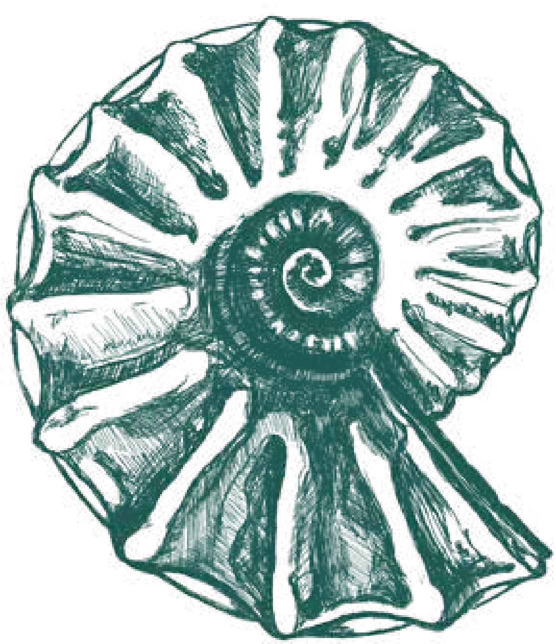

11TH INTERNATIONAL

CRETACEOUS SYMPOSIUM

Warsaw, Poland, 2022

Abstract Volume

John W.M. Jagt and Elena Jagt-Yazykova,
Ireneusz Walaszczyk and Anna Żylińska

Warsaw, 2022

11th International Cretaceous Symposium

Warsaw, Poland, 2022

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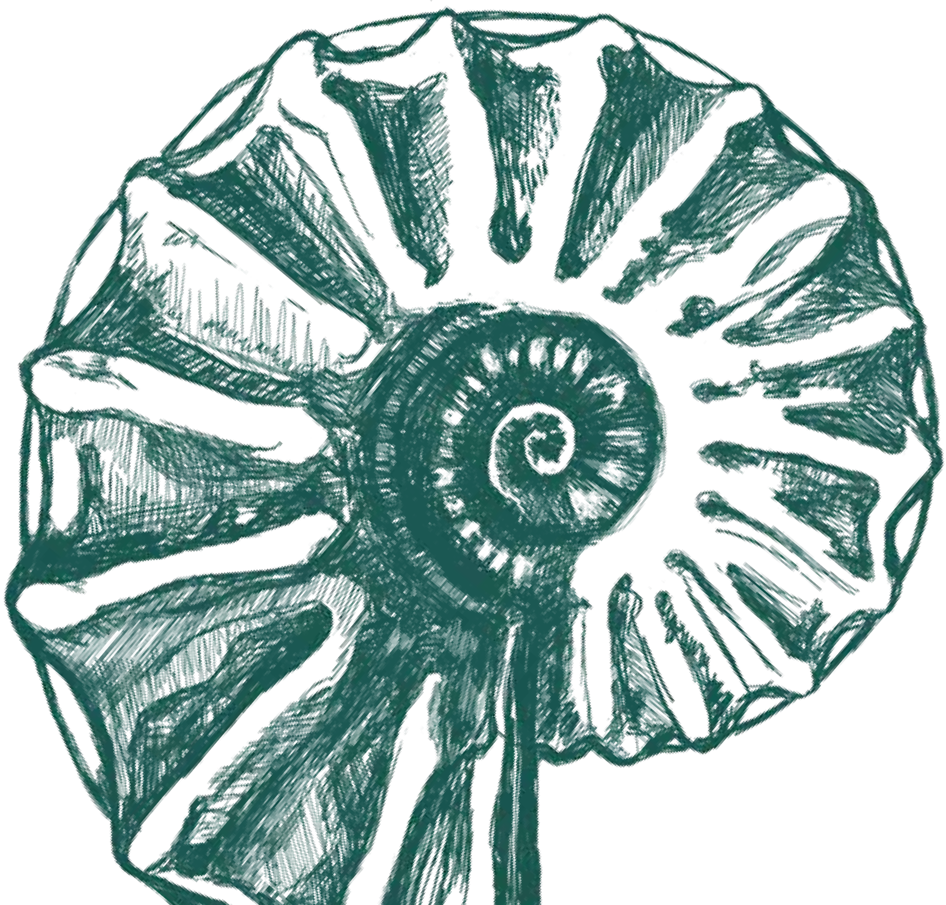


INTRODUCTION

11th International Cretaceous Symposium

Warsaw, 22-26 August 2022

We cordially welcome you to the 11th International Cretaceous Symposium, which is held in the historical buildings of the University of Warsaw, in the center of Warsaw.

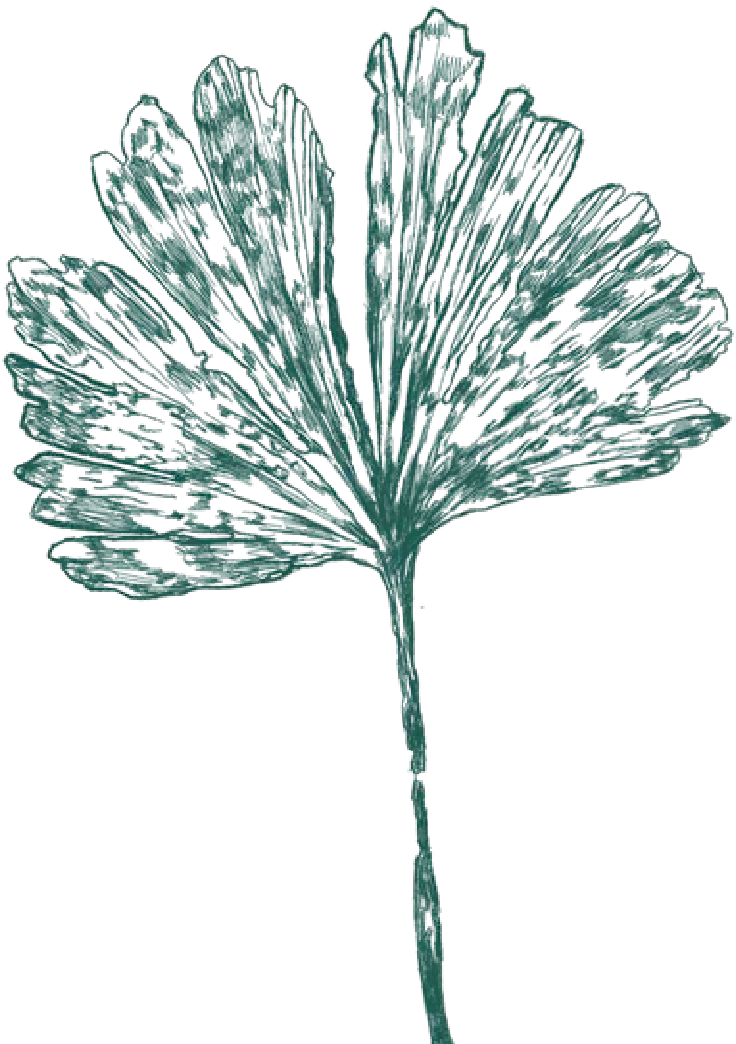
About 170 scientists from across the world registered for this Symposium, with a diverse program of oral and poster presentations, formal and informal meetings, and workshops. A range of field excursions through Poland is offered, and we hope that you will enjoy the variable aspects of the Cretaceous System exposed in the Polish Uplands, Sudetes Mountains, and Carpathians.

During the Opening Ceremony, we will celebrate the scientific life of William James Kennedy, our colleague, friend, teacher, and an enormous figure in studies of Cretaceous ammonites.

The 11th International Cretaceous Symposium was originally planned to occur in 2021, as decided during the final session of the 2017 Vienna Symposium. Due to the COVID-19 pandemic, it was postponed to 2022. The ongoing war in Ukraine has contributed further difficulties, and in light of these crises we are even more happy to see so many of you, both in-person and remotely.

This Symposium would have not been possible without the financial and logistic help of the University of Warsaw. We would like to express our warmest thanks to the Rector and, additionally, several other people from the University (in particular, from the Faculty of Geology of the University of Warsaw) for constant support and assistance.

The warmest thanks go the Ministry of Science and Education for financial support through a project financed in the frame of the program 'Doskonała Nauka" for the year 2022.



Our cordial thanks also go to the authorities of the co-organizing institutions for their help and financial support: these include the Polish Geological Institute, Institute of Palaeobiology of the Polish Academy of Sciences, Institute of Geological Sciences of the Polish Academy of Sciences, Jagiellonian University in Krakow, AGH Mining Academy in Krakow, University of Opole, and University of Wrocław.

The symposium benefited greatly from the help of various people and organisations. We particularly would like to thank Maria Rose Petrizzo, Università degli Studi di Milano, who was always ready to join us throughout the organizational process; William James Kennedy, who prepared a series of posters on the giants of Cretaceous geology to celebrate the 200th Anniversary of the Cretaceous System; Agnieszka Bul, Magdalena Bieniawska, and Sylwia Niedźwiedzka from the Financial Department of the Faculty of Geology of the University of Warsaw, for financial advice and supervision; Aleksandra Szmielew and Łucja Stachurska, for their careful work editing the Field Trip Guide and Abstract Volumes; our printer, Mieczyslaw Pohl of Gimpo-Print, Warsaw, who endured constantly shifting deadlines; and our students Oliwia Czarnecka, Katarzyna Grygorczyk, Agnieszka Pałczyńska, Bartlomiej Szefner, Dorota Szwoch, and Jakub Zalewski, for joining us in the organization of the event. During the organization of the field trips, a number of regional institutions and authorities offered their help and support. We are particularly grateful to Hieronim Zonik, the mayor of Siedliszcze, Piotr Kondraciuk, head of the Nadwiślańskie Museum at Kazimierz Dolny, Joanna Szkuat, head of the Natural History Museum (a branch of the Nadwiślańskie Museum), and Magdalena Wójcik, the head of the Mełgiew commune, for their help and assistance during preparations for the K-Pg excursion.

