adopted as optimal. In order to validate this transfer function we investigated its performance along localised hydrological gradients (in four *Sphagnum*-dominated sites in European Russia), which is a useful analogue for predictive ability through time. The performance of the transfer function with the independent test-set was generally weaker than for the leave-one-out or bootstrap cross-validation. However, the transfer function was robust for the reconstruction of relative changes in water-table depth, provided the presence of good modern analogues and overlap in water-table depth ranges. This transfer function was applied in reconstructions of Holocene climate history in several peatlands of European Russia.

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P165

STAMPS OF POLLEN AS AN ARTISTIC TECHNIQUE FOR PALYNOLOGICAL DIVULGATION

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Microscopic objects have shapes and ornamentations, which are worth showing. Presentation of pollen through pictures and the sharing of copies in handouts is possible. However, in exercise books students need to cut and stick the pictures, which does not always look good. I present stamps as a artistic technique for teaching and spreading pictures of pollen grains in an unlimited number on any smooth material (paper, textile, wood or iron).

Determination of pollen is possible only by combination of characteristic features, which can be seen on the surface, inside exine or in a cross section. So, we usually need several photorgaphs from different optical levels. Drawings can overcame this problem easily, but they take time. Thus I combined both techniques and came up with contrast images as stamp templates.

The design process does not need any special programmes and expensive devices, I used Canon EOS 100D and open source programmes: DigiCamControl, which allows you to connect any reflex camera to the computer, GIMP and its functions: bleach, threshold, brush, cutting pasting ... etc. and Inkscape, which converts the raster image into a vector. Vector image is the required format by companies producing classical stamps. Give a try and make pollen stamps of your study period/area!

The stamps preserve the difference in size of pollen taxa, all of them are magnified ca. 1100 times. I will carry stamps of *Pinus*, *Tilia*, *Alnus* and *Corylus* pollen and two wash-resistant stamp colours (yellow and black). Bring your paper notebooks, clothes or whatever, stamp or get stamped by pollen!

P166

THE MAASTRICHTIAN KAKANAUT FLORA OF THE NORTH-EAST OF RUSSIA

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Numerous fossil plants were found in deposits of the Kakanaut Formation, which is exposed in the Kakanaut River Basin, south-eastern part of the Koryak Upland, in the North-East of Russia. Nonmarine volcanogenic-terrigenous sediments of the Kakanaut Formation consist of tuffs, tuffites and andesibasaltic rocks, tuffaceous sandstones and siltstones (Volobueva, Terekhova, 1974). These deposits were accumulated in coastal lowlands near an active volcano (Volobueva, Krasniy, 1979; Golovneva, Shczepetov, 2010). The age of the Kakanaut Formation was determined as early late Maastrichtian (Golovneva, Shczepetov, 2010).

The Kakanaut floristic assemblage contains more than 50 species, including bryophytes, horsetails, ferns, cycadophytes, ginkgos, conifers and angiosperms. The prevailing groups are conifers and angiosperms. The cycadophytes (Nilssonia, Encephalartopsis) and Ginkgo are abundant in some layers, usually forming monodominant associations. The conifers are represented by the families Cupressaceae and Pinaceae as well as several genera of unknown systematic position. Angiosperms include about 30 species from the following families: Platanaceae (Platanus), Hamamelidaceae (Platimelis), Betulaceae (Craspedodromophyllum), Fagaceae (Fagopsiphyllum) and Rosaceae (Peculnea, Arctoterum), Cercidiphyllaceae (Trochodendroides). The other genera, such as Zizyphoides, Celastrinites, Cissites, Liriophyllum and Kakanautia appear to belong to ancient groups, exhibiting no clear phylogenetic links to modern taxa.

The Kakanaut flora is the richest Maastrichtian palaeoflora of the Arctic area. This flora considerably differs from the Maastrichtian floras of Sakhalin and Canada, at both the generic and specific levels. Noteworthy, that the Early Cretaceous relict elements, such as Pterophyllum, Nilssonia, are encountered in the Kakanaut flora together with representatives of typical Paleogene families Fagaceae, Rosaceae and Betulaceae.

This formation also has a rich dinosaur fauna which includes representatives of seven families (Godefroit et al., 2009). Mean annual temperature in this area according to a CLAMP-analysis was about 10 °C, and mean temperature during cold months was 0 °C - 6 °C. Although climatic conditions in the Kakanaut area were significantly warmer than now, because cold winters are usually considered to be incompatible with existence of large thermophilic reptiles.