We wish you all a fruitful and exciting event and, once again, thank you for joining us for what promises to be a fruitful week of scientific discussion and inquiry.

With kind regards, on behalf of the organizers

Ireneusz Walaszczyk, Jacek Grabowski, Agata Jurkowska, Piotr Krzywiec, Marcin Machalski, Zbigniew Remin, Jordan P. Todes, Alfred Uchman and Jurand Wojewoda

COMMITTEES

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COMMITTEES

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- **The University of Warsaw New Library**
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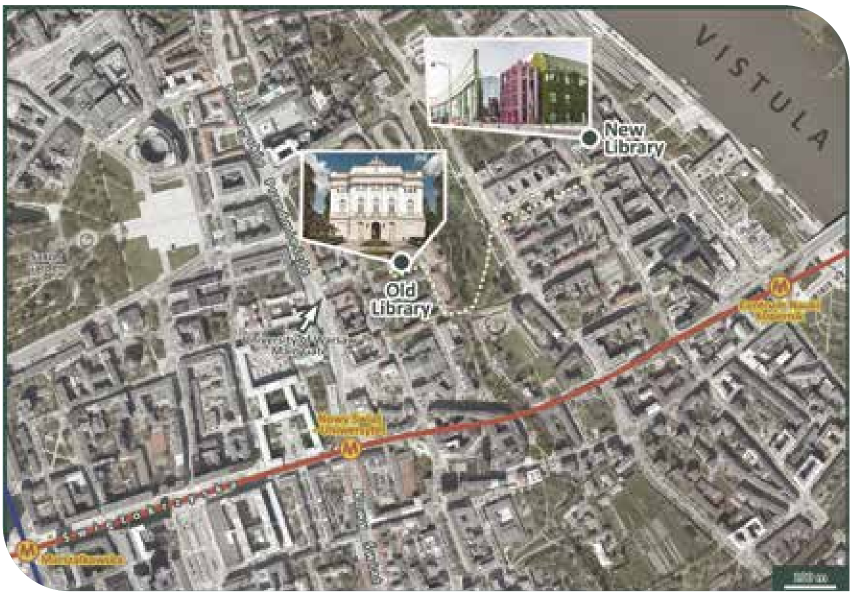

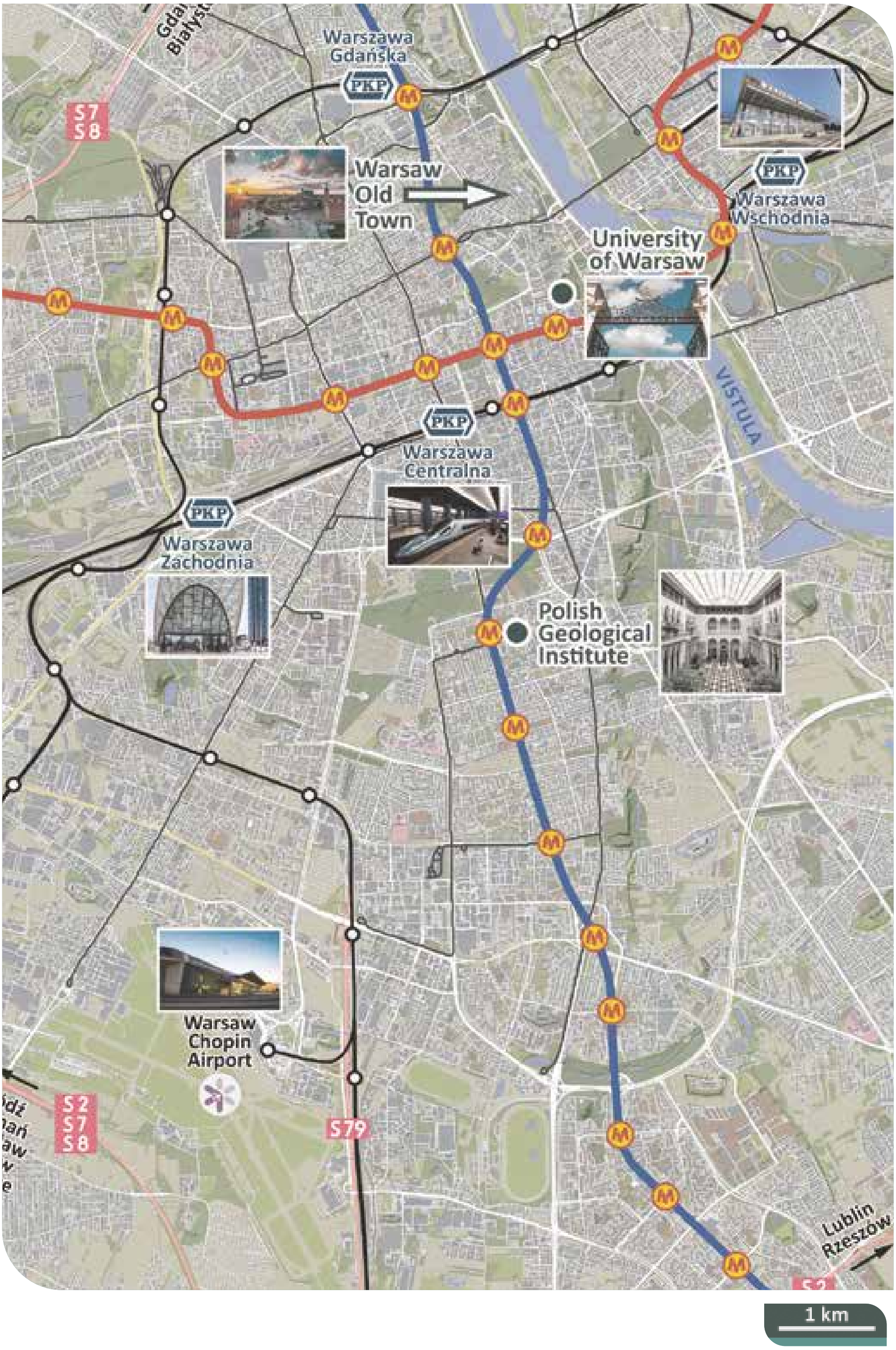

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S7 S8
S2 S7 S8
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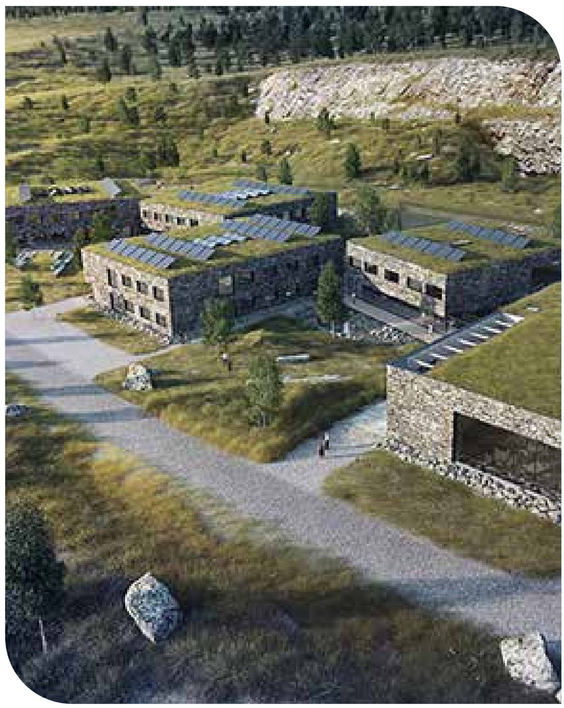
VENUE



The University of Warsaw, Old Library

ul. Krakowskie Przedmieście 26/28, 00-927 Warszawa

This is an iconic building of the University of Warsaw: initially built in 1894, at the beginning of the 21st century it was fully renovated into a modern lecture and conference centre. [During World War II, Czesław Miłosz, the 1980 Nobel laureate in Literature, worked here as a janitor.] We will meet here for the Opening Ceremony.

The majority of the symposium will be hosted here.

The University of Warsaw, New Library

Dobra 56/66, 00-312 Warszawa, Polska

The new University of Warsaw Library is a building of surprising diversity, fusing the functionality of a modern library with the atmosphere of an old town.

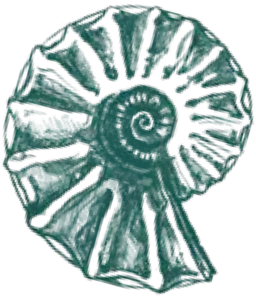
The interior of the building is stunning, centered around a three-story monumental 'Passage' leading to the library itself, and open spaces connecting reading halls, resting places, and the books themselves.

The roof of the library hosts one of the largest, most beautiful rooftop gardens in Europe, and is an attractive resting place for students and tourists alike. From the roof, visitors can admire both the Varsovian skyline and the Vistula River.

EuropeanCenter for Geological Education in Chęciny (ECEG)

ECEG is the University of Warsaw's geologic field center, built within an abandoned Devonian dolomite quarry in the medieval town of Chęciny, in the heart of the Gòry Świętokrzyskie (the Holy Cross Mountains). With state-of-the-art geological laboratories, lecture rooms, hotel accommodations, and all of the other facilities that may be useful for comfortable field work, it is a perfect place to carry out student field camps and geologic research.

SCIENTIFIC SESSIONS



As listed below, the scientific sessions of the Symposium encompass a broad variety of topics linked to the Cretaceous, including – but not limited to – the history of the Cretaceous System, palaeontology and palaeobiology, palaeobiogeography, palaeoenvironments, stratigraphy, geophysics and geodynamics, regional geology, and mineral resources.

S1

200th Anniversary of the Cretaceous System

Maria Rose Petrizzo,
Irenuesz Walaszczyk

S2

Global Boundary Stratotype Sections and Points (GSSPs) of the Cretaceous System

Maria Rose Petrizzo

S3

Cretaceous geochemistry and global change: open session

Jordan Todes
Silke Voigt

S4

Cretaceous chemostratigraphy

Jordan Todes
Silke Voigt

S5

Cretaceous geochronology, timescales, astrochronology and cyclostratigraphy

Andy Gale
Brad Singer

S6

Cretaceous invertebrate palaeontology: open session

Martin Košťák
Frank Wiese

S7

Cephalopod palaeobiology and stratigraphy

Marcin Machalski
Markus Wilmsen

S8

Lower Cretaceous ammonites (Kilian Group meeting)

Ottilia Szives

S9

Cretaceous vertebrates: open session

Ashu Khosla

S10

Cretaceous micropalaeontology

Bruno Granier
Danuta Peryt

S11

Cretaceous palynology

Mariusz Niechwedowicz

S12

Palaeobotany and terrestrial palaeoenvironments

Adam Halamski

S13

Cretaceous Fossil–Lagerstätten

Marcin Machalski
Markus Wilmsen

S14

Cretaceous–Paleogene boundary and events

John Jagt
Marcin Machalski

S15

In memory of Professor Lamolda: Biostratigraphy and environmental change in the Cretaceous

Mihaela Melinte
Florentin Maurrasse

S16

Cretaceous palaeoenvironment, palaeoclimate and palaeoceanography

Brian Huber
Maria Rose Petrizzo

S17

Cretaceous marine and non–marine plankton

Jakub Witkowski

S18

Cretaceous tectonics and syn–tectonic sedimentation

Piotr Krzywiec
Zbyszek Remin

S19

Cretaceous regional geology:

Piotr Krzywiec
Zbyszek Remin

S20

Geodynamics of the Cretaceous basins and sedimentary record

Jurand Wojewoda

S21

Cretaceous Geoparks and World Heritage

Ireneusz Walaszczyk

Sunday 21st of August

11:00–13:00 [S8] Lower Cretaceous ammonites (Kilian Group meeting) [University Old Library, Room 106]
Josep Anton Moreno-Bedmar* and Ricardo Barragán – *Aptian ammonite biozonation for the Central Atlantic Province*
Ottilia Szives* and István Főzy – *Towards an ammonite zonation for the Jurassic/Cretaceous transition: new data from the Ammonitico Rosso/Biancone sections in the Transdanubian Range (Hungary)*
Ottilia Szives*, Jean-Louis Latil, Josep Anton Moreno-Bedmar, Jens Lehmann, Emmanuel Robert and Hugh G. Owen – *Critical revision of Aptian–Albian zones in the standard Mediterranean ammonite zonal scheme: new proposals and correlation possibilities*

15:00–20:00 REGISTRATION [University Old Library entrance hall]

Monday 22nd of August

7:00–9:30 REGISTRATION [University Old Library entrance hall]

9:30–10:40 OPENING SESSION [University Old Library Auditorium]

9:30–9:45 Welcoming speech and introductory remarks
9:45–10:10 Andrew S. Gale – *The 200-year history of the Cretaceous – 1822–2022*
10:10–10:40 Malcom Hart – *200 Years of the Cretaceous System: A personal viewpoint* **[online]**

10:40–11:20 COFFEE BREAK AND POSTERS

11:20–12:00 RECOGNITION CEREMONY FOR WILLIAM JAMES 'JIM' KENNEDY [University Old Library Auditorium]

12:00–12:40 PARALLEL SESSIONS

Auditorium	**Room 116**
S16 Cretaceous palaeoenvironment, palaeoclimate and palaeoceanography Chairpersons: Brian Huber and Maria Rose Petrizzo	**S7 Cephalopod palaeobiology and stratigraphy** Chairpersons: Marcin Machalski and Markus Wilmsen
	12:00–12:20 Marcin Machalski* – *Growth pattern and mode of life of the Maastrichtian scaphitid* Hoploscaphites constrictus*: potential lessons for ammonoid palaeobiology*

12:00–12:40 Brian T. Huber*, Kenneth G. MacLeod, Maria Rose Petrizzo and David Watkins – *Albian–Cenomanian prelude to the hot Cretaceous greenhouse climate at southern high latitudes*	12:20–12:40 Ottilia Szives*, Jean-Louis Latil, Josep Anton Moreno-Bedmar, Jens Lehmann, Emmanuel Robert and Hugh G. Owen – *Critical revision of Aptian–Albian zones in the standard Mediterranean ammonite zonal scheme: new proposals and correlation possibilities*

12:40–14:00 LUNCH

14:00–15:40 PARALLEL SESSIONS

Auditorium	Room 116
S16 Cretaceous palaeoenvironment, palaeoclimate and palaeoceanography Chairpersons: Brian Huber and Maria Rose Petrizzo	**S7 Cephalopod palaeobiology and stratigraphy** Chairpersons: Marcin Machalski and Markus Wilmsen
14:00–14:20 Takashi Hasegawa*, Akiko S. Goto, Hiromichi Komiya, Yusuke Takagi, Toshiyuki Matsuta and Tsukiko Takahashi – *Mid-Cretaceous climatic perturbation in the southern high latitude ocean: drastic warming and cooling across the OAEs and the mid-Cenomanian event*	14:00–14:20 Stijn Goolaerts* and Bernard Mottequin – *A digital cephalopod world: micro-CT imaging in the study of Cretaceous Cephalopoda*
14:20–14:40 Maria Rose Petrizzo*, Kenneth G. MacLeod, David K. Watkins, Erik Wolfgring and Brian T. Huber – *Late Cretaceous palaeoceanographical changes and onset of Santonian cooling revealed by planktic foraminifera and stable isotopes at southern high latitudes*	14:20–14:40 Christina Ifrim*, Wolfgang Stinnesbeck, Arturo H. González González, Nils Schorndorf and Andrew S. Gale – *The world's largest ammonite,* Parapuzosia (P.) seppenradensis*: its ontogeny, evolution and palaeogeographical distribution*
14:40–15:00 Erik Wolfgring*, Maria Rose Petrizzo, Kenneth G. MacLeod, Brian T. Huber and David K. Watkins – *Changes in benthic foraminiferal assemblages during the onset of Late Cretaceous cooling in the Santonian, IODP site U1513 (Indian Ocean)*	14:40–15:00 Izabela Ploch*, Marcin Barski, Stan Duxbury and Jim Fenton – *Palaeoenvironmental and palaeogeographic implications of the Valanginian in the Polish Basin based on ammonites and dinoflagellate cysts*
15:00–15:20 Agata Jurkowska* and Ewa Świerczewska-Gładysz – *Upper Cretaceous opoka as a record of the silica cycle in the epicontinental European Basin*	15:00–15:20 Mikel A. López-Horgue* and Hugh G. Owen – *Mortoniceratinae (Cretaceous Ammonitina) from the Basque-Cantabrian basin (BCB, Western Pyrenees): a key to understanding Upper Albian biostratigraphy*
15:20–15:40 Ana Fociro* and Afat Serjani – *Upper Cretaceous phosphorites of the Ionian Zone (Albania) as part of the Mediterranean (Tethyan) phosphogenic province* **[online]**	15:20–15:40 Neil H. Landman*, Matthew P. Garb, Corinne E. Myers, James D. Witts, Nicolas Thibault, Jone Naujokaityte, Kirk J. Cochran, Ekateryna Larina, Remy Rovelli, Kayla Irizarry, Natalie Dastas, Chris Lowery, Ana Raskova, George Phillips and Robert DePalma – *Ammonites at Cretaceous–Paleogene sections in North America* **[online]**

15:40–16:00 COFFEE BREAK AND POSTERS

16:00–17:20 PARALLEL SESSIONS

Auditorium	Room 116
S16 Cretaceous palaeoenvironment, palaeoclimate and palaeoceanography Chairpersons: Brian Huber and Maria Rose Petrizzo	**S7 Cephalopod palaeobiology and stratigraphy** Chairpersons: Marcin Machalski and Markus Wilmsen
16:00–16:20 Francesca Falzoni* and Maria Rose Petrizzo – *Evidence for changes in sea-surface circulation patterns and ~20° equatorward expansion of the Boreal bioprovince during a cold snap of Oceanic Anoxic Event 2 (Late Cretaceous)*	16:00–16:20 Martin Košťák*, Frank Wiese, Zuzana Kozlová, Martin Souček and Adam Culka – *A specimen of* Prionocyclus germari *(Reuss, 1845) from the Upper Turonian of the Bohemian Cretaceous Basin (Czech Republic) with jaws preserved*
16:20–16:40 Alfred Uchman* and Francisco J. Rodríguez-Tovar – Ichnological aspects of some Late Cretaceous events	16:20–16:40 Ondřej Kohout*, Martin Košťák and Frank Wiese – *A possibly new and endemic ammonite species from the Lower Turonian of the Bohemian Cretaceous Basin (Czech Republic)*
16:40–17:00 Bodil W. Lauridsen*, Emma Sheldon, Stefanie Lode, Kresten Anderskouv and Jon Ineson – *A new view of the Munk Marl Bed – palaeoecological study of a condensed section (Upper Hauterivian to Lower Barremian) in the Danish Central Graben*	16:40–17:00 Luciana S. Marin, Verónica V. Vennari, Marina A. Lescano and Beatriz Aguirre-Urreta* – *First record of* Bochianites neocomiensis *(Ammonoidea) from Argentina and associated calcareous nannofossil bioevents: strengthening the Early Valanginian correlation of the Andes with the Mediterranean Tethys*
17:00–17:20 Uroš Barudžija – *Upper Albian carbonate facies and diagenesis in the Western Istrian Anticline (WIA), Croatia* **[online]**	17:00–17:20 Zbyszek Remin – *Tracking abnormalities in the cephalopod fossil record: on the origin of the Late Cretaceous belemnite* Fusiteuthis polonica *and its relationship with other diversified cephalopods*

FROM 18:30 ICE-BREAKER PARTY [GARDENS of the UNIVERSITY NEW LIBRARY]