The analysis of species composition and plant life-forms allows us to reconstruct certain types of vegetation that may have grown in this coastal lowland. They are: cycadophyte (Nilssonia, Encephalartopsis) shrubby communities; Ginkgo forests; flooded conifer forests with Parataxodium, Glyptostrobus and Mesocyparis; riparian forests with a predominance of Platanus and Trochodendroides; redwood forests with a predominance of Sequoia and an admixture of certain other conifers and angiosperms; fern marsh and water vegetation with Quereuxia angulata.

P167

PALAEOENVIRONMENTAL RECONSTRUCTION OF THE LATE CRETACEOUS IHARKÚT (HUNGARY) DINOSAUR LOCALITY BASED ON ANGIOSPERM MESOFOSSILS

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At the end of the Santonian Age of the Late Cretaceous Epoch, a considerable landmass existed in the area of the Transdanubian Mountain Range (Hungary). A more detailed study of the worldwide known dinosaur locality, Iharkút is important because there are fewer than a dozen Late-Cretaceous localities in Europe where plant remnants are fossilised together with vertebrate remains. Its fauna is already substantially well understood, however, there is only a little knowledge about the vegetation that existed here.

The studied mesofossils that poorly tolerated transport, thus, provide information only about areas close (a few tens – hundred meters) to their habitat. The dominant form in the bone bed is a new Normapolles-related mesofossil genus (Sphaeracostata barbackae). These fruits are small, spherical to ovoid in shape with a ribbed surface. The inner structure is always divided by an endopleura which most likely represents the cotyledon. The second most common form is related to Magnoliaceae. These Padragkutia fossils are closely related to recent Liriodendron. Both groups represent the canopy level. Based on endocarp morphology, Sabia menispermoides was also described from the locality – the recent family Sabiaceae consists of trees, shrubs, and lianas. Hamamelidaceae and Urticaceae seeds are also reported. Angiosperms dominate the macroflora as well. Monocots are represented mainly by Pandanites leaves. The most common leaf fossils found are dicots.

Based on these preliminary results on plant remains, a Normapolles-dominated forest with herbaceous angiosperm- and fern-dominated understory growing in a tropical or subtropical climate can be reconstructed at this locality.

The project has been implemented with the support provided from the National Research, Development and Innovation Fund of Hungary, financed under the PD-124971; FK-125198; K-116665 funding scheme. The studies were financially supported by the MFGI (Geological and Geophysical Institute of Hungary) 11.1 project between 2012 and 2017, later by the MBFSZ (Mining and Geological Survey of Hungary).

P169

PLANT MESOFOSSILS FROM THE CAMPANIAN–MAASTRICHTIAN OF LO HUECO, CUENCA, SPAIN

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Well-preserved megafossils of plants, molluscs (bivalves and gastropods), actinopterygians and teleosteans fishes, amphibians, panpleurodiran (bothremydids) and pancryptodiran turtles, squamate lizards, eusuchian crocodyliforms, rhabdodontid ornithopods, theropods (mainly dromaeosaurids), and titanosaur sauropods have been reported from the Campanian–Maastrichtian locality of Lo Hueco, near the village Fuentes, Cuenca province, Spain (Ortega et al., 2015). This exceptional palaeontological assemblage was deposited in a near-coast continental muddy floodplain influenced intermittently by freshwater, brackish and marine environments as well as desiccation events. Palynology indicated a large dominance of angiosperms (80%, more than 20 taxa) associated with conifers and ferns (Peyrot et al., 2013). A few plant megafossils include Brachyphyllum- and Pagiophyllum-type conifers, rare specimens resembling the freshwater free-floating hydrophyte Limnobiophyllum, a probable inflorescence head, and several types of unidentified seeds (Ortega et al., 2015). We provide for the first time a preliminary description of a diverse plant mesofossil assemblage extracted after washing and sieving of the rock matrix surrounding the animal fossils.