Tuesday 23rd of August

9:00–10:40 PARALLEL SESSIONS

Auditorium	Room 116
S16 Cretaceous palaeoenvironment, palaeoclimate and palaeoceanography Chairpersons: Brian Huber and Maria Rose Petrizzo	**S9 Cretaceous vertebrates** Chairperson: Ashu Khosla
9:00–9:20 Kenneth G. MacLeod*, Louie Lovelace, Matthew M. Jones, Erik Wolfgring, Sierra V. Petersen, Brian T. Huber and Maria Rose Petrizzo – *An estuarine explanation for consistently low oxygen isotopic values in inoceramid bivalves at IODP site U1512 (Great Australian Bight)*	9:00–9:20 Ashu Khosla – *Cretaceous dinosaurs from India and their palaeobiogeographical implications*
9:20–9:40 Wolf Dummann*, Peter Hofmann, Jens Olaf Herrle, Martin Frank and Thomas Wagner – *Cretaceous peak warming caused by the early opening of the Equatorial Atlantic Gateway*	9:20–9:40 Jongyun Jung* and Min Huh – *The pterosaur track assemblage in the Hwasun Seoyuri tracksite of Korea: diversity of pterosaurian ichnofossils of the Korean Peninsula*

9:40–10:00 Barbora Krizova*, Lorenzo Consorti, Giorgio Tunis, Lorenzo Bonini, Marco Franceschi, Sahara Cardelli and Gianluca Frijia – *High-resolution palaeotemperature reconstructions for Cenomanian–Coniacian shallow–water carbonates of the Friuli carbonate platform*	9:40–10:00 Nicholas R. Longrich – *Oceanic dispersal of Cretaceous dinosaurs and Paleogene mammals*
10:00–10:20 Damian Gerard Lodowski*, Jacek Grabowski, Stéphane Reboulet, Mathieu Martinez, Emanuela Mattioli, Andrzej Chmielewski and Jolanta Iwańczuk – *Late Berriasian–Early Valanginian palaeoenvironment in the Vergol section (Vocontian Basin, south-east France): evidence from magnetic susceptibility, portable XRF and gamma-ray spectroscopy*	10:00–10:20 Justyna Słowiak-Morkovina*, Tomasz Szczygielski, Michał Surowski and Krzysztof Owocki – *How does the bone microstructure of* Tarbosaurus bataar *compare to that of* Tyrannosaurus rex *(Theropoda, Tyrannosauridae)?*
10:20–10:40 Felipe Gil-Bernal*, Juan Josué Enciso-Cárdenas, Fernando Núñez-Useche, Genaro de la Rosa Rodríguez and Julián I. Mesa-Rojas – *The Eagle Ford Formation in north-east Mexico: facies and gamma-ray correlation* **[online]**	10:20–10:40 Nicholas R. Longrich*, Nour-Eddine Jalil, Fatima Khaldoune, Oussama Khadiri Yazami, Xabier Pereda-Suberbiola and Nathalie Bardet – *A giant carnivorous mosasaurid (Squamata) from the Upper Maastrichtian phosphates of Morocco*

10:40–11:20 COFFEE BREAK AND POSTERS

11:20–12:40 PARALLEL SESSIONS

Auditorium	**Room 116**
S16 Cretaceous palaeoenvironment, palaeoclimate and palaeoceanography Chairpersons: Brian Huber and Maria Rose Petrizzo	**S9 Cretaceous vertebrates** Chairperson: Ashu Khosla
11:20–11:40 Ulrich Heimhofer*, Hitoshi Hasegawa, Niiden Ichinnorov, Sascha Flögel, Sebastian Steinig, Laura Zieger and Ralf Littke – *Early Cretaceous lignites from inner-continental Asia as a palaeoclimate archive*	11:20–11:40 Rute Coimbra*, Miguel Moreno-Azanza, José Manuel Gasca and Adrian Immenhauser – *Geochemical signature of Cretaceous dinosaur eggshells: fingerprints of time and/or place?* **[online]**
11:40–12:00 Weronika Wierny*, Maciej Bojanowski, Nicolas Thibault and Zofia Dubicka – *Foraminiferal record of the Mid-Maastrichtian Event (MME)*	**S21 Cretaceous Geoparks and World Heritage** Chairperson: Ireneusz Walaszczyk 11:40–12:00 Min Huh*, Yeon Woo, Jongyun Jung, Seongbong Seo, Hyemin Jo and Minguk Kim – *The Mudeungsan UNESCO Global Geopark in the Republic of Korea: academic values*
12:00–12:20 Jakub Kotowski*, Danuta Olszewska-Nejbert, Krzysztof Nejbert and Marnie Forster – *The provenance of Albian arenites in Southern Poland: CHIME geochronology of detrital monazites and muscovite* $^{40}Ar/^{39}Ar$ *dating*	**S5 Cretaceous geochronology, timescales, astrochronology and cyclostratigraphy** Chairpersons: Andy Gale and Brad Singer 12:00–12:20 Brad S. Singer*, Youjuan Li, Mark D. Schmitz, Brad B. Sageman, Katarina Savatik, David Selby, Reishi Takashima and Brian R. Jicha – *Foundation for the next generation of palaeoceanographical and biogeochemical studies: developing a new Lower Cretaceous time scale*

12:20–12:40 İsmail Ömer Yılmaz*, Oğuz Mülayim, Bilal Sarı, Kemal Taslı, Sacit Özer and İzzet Hoşgör – *Evolution of the Arabian carbonate platform (Aptian–Campanian) in south-east Turkey: responses to palaeoclimate, tectonics and palaeoceanographical changes*	

12:40–14:00 LUNCH

14:00–15:40 PARALLEL SESSIONS

Auditorium	**Room 116**
S16 Cretaceous palaeoenvironment, palaeoclimate and palaeoceanography Chairpersons: Brian Huber and Maria Rose Petrizzo	**S5 Cretaceous geochronology, timescales, astrochronology and cyclostratigraphy** Chairpersons: Andy Gale and Brad Singer
14:00–14:20 Giulia Amaglio*, Maria Rose Petrizzo, Wolfgang Kuhnt and Ann Holbourn – *Benthic foraminiferal assemblages and palaeoenvironments across the Cenomanian–Turonian boundary interval and the OAE 2 at Clot Chevalier (Vocontian Basin, south-east France)*	14:00–14:20 Jiří Laurin*, David Uličný, Dave Waltham, Petr Toman, Michael Warsitzka, Bradley B. Sageman and Petr Kolář – *Response of sea level change to orbital eccentricity in a greenhouse climate*
14:20–14:40 Lucie Kunstmüllerová* and Martin Košťák – *Changes in bivalve assemblages at the onset of the OAE 2 event in the Bohemian Cretaceous Basin (Czech Republic): palaeoecological implications*	14:20–14:40 Mathieu Martinez*, Beatriz Aguirre-Urreta, Guillaume Dera, Marina Lescano, Julieta Omarini, Maisa Tunik, Luis O'Dogherty, Roque Aguado, Miguel Company and Stéphane Bodin – *Synchronising the timing of carbon cycle, volcanism and pacing of the Earth's orbit during the Early Cretaceous*
14:40–15:00 Sahara Cardelli*, Barbora Krizova, Lorenzo Consorti, Renato Posenato, Michele Morsilli, Giuseppe Cruciani, Adatte Thierry, Brahimsamba Brahim, Amerigo Corradetti and Gianluca Frijia – *The sedimentary and geochemical record of the Oceanic Anoxic Event 2 in the shallow water carbonates of the Friuli Region (NE Italy)*	14:40–15:00 Fatima-Zahra Ait-Itto*, Mathieu Martinez, Danny Boué, Jean-François Deconinck and Stéphane Bodin – *Astrochronology of the Aptian–Albian transition: a case study from the Vocontian Basin, France*
15:00–15:20 Andy Davies, David C. Ray, Mike Simmons*, Benjamin Greselle, Frans S.P. van Buchem and Graham Baines – *The magnitude and cause of short-term eustatic Cretaceous sea level change*	15:00–15:20 Agata Kuźma*, Krzysztof Ninard, Łukasz Weryński, Agata Biała, Julia Dziewońska and Julia Krzyżowska – *Late Campanian sea level fall and orbital cycles recorded from the Piotrawin site (Middle Vistula River section, Poland)*
15:20–15:40 Michał Cyglicki* and Zbyszek Remin – *Hydrodynamics of a depositional environment derived from the rutile-to-tourmaline ratio (RuTi) – a case study from the Campanian Szozdy delta system, south-east Poland*	15:20–15:40 Nicolas Randazzo*, Tuoyu Wu, Janok Bhattacharya, Monica Walecki, Katrina Fries, Rachel Nelson, Sang-Tae Kim, Brian Jicha and Bradley Singer – *Plausibility of Milankovitch cycles in an ultra-greenhouse world: stratigraphic correlation and sea level reconstruction of the Turonian Western Interior Seaway using tephrochronology and biostratigraphy* **[online]**

15:40–16:00 COFFEE BREAK AND POSTERS

16:00–19:00 PARALLEL SESSIONS/BUSINESS MEETINGS/WORKSHOP

Auditorium	Room 116	
S16 Cretaceous palaeoenvironment, palaeoclimate and palaeoceanography Chairpersons: Brian Huber and Maria Rose Petrizzo	**S20 Geodynamics of the Cretaceous basins and sedimentary record** Chairperson: Jurand Wojewoda	**16:00 – 19:00 INOCERAMID WORKSHOP**
16:00–16:20 Jean-François Deconinck*, Francis Amédro, Serge Ferry, Ludovic Bruneau, Emilia Huret, Ivan Jovovic, Philippe Landrein and Anne Lise Santoni – *Stratigraphical revision and palaeoenvironments of the Lower Cretaceous in the south-east of the Paris Basin (France)*	16:00–16:20 Mikel A. López-Horgue*, Arantxa Bodego, Eneko Iriarte, Irantzu Álvarez, Victor H. Pinto and Gianreto Manatschal – *Hydrothermal systems in hyperextended rift basins: insights gained from the mid-Cretaceous Basque-Cantabrian Basin (Western Pyrenees, Spain)*	
16:20–16:40 Vanessa Schlidt*, Hans-Michael Seitz, Ulrich Heimhofer, Stefan Huck and Silke Voigt – *First record of rudist-derived lithium isotope data across Oceanic Anoxic Event 1a*	16:20–16:40 Jan Woyda*, Anna Waśkowska and Zbyszek Remin – *The time of relocation of exotic rocks into flysch deposits of the Skole Nappe in the area of Przemyśl, Polish Outer Carpathians*	
16:40–17:00 Andrzej Szydło*, Tomasz Malata and Piotr Nescieruk – *Responses of foraminifera to environmental crises during the Cretaceous in the Northern Tethys (Polish Outer Carpathians)*	16:40–17:00 El Hassane Chellai* and Mohamed Aquit – *Evidence from XRF scanner-derived elemental records and bulk carbonate stable isotopes: example of the depositional and sea level history of the Tarfaya Atlantic coastal basin, south-west Morocco*	
17:00–17:20 Gianluca Frijia*, J. Fietzke, E. Anagnostou, V. Testa, S. Morelli, M. Parente and L. Lusvarghi – *Interrogating potential short lived episodes of ocean acidification during Oceanic Anoxic Event 2*	17:00–17:20 Zbyszek Remin*, Michał Cyglicki and Mariusz Niechwedowicz – *The development of the Szozdy deltaic system – the effect of active Late Cretaceous inversion tectonics of the axial part of the Polish Basin: Roztocze Hills, south-east Poland*	
17:20–17:40 Sandra J. Huber*, Jorit F. Kniest, H.-Michael Seitz, Jacek Raddatz, Horst R. Marschall and Silke Voigt – *A lithium isotope curve based on Upper Campanian–Maastrichtian boreal chalk: evidence of a strong connection between weathering intensity, deep-sea temperature and sea level fall across the Campanian–Maastrichtian Boundary Event*	17:20–17:40 Amruta Paranjape*, Anand Kale and Kantimati Kulkarni – *Sequence stratigraphy of Upper Aptian–?Middle Turonian sediments in the Cauvery Basin, Ariyalur area (Tamil Nadu, India)* **[online]**	
17:40–18:00 Adam Wierzbicki*, Erik Wolfgring, Michael Wagreich, Mariusz Kędzierski and Regina Mertz-Kraus – *Astronomically controlled deep-sea life in the Late Cretaceous reconstructed from an ultra-high-resolution bivalve shell archive*	**17:40–19:00 MEETING OF THE VALANGINIAN WORKING GROUP** Room 116	
18:20–19:00 MEETING OF THE SKS Room 106		

Wednesday 24th of August

9:00–10:00 MARIA ROSE PETRIZZO – PLENARY TALK [University Old Library Auditorium]

10:00–10:40 PARALLEL SESSIONS

Auditorium	**Room 116**
S2 GSSPs Chairperson: Maria Rose Petrizzo	**S15 In memory of Professor Lamolda** Chairpersons: Mihaela Melinte-Dobrinescu and Florentin J-M.R. Maurrasse
10:00–10:20 Jacek Grabowski*, Beatriz Aguirre-Urreta, Jean-Francois Deconinck, Elisabetta Erba, Camille Frau, Gang Li, Mathieu Martinez, Atsushi Matsuoka, Jozef Michalík, Joerg Mutterlose, Gregory Price, Daniela Reháková, Mark D. Schmitz, Peter Schnabl, Ottilia Szives and Andrzej Wierzbowski – *Recent progress in defining the Tithonian/Berriasian and Jurassic/Cretaceous boundaries*	10:00–10:20 Mihaela Melinte-Dobrinescu*, Xi Chen, Relu-Dumitru Roban, Dragoş Mitrică, Vlad Apotrosoaei and Eliza Anton – *Biotic and palaeoenvironmental changes in the Albian–Cenomanian boundary interval of the Tethys Ocean*
10:20–10:40 Beatriz Ponce and Christian Salazar* – *Palaeontology and biostratigraphy of bivalves and gastropods from the LO VALDÉS Formation (Tithonian–Hauterivian) in central Chile*	10:20–10:40 Florentin J-M.R. Maurrasse*, Yosmel Sanchez-Hernandez, Jose Llaguno and Carlos Herdocia – *Chemostratigraphical characterization of the Barremian–Aptian boundary: a proposed chronology based on C-isotope stratigraphy*

10:40–11:20 COFFEE BREAK AND POSTERS

11:20–12:40 PARALLEL SESSIONS

Auditorium	**Room 116**
S2 GSSPs Chairperson: Maria Rose Petrizzo	**S15 In memory of Professor Lamolda** Chairpersons: Mihaela Melinte-Dobrinescu and Florentin J-M.R. Maurrasse
11:20–11:40 Petr Schnabl*, William A.P. Wimbledon, Camille Frau, Luc Bulot, Daniela Reháková, Andrea Svobodová, Kristýna Čížková, Šimon Kdýr, Tiiu Elbra, Radek Mikuláš, Lada Kouklíková and Petr Pruner – *Biostratigraphy and magnetostratigraphy of the Berrias section, France*	11:20–11:40 Camilo Ponton* and Florentin J-M.R. Maurrasse – *Barremian–Aptian facies diversity around the Tethys realm: global oceanic factors vs local physiographical conditions*
11:40–12:00 Ottilia Szives* and István Főzy – *Towards an ammonite zonation for the Jurassic/Cretaceous transition: new data from the Ammonitico Rosso/Biancone sections in the Transdanubian Range (Hungary)*	11:40–12:00 Iuliana Lazăr*, Ioan I. Bucur, Mihaela Melinte-Dobrinescu, Mihaela Grădinaru and Eugen Grădinaru – *Late Valanginian drowning of the Getic carbonate platform (Southern Carpathians) associated with the Weissert Oceanic Anoxic Event*
12:00–12:20 William A.P. Wimbledon, Daniela Reháková, Andrea Svobodová, Petr Schnabl*, Petr Pruner, Šimon Kdýr, Camille Frau, Luc Bulot, Alberto Riccardi, Maria	12:00–12:20 Nicté Andrea Gutiérrez-Puente*, Ricardo Barragán, Juan Josué Enciso-Cárdenas, Luis Fernando Camacho-Ortegón, Julián Leonardo Mesa-Rojas and

P. Inglesia Llanos, Diego A. Kietzmann and Rafael López-Martínez – *An effective and realistic definition of the base of the Berriasian Stage (J/K boundary)*	Fernando Núñez-Useche – *Planktic foraminiferal biostratigraphy and palaeoenvironmental inferences for the Upper Cretaceous of the Sabinas Basin, Coahuila (Mexico)*
12:20–12:40 Atsushi Matsuoka – *Jurassic–Cretaceous transition sequences in East Asia and the Pacific: radiolarian markers around the J/K boundary* **[online]**	12:20–12:40 Carlos Herdocia* and Florentin J-M.R. Maurrasse – *Geochemical and biomarker analyses of the Lower Aptian succession in the Basque-Cantabrian Basin, Spain: implications for organic matter sources during OAE 1a*

12:40 – 14:00 LUNCH

14:00 – 15:40 PARALLEL SESSIONS

Auditorium	**Room 116**
S2 GSSPs Chairperson: Maria Rose Petrizzo	**S15 In memory of Professor Lamolda** Chairpersons: Mihaela Melinte-Dobrinescu and Florentin J-M.R. Maurrasse
14:00–14:20 Brahimsamba Bomou*, Éric De Kaenel, Nicolas Thibault, Jorge Spangenberg and Thierry Adatte – *Coniacian–Santonian boundary diachronism: examples from the GSSP of Olazagutia (Spain) and Ten Mile Creek-Arbor Park (USA)*	14:00–14:20 Vanessa Londoño* and Laurel S. Collins – *Palaeoenvironmental changes during Oceanic Anoxic Event 2 at the Western North Atlantic IODP site U1407: evidence from geochemical proxies and microfossil abundances*
14:20–14:40 Andrew S. Gale – *A proposed GSSP for the Campanian Stage*	14:20–14:40 Ramona Bălc*, Raluca Bindiu-Haitonic, Szabolcs-Attila Kövecsi, Mihai Ducea, Matyas Vremir, Zoltan Csiki-Sava, Daniel Ţabără and Ştefan Vasile – *Integrated biostratigraphy of Upper Cretaceous deposits in an exceptional continental vertebrate-bearing marine section (Transylvanian Basin, Romania)*
S6 Cretaceous invertebrate palaeontology Chairpersons: Martin Košťák and Frank Wiese	14:40–15:00 Fernando Núñez-Useche*, Thierry Adatte, Jorge E. Spangenberg, Juan Josué Enciso-Cárdenas, Julian Mesa-Rojas and Yutzil Sarai Peláez-Godínez – *Evidence for oxic conditions and hydrothermal influence during Oceanic Anoxic Event 2 in the Mexican Interior Basin*
14:40–15:00 John W.M. Jagt* and Michael R. Cooper – *New Late Maastrichtian trigoniid bivalves from the south-east Netherlands*	
15:00–15:20 Alina Chrząstek – *Trace and body fossils from the controversial 'Lower Idzików Member' (Sudetes, south-west Poland)*	15:00–15:20 Dangpeng Xi*, Benjamin Sames and Xiaoqiao Wan – *Cretaceous stratigraphy and biota in the Songliao Basin, north-east China*
15:20–15:40 Ayaka Ito*, Shin-ichi Sano, Yasuhiro Iba, Peter W. Skelton, Yolanda M. Aguilar, Roberto S.P. De Ocampo and Tomoki Kase – *An enigmatic new taxon from the Philippines suggests that the rudist family Hippuritidae originated in the Pacific Realm* **[online]**	15:20–15:40 Johanset Orihuela* and Florentin J-M.R. Maurrasse – *The Pons Formation of the Infierno Unit in north-western Cuba: its relation to Early Cretaceous anoxic events*