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P170

THE CRETACEOUS FLORA OF WESTPHALIA, GERMANY, REVISITED

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The Münsterland Basin is the largest continuous Cretaceous deposit in Germany, but the marine strata are commonly not very rich in plant fossils. The exceptions are various localities at the basin margins that indicate the Cretaceous coastline. From the north-eastern basin margin, a few fern frond fragments have been reported from Aptian strata, while almost no macrofossil remains are known from coeval deposits of the southern margin. The oldest of the several remains from the southern basin margin is a Geinitzia-bearing specimen from the Cenomanian together with some indeterminable wood fragments. In the Turonian, a quite diverse angiosperm flora developed in Westphalia along the southern margin of the Münsterland Basin, including Laurophyllum, Myrica, Proteoides and Salix together with few Geinitzia and Sequoia fragments, whereas remains reported from the Coniacian include only a few leafy Geinitzia twigs. The angiosperm flora re-flourished in the Santonian, including seven angiosperm genera (Credneria, Debeya (Dewalquea), Proterophyllum, Lauraceae, amongst others) and one gymnosperm, reported from the southern margin of the basin. The highest diversity of the flora was achieved so far in the Campanian. In the Baumberge hills northwest of Münster, Hosius and von der Marck (1880) described a flora containing fern fragments, several gymnosperm taxa and a diverse array of angiosperm taxa assignable to Fagaceae, Lauraceae, Myricaceae, Platanaceae, amongst others, including several sea grasses. Since then, work and interest in the Cretaceous flora from Westphalia ceased, except for a few reports of individual specimens and taxa in local literature. Recent case studies (e.g., Halamski & Kvacek 2013) already have suggested that many of the taxon names are outdated. Thus, thorough identification of the original material is warranted demonstrating the Cretaceous flora of Westphalia being in strong need of a revision. As a consequence, and since the fossil assemblage contains a number of specimens being types, a research project studying the original plant fossil material of the Cretaceous strata of Westphalia has been initiated by the author, involving the examination of the original localities, as far as they are accessible after almost 150 years of dormancy.

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P171

NON-POLLEN PALYNOMORPHS (NPPS) FROM ALDER CARR SURFACE SAMPLES (NE GERMANY)- A TOOL FOR RECONSTRUCTING PAST SITE CONDITIONS –

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Alnus glutinosa woodlands on fens, the so called Alder carrs, occur widespread across Europe. Alder carrs occupy sites with base rich, moving groundwater and a stable water table. They are considered an azonal terminal vegetation type.

Alder cultivation for timber or biofuel is an option for responsible use of peatlands (paludiculture) that preserves the peat and reduces greenhouse gas emissions. The question remains, however, which water level is ideal to guaranty high yields on the one side is and peat preservation or even sequestration on the other side. We have shown earlier that long term accumulation rates (LORCAs) in Alder carrs range from 40 to 130 g m^{-2} yr^{-1}.

To find out, whether different LORCAs are related to specific site conditions, we use a palaeoecological approach. Analysis of pollen and macrofossils alone does not allow to reconstruct past site conditions because these remnants are often poorly preserved or do not differentiate Alder carrs in different site conditions. NPPs provide valuable additional information for better understanding of the palaeo-record.

To increase the number and spectrum of interpretable NPPs, we studied NPP assemblages in surface samples from a range of Alder carrs growing under different site conditions. At each site, samples from different micro-sites were collected and a range of site parameters was measured. In result, more than a 100 NPP types were newly described mainly fungal spores and remnants of corroded wood. While a number of NPPs allowed distinguishing open and forest phases in Alder wood peat, the newest NPP types additionally allow distinguishing Alder carr types that grow in different site conditions.

This improved tool set allows refined analysis of peat sequences, i.e. enables to link LORCAs with different Alder carr types that represent different site conditions. These results help to identify best site conditions for responsible Alder cultivation on peatlands.

P172

RECONSTRUCTION OF ATMOSPHERIC CO_2 CONCENTRATION DURING THE LATE CHANGHSINGIAN BASED ON FOSSIL CONIFERS FROM THE DALONG FORMATION IN SOUTH CHINA

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A single species of fossil conifer with well-preserved cuticles from multiple layers of the Dalong Formation in two sections in Duanshan Town, Guizhou Province, Southwestern China has been used to reconstruct palaeo-atmospheric pCO_2. The age of these layers can be dated back to the late Changhsingian (latest Permian), corresponding to the *Clarkina changxingensis* and *Clarkina yini* conodont zones. Two calibration approaches were employed in this study. Using the stomatal ratio method, the pCO_2 curves of the two sections showed similar trends, with levels decreasing in the middle of the profile, and similar ranges at ca. 340-510 ppm and ca. 300-440 ppm. Similar values (ca. 360-520 ppm), yet with wider error ranges, were obtained when the mechanistic model proposed by Franks et al. in 2014 was applied to one of the sections. Our results are lower than the mean pCO_2 values from coeval palaeosols, but will partly overlap with them when taking error ranges into consideration. More independent works are needed to evaluate the discrepancies between the two proxy methods. The low atmospheric CO_2 concentrations in this study suggest a cool climate rather than glaciation for the brief period of the late Changhsingian, which is supported by the oxygen isotope record of conodont apatite and a major restructuring of Late Permian flora and fauna.

KEYWORDS: Carbon dioxide; Cuticles; Stomatal proxy; Mechanistic gas exchange model; Latest Permian; Climatic change

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AUTHOR INDEX