15:40–16:00 COFFEE BREAK AND POSTERS

16:00–18:00 PARALLEL SESSION/BUSINESS MEETING

Auditorium	
S6 Cretaceous invertebrate palaeontology Chairpersons: Martin Košťák and Frank Wiese	**16:00–18:30 MEETING OF THE BERRIASIAN WORKING GROUP** Room 116
16:00–16:20 John W.M. Jagt* and Mart J.M. Deckers – *'Changing of the guard' amongst echinoids in the Upper Maastrichtian of the south-east Netherlands:* Echinocorys *out,* Hemipneustes *in*	
16:20–16:40 Marcin Machalski*, Danuta Olszewska-Nejbert and Markus Wilmsen – *The Albian–Cenomanian (mid-Cretaceous) phosphorite interval in Central Poland: a stratigraphical and geochemical reappraisal*	
16:40–17:00 Mohamed Benzaggagh*, Mariusz A. Salamon, Mohamed Oumhamed, Benjamin Musavu-Moussavou and Bruno Ferré – *Albian–Cenomanian faunal diversity of the El Mizab Formation (Talerhza Basin, north-western Morocco)*	
17:00–17:20 Dawid Mazurek* and Elena Jagt-Yazykova – *Unstable life: the diversity of Turonian benthos and its strategies – a view from Opole*	
17:20–17:40 Frank Wiese*, Richard D. Norris and Oliver Friedrich – *The response of terminal Maastrichtian deep-sea echinoids to the Latest Maastrichtian Warming Event (LMWE) and the K/Pg Boundary Event*	

FROM 19:30 CONFERENCE DINNER [POLISH GEOLOGICAL INSTITUTE]

Thursday 25th of August

9:00–10:40 PARALLEL SESSIONS

Auditorium	Room 116
S18-19 Cretaceous tectonics and syn-tectonic/Cretaceous regional geology Chairpersons: Christian Hübscher and Piotr Krzywiec	**S10 Cretaceous micropalaeontology** Chairpersons: Bruno Granier, Danuta Peryt and Nicolas Thibault
9:00–9:20 Piotr Krzywiec*, Quong Nguyen, Łukasz Słonka, Michał Malinowski, Regina Kramarska, Christian Huebscher and Niklas Ahlrichs – *Tectonic control on Late Cretaceous sedimentation within the southern Baltic Sea, as revealed by regional analysis of seismic reflection data*	
9:20–9:40 Relu D. Roban*, Mihai N. Ducea, Vlad Mihalcea, Peter I. Luffi, Ioan Munteanu, Victor Barbu, Marius Tiliță, Mihai Vlăsceanu and V. Ene – *Constraining the onset of subduction through sediment provenance changes: the Ceahlău-Severin ocean of the Eastern Carpathians*	
9:40–10:00 Aleksandra Stachowska* and Piotr Krzywiec – *New insight into the depositional architecture of the Upper Cretaceous in northern and central Poland – seismic evidence for syntectonic sedimentation and bottom currents*	9:40–10:00 German D. Patarroyo*, Karlos G.D. Kochhann, Daiane Ceolin, Rodrigo M. Guerra, Marlone H.H. Bom, José M. Torres and Laia Alegret – *Microfossil assemblages and palaeoenviromental changes in the Maastrichtian epicontinental seas of northern South America*
10:00–10:20 Piotr Krzywiec*, Aleksandra Stachowska and Łukasz Grzybowski – *Upper Cretaceous inversion-related contourites within the Polish Basin – their seismic expression and geodynamic significance*	10:00–10:20 Jakub Witkowski*, Wolf Dummann, David Harwood, Megan Heins, Jens Herrle, Kevin McCartney and Claudia Schroder-Adams – *New records of fossil siliceous phytoplankton from the Cretaceous Arctic: work in progress*
10:20–10:40 Vincenzo Randazzo*, Fabrizio Berra, Andrea Zanchi, Stefano Zanchetta, Maria Rose Petrizzo, Felix Schlagintweit and Hamid Reza Javadi – *Mode and timing of the Cretaceous transgression in Central Iran: depositional environments and stratigraphical evolution* **[online]**	10:20– 0:40 Cemile Solak* and Kemal Taslı – *Stratigraphical distribution and importance of some imperforate benthic foraminifera from the Upper Campanian–Maastrichtian of the Tauride carbonate platform, Turkey* **[online]**

10:40–11:20 COFFEE BREAK AND POSTERS

11:20–12:40 PARALLEL SESSIONS

Auditorium	Room 116
S18-19 Cretaceous tectonics and syn-tectonic/Cretaceous regional geology Chairpersons: Christian Hübscher and Piotr Krzywiec	**S10 Cretaceous micropalaeontology** Chairpersons: Bruno Granier, Danuta Peryt and Nicolas Thibault
11:20–11:40 Matias Sanhueza, Christian Salazar* and Hermann Rivas – *Microfacies and sequence stratigraphy of the Jurassic–Cretaceous transition in Central Chile*	11:20–11:40 Andrew S. Gale – *Cretaceous microcrinoids – phylogeny, biostratigraphy and palaeoceanography*

11:40–12:00 Bruno R.C. Granier – *The Kalkowsky Project: a decade of advances in our knowledge of calcite ooids, illustrated by Cretaceous examples*	11:40–12:00 Mariusz Niechwedowicz*, Zbyszek Remin and Michał Cyglicki – Distribution pattern and palaeoenvironmental significance of palynomorph assemblages from the Middle Campanian (Upper Cretaceous) deltaic succession of Szozdy (Roztocze hills, south-east Poland)
12:00–12:20 Khaled Trabelsi, Anna Tamara Mai, Benjamin Sames, Jens O. Herrle and Frank Wiese* – *Biostratigraphical reassessment of the Cuchia Wealden section (North Cantabrian Basin, Northern Spain) based on a high-diverse charophyte flora: implications for palaeobiogeography and regional tectono-sedimentary evolution*	12:00 – 12:20 Raquel Bryant, R. Mark Leckie*, Serena Dameron, Khalifa Elderbak, Christopher M. Lowery, Amanda Parker, Matthew M. Jones, Libby J. Robinson, Bradley B. Sageman and Jessica H. Whiteside – *The mid-Cretaceous Western Interior Seaway: ocean gateways and the onset of Oceanic Anoxic Event 2*
12:20–12:40 Mayuko Kamimura*, Takashi Hasegawa and Koich Hoyanagi – *Carbon-isotope stratigraphy and preliminary regional correlation of the Jurassic–Cretaceous Tetori Group in Central Japan* **[online]**	12:20–12:40 Ludmila Kopaevich*, Elena Yakovishina and Sergej Bordunov – *Integrative characteristics of the Turonian–Coniacian boundary in the North-Western Caucasus* **[online]**

12:40–14:00 LUNCH

14:00–15:40 PARALLEL SESSIONS

Auditorium	**Room 116**
S3-4 Cretaceous geochemistry and global change and Cretaceous chemostratigraphy Chairpersons: Michael Wagreich, Jordan Todes, Silke Voigt	**S10 Cretaceous micropalaeontology** Chairpersons: Bruno Granier, Danuta Peryt and Nicolas Thibault
14:00–14:20 Ian Jarvis – *Carbon isotope events as the ultimate tool for global correlation and dating: example of the Turonian and Campanian stages*	14:00–14:20 Krzysztof Bąk*, Marta Bąk and Zbigniew Górny – *No evidence for long-term bottom anoxia during Oceanic Anoxic Event 1d in deep environments of the Western Tethys: a record of benthic foraminiferal assemblages and chemical indices*
14:20–14:40 Jordan P. Todes*, Ireneusz Walaszczyk and Bradley B. Sageman – *Hiatal and lithostratigraphic implications for Coniacian chemostratigraphy in the Pueblo succession (Colorado, USA)*	14:20–14:40 Mike D. Simmons* and M.D. Bidgood – *Cenomanian marine biostratigraphy: a critical review*
14:40–15:00 Ahmed Mansour and Michael Wagreich* – *The last of the Cretaceous anoxic events, OAE 3: Coniacian–Santonian earth system changes* **[online]**	14:40–15:00 Bruno R.C. Granier*, Serge Ferry and Mohamed Benzaggagh – *Calpionellid biostratigraphy judged by the yardstick of sedimentology*
15:00–15:20 Markus Wilmsen*, Udita Bansal and Philipp Böning – *Intense chemical weathering of the continents: a key for widespread shallow-marine glaucony formation during the Late Cretaceous*	15:00–15:20 Adam T. Halamski* and Ewa Durska – *The hidden diversity of cretaceous angiosperms: small tricolpate pollen from the Coniacian–Santonian of Lower Silesia, Poland*
15:20–15:40 Fernando Núñez-Useche*, Ricardo Barragán, Nicté A. Gutiérrez-Puente, Juan Josué Enciso-Cárdenas, Luis Fernando Camacho-Ortegón and Mario Martínez-Yáñez – *Climate and oceanographic conditions associated with the accumulation of organic matter during OAE 1a and OAE 1b in Central Mexico*	15:20–15:40 Margarita Latypova*, Ludmila Kopaevich, Eleonora Bugrova and Aleksandr Gusev – *Identification of ancient stratigraphical intervals based on studies of foraminiferal tests from clays of the mud volcano Shugo (Taman Peninsula, Russia)* **[online]**

15:40–16:00 COFFEE BREAK AND POSTERS

16:00 – 18:00 POSTER SESSION	
POSTER SESSION	**16:40–19:00 MEETING OF THE CRETACEOUS SUBCOMMISSION** Room 106

Friday 26th of August

9:00–11:00 PARALLEL SESSIONS

Auditorium	
S14 Cretaceous–Paleogene boundary and events Chairpersons: John Jagt and Marcin Machalski	**POSTER SESSION**
9:00–9:20 Thierry Adatte*, Marcel Regelous, Eric Font, Jorge E. Spangenberg, Gerta Keller, Uygar Karabeyoglu and Jahnavi Punekar – *Timing and tempo of Deccan volcanism relative to the K/Pg extinction revealed by mercury and tellurium anomalies*	
9:20–9:40 Uygar Karabeyoglu*, Jorge Spangenberg and Thierry Adatte – *Faunal and environmental changes across the Cretaceous–Paleogene boundary (K/Pg) in Central Anatolia, Turkey*	
9:40–10:00 Zbyszek Remin*, Michał Cyglicki, Marcin Barski, Zofia Dubicka and Joanna Roszkowska-Remin – *The K/Pg boundary section at Nasiłów, Poland – new data on biostratigraphy and palaeomagnetism*	
10:00–10:20 Lauren K. O'Connor*, Rhodri M. Jerrett, Gregory D. Price, Bart E. van Dongen, Emily D. Crampton-Flood and Sabine K. Lengger – *Extreme warmth and rapid and drastic temperature change in the Canadian Arctic during the latest Cretaceous and earliest Paleogene*	
10:20–10:40 Marcin Machalski – *Burrow-generated pseudobreccia – an important phenomenon for interpretation of some Cretaceous–Paleogene (K–Pg) successions*	

10:40–11:20 COFFEE BREAK

11:20–12:40 CLOSING CEREMONY [University Old Library Auditorium]

12:40–14:00 LUNCH

LIST OF POSTERS.

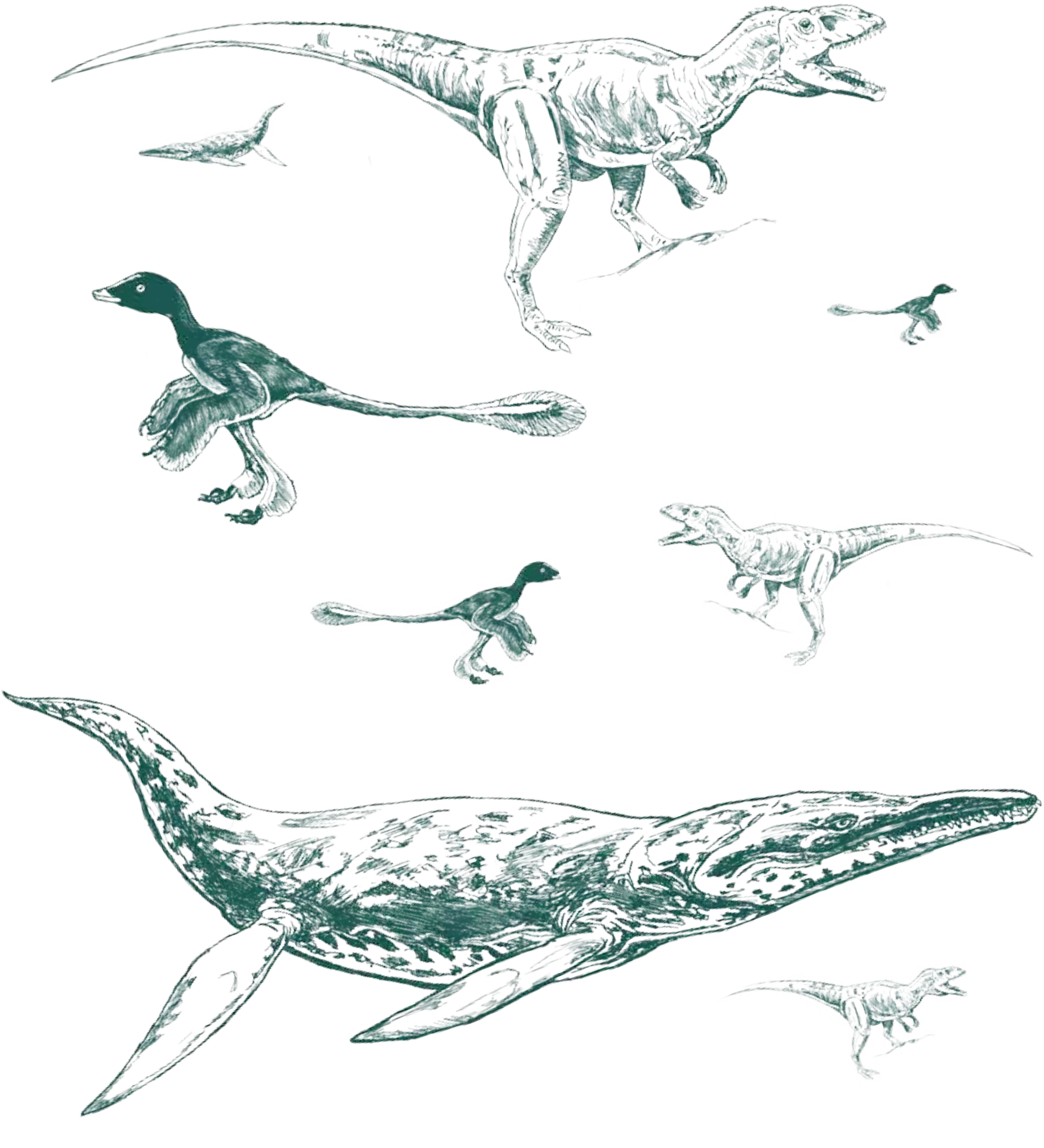
POSTERS

S1	**200th Anniversary of the Cretaceous System**	**William James Kennedy** – *The giants of the Cretaceous – The Sowerbys: James (1757–1822) and James de Carle (1787–1871)*
		Markus Wilmsen and William James Kennedy – *The giants of the Cretaceous – Hanns Bruno Geinitz (1814–1900)*
		William James Kennedy – *The giants of the Cretaceous – Alcide Dessalines d'Orbigny (1802-1857)*
		William James Kennedy – *The giants of the Cretaceous – Daniel Sharpe (1806–1856)*
		William James Kennedy – *The giants of the Cretaceous – Ferdinand Stoliczka (1838–1874)*
		William James Kennedy – *The giants of the Cretaceous – Édouard Guerangér (1801–1895)*
		William James Kennedy – *The giants of the Cretaceous – Clemens August Schlüter (1835–1906)*
		William James Kennedy and Markus Wilmsen – *The giants of the Cretaceous – Franz Kossmat (1871–1938)*
		William James Kennedy – *The giants of the Cretaceous – Albert de Grossouvre (1849–1932)*
		William James Kennedy – *The giants of the Cretaceous – Alphaeas Hyatt (1838–1902)*
		William James Kennedy – *The giants of the Cretaceous – Léon Pervinquière (1873–1913)*
		William James Kennedy – *The giants of the Cretaceous – Leonard Frank Spath (1882–1957)*
		William James Kennedy – *The giants of the Cretaceous – Maurice Collignon (1893-1978*
		William James Kennedy – *The giants of the Cretaceous – Tatsuro Matsumoto (1913–2009)*
		William James Kennedy – *The giants of the Cretaceous – Claud William Wright (1917–2010)*
		William James Kennedy – The giants of the Cretaceous – *Willliam Aubrey "Bill" Cobban (1916–2015)*
S2	**GSSPs**	**Christina Ifrim* and Wolfgang Stinnesbeck** – Ammonoid and inoceramid biostratigraphy and chemostratigraphy of the Tepeyac section (Coahuila, Mexico), a candidate for associated stratotype section and point for the base of the Campanian
		Martin Košťák*, Daniela Reháková, Lucie Vaňková, Petr Pruner and Andrea Svobodová – *A slight carbon perturbation at the J/K boundary (base of the* Alpina Subzone*) at selected Tethyan localities*
		Michael Wagreich* and Maria Rose Petrizzo – *Strontium isotope stratigraphy around the base of the Campanian (Italy and Austria)*
		Silviya Petrova, Daniela Reháková, Elisabetta Erba, Jacek Grabowski* and Helmut Weissert – *Revised calpionellid stratigraphy and microfacies of the Torre de' Busi section (Lombardy Basin, J/K boundary)*
		Petr Schnabl*, Tiiu Elbra, Andrea Svobodová, Daniela Reháková, Miroslav Bubík, Lilian Švábenická, Martin Košťák, Petr Skupien, Petr Pruner and Šimon Kdýr – *The Tithonian–Berriasian boundary interval in the Ropice section (Czech Republic) from the perspective of palaeomagnetism and biostratigraphy*
S4	**Cretaceous chemostratigraphy**	**André Bornemann*, Jochen Erbacher, Martin Blumenberg and Silke Voigt** – *A new Berriasian to Coniacian composite carbon isotope record for the Boreal Realm*
		Šimon Kdýr*, Volodymyr Bakhmutov, Miroslav Bubík, Tiiu Elbra, Jacek Grabowski, Jozef Michalík, Daniela Reháková, Petr Schnabl, Petr Skupien and Ján Soták – *Mercury occurrence in basal and top Cretaceous boundary intervals of Carpathian sedimentary sequences*
		Yasser F. Salama and Gouda I. Abdel-Gawad* – *Barremian to Turonian carbon and oxygen isotope data from the Sinai Platform, Egypt*
S6	**Cretaceous invertebrate palaeontology**	**Gouda I. Abdel-Gawad*, Mohamed Fouad Aly and Yasser Salama** – *Cretaceous trigoniid bivalves from Sinai, Egypt: a review*
		Birgit Niebuhr* and Markus Wilmsen – *Large-sized Late Turonian–Early Coniacian (Late Cretaceous) inoceramid bivalves from Germany: taxonomic issues, temporal framework and palaeoecological implications*

		Adam Wierzbicki*, Michał Stachacz and Klaudiusz Salamon – *A possibly new ichnospecies of* Rogerella *(barnacle bioerosion trace) in a mid-Maastrichtian inoceramid shell from Poland*
S7	**Cephalopod palaeobiology**	**Camille Frau* and Pierre-Yves Boursicot** – *Learning from beautiful monsters: the case of 'sex reversals' in the Ammonoidea and their significance*
		Jan Geist* and Lucie Vaňková – *Geochemical characterization of belemnite rostra from north-west Bohemia (Upper Cenomanian) – a contribution to the palaeoenvironmental interpretation of a Peri-Tethyan shelf*
		Zuzana Kozlová*, Martin Košťák, Tomáš Kočí, Martin Souček, Jan Sklenář and Adam Culka – *Cephalopod jaws from the Bohemian Cretaceous Basin – preservation, taxonomy and stratigraphical implications*
		Krystyna Waindzoch and Dawid Mazurek* – Pachydiscus neubergicus *(Von Hauer, 1858) – important as well as problematic*
S8	**Lower Cretaceous ammonites (Kilian Group meeting)**	**Ricardo Barragán and Josep Anton Moreno-Bedmar*** – *How problematic is it to develop an ammonite zonation for the lower to middle part of the lower Aptian in America?*
S9	**Cretaceous vertebrates**	**Hyemin Jo*, Minguk Kim, Jongyun Jung, Yeon Woo and Min Huh** – *Overview of Cretaceous dinosaur eggs from South Korea*
		Martin Mazuch*, Martin Košťák, Radek Mikuláš, Adam Culka, Ondřej Kohout and John W.M. Jagt – *Bite marks of a large vertebrate predator of mosasaur type (?) on the Early Turonian ammonite Mammites nodosoides from the Czech Republic*
S10	**Cretaceous micropalaeontology**	**Richard M. Besen*, Mareike Achilles, Mauro Alivernini, Thomas Voigt, Peter Frenzel and Ulrich Struck** – *Stratigraphy and palaeoenvironments in the Upper Turonian to Lower Coniacian of the Saxonian Cretaceous Basin (Germany) – insights from calcareous and agglutinated foraminifera*
		Vitalii Syniehubka – *General characteristics of Cenomanian–Turonian ostracod faunas from Ukraine*
		Bat-Erdene Tumurchudur*, Ganbayar Gunchinbat and Bayanmunkh Tumen-Ulzii – *Distribution and comparison of Upper Cretaceous deposits in the Gobi of Trans-Altai*
		Mike D. Simmons* and M.D. Bidgood – *Cenomanian marine biostratigraphy: a critical review*
		Paula Granero*, Adam Wierzbicki and Michael Wagreich – *Morphometrical analysis of Arkhangelskiella cymbiformis – a case study from the Santonian-Campanian boundary interval in the Eastern Alps (Loibichl, north-west Austria)*
		Tamara T. Gavtadze*, Khatuna E. Mikadze and Z.M. Chkhaidze – *Micropalaeontological characteristics of Upper Cretaceous deposits in sections of eastern Georgia*
		Khatuna Mikadze*, Giorgi Tlashadze, Nana Ikoshvili and Anna Katamidze – *Biostratigraphy of the Cenomanian- Lower Turonian in the Transcaucasian Intermountain Region (Georgia)*
		Elżbieta Machaniec, Alfred Uchman* and Marian Adam Gasiński – *A new late Maastrichtian zone based on benthic agglutinated foraminifera: the* Goessella rugose / Remesella varians *Zone*
S11	**Cretaceous palynology**	**Niiden Ichinnorov*, Adiya Eviikhuu, Sukhbat Purevsuren and Nyamsambuu Odgerel** – *Palynological stuies of the Tukhum coal deposit, eastern Mongolia*
		Mariusz Niechwedowicz – *New stratigraphically important dinoflagellate cyst species from the Upper Campanian–lowermost Maastrichtian (Upper Cretaceous) of Poland*
		Veronika Veselá*, Marcela Svobodová and Jiří Kvaček – *Palynological investigation of selected taxa from Cenomanian strata at Hloubětín-Hutě, Praha (Czech Republic)*

S13	Fossil-Lagerstätten	**Markus Wilmsen* and Vachik Hairapetian** – *The Upper Cenomanian Takhte-Sheitan Member (Kolah-Qazi Formation, Esfahan, Central Iran): taphonomic processes and ammonites of a classic 'Konzentrat-Lagerstätte'*
S14	Cretaceous/Paleogene boundary and events	**Maisa Tunik*, Beatriz Aguirre-Urreta, Martín Parada and Jahandar Ramezani** – *Microbial activity around the K/Pg boundary, Neuquén basin, Argentina: a response to the mass extinction event?*
S15	In memory of Professor Lamolda	**Roque Aguado*, Miguel Company, José Manuel Castro, Ginés A. de Gea, Luis O'Dogherty, José Sandoval, María Luisa Quijano, Mathieu Martinez, Sandro Froehner and Cristina Sequero** – *Geochemical and calcareous nannofossil evidence of two Late Barremian episodes of environmental change in south-east Spain*
		Andrei Briceag* and Mihaela C. Melinte-Dobrinescu – *Shallow- to deep-marine Cretaceous palaeosetting in the north-western Black Sea onshore and offshore*
		Docho Dochev*, Michael Wagreich, Veronika Koukal and Polina Pavlishina – *The Santonian–Campanian boundary interval in the Kyunetsa section, Western Srednogorie Zone (Bulgaria)*
		Edgar Juárez-Arriaga*, Ricardo Barragán, Fernando Núñez-Useche and Josep A. Moreno-Bedmar – *Microfacies and depositional environment of the Lower Cretaceous Tlayúa Formation in southern Mexico*
		Polina Pavlishina*, Docho Dochev, Michael Wagreich and Veronika Koukal – *An integrated study (calcareous nannofossils, dinoflagellate cysts, inoceramid bivalves, carbon isotopes) of the Campanian in the Petrich section, Central Srednogorie Zone (Bulgaria)*
		Danuta Peryt*, Zofia Dubicka and Weronika Wierny – *Planktic foraminiferal biostratigraphy of the Upper Cretaceous in the Central European Basin*
S16	Cretaceous palaeoenvironment, palaeoclimate and palaeoceanography	**Marta Bąk*, Krzysztof Bąk, Agnieszka Ciurej and Zbigniew Górny** – *Will the Cretaceous fossil record help us predict the future of marine biota in the face of modern climate change?*
		Marta Bąk*, Zbigniew Górny and Krzysztof Bąk – *From shallow Peri-Tethyan Platform to deep Silesian Basin – how did biotic micro-constituents respond to global sea level and Cretaceous OAE's during the latest Albian through Middle Cenomanian*
		Wolf Dummann*, Claudia Schröder-Adams, Peter Hofmann, Volker Wennrich and Jens Olaf Herrle – *Was OAE 2 triggered by the emplacement of the High-Arctic Large Igneous Province (HALIP)?*
		Michał Fąfara – *Foraminifera in the biostratigraphical and palaeoenvironmental context of the Belgorod chalk*
		Mariusz Kędzierski and Adam Wierzbicki* – *The Mid-Maastrichtian Event recorded in the flysch basin (Outer Carpathians, Skole Nappe, Poland)*
		Maria Rose Petrizzo*, David K. Watkins, Kenneth G. MacLeod, Takashi Hasegawa, Brian T. Huber, Sietske J. Batenburg and Tomonori Kato – *Exploring the palaeoceanographical changes registered by planktic foraminifera across Oceanic Anoxic Event 2 at IODP site U1516 (Mentelle Basin, south-east Indian Ocean)*
		Fritz Stoepke*, Ulrich Heimhofer, Julia Gravendyck, Martin Blumenberg, Jochen Erbacher, Annette E. Götz, Roberto Pierau and Robert Schöner – *Composition and distribution of sedimentary organic matter in the distal Wealden facies (KB Rehburg-2) of the Lower Saxony Basin, Germany*
		Andrzej Szydło*, Tomasz Malata and Piotr Nescieruk – *Changes in foraminiferal assemblages during the Cretaceous/Paleogene boundary crisis: a case study from the Polish Outer Carpathians*

		Erik Wolfgring, Michael A. Kaminski*, Anna Waśkowska, Carmine C. Wainman, Maria Rose Petrizzo, Eun Young Lee, Trine Edvardsen and Se Gong – *Foraminiferal stratigraphy and paleoenvironments of a high latitude marginal marine basin – a Late Cretaceous record from IODP site U1512 (Great Australian Bight)*
		Erik Wolfgring* and Maria Rose Petrizzo – *Benthic foraminiferal assemblage changes during Oceanic Anoxic Event 2 in the southern high latitudes – IODP site U1516*
S19	**Cretaceous regional geology**	**Birgit Niebuhr*, Thomas Pürner, Annette E. Götz, Frank Holzförster and Markus Wilmsen** – *The continental Hessenreuth Formation (Danubian Cretaceous Group, Bavaria, Germany): syntectonic deposition during Late Cretaceous inversion*
		Birgit Niebuhr* and Markus Wilmsen – *The history of transgressions in the Saxonian Cretaceous revisited, or, an imperative for a complete stratigraphical reappraisal (Cenomanian, Elbtal Group, Germany)*
		Halyna Medvid, Vasyl Harasymchuk, Andriy Poberezhskyy*, Oksana Stupka – *Influence of geodynamic factor on hydrogeochemical indicators of Upper Cretaceous deposits of the Lviv Paleozoic foredeep*
		Johan Vellekoop*, Pim Kaskes, Matthias Sinnesael and John W.M. Jagt – *An update on the Maastrichtian Geoheritage project*
		Markus Wilmsen*, Michaela Berensmeier, Franz Theodor Fürsich, Vachik Hairapetian, Felix Schlagintweit and Mahmoud Reza Majidifard – *The Cretaceous succession at the eastern rim of the Anarak Metamorphic Complex (Central Iran): integrated stratigraphy and facies development at the margin of the Khur Basin*
		Markus Wilmsen*, Birgit Niebuhr and William James Kennedy – *Middle Cenomanian ammonites from the Oberhäslich Formation (Elbtal Group, Germany): their impact on the stratigraphy and palaeogeography of the Saxonian Cretaceous*
S20	**Geodynamics of the Cretaceous basins and sedimentary record**	**Alina Chrząstek* and Jurand Wojewoda** – Rosselia *– a trace fossil indicator of beach-shoreface sedimentary settings in both transgressive and regressive sedimentary sequences of the Intra-Sudetic Cretaceous Basin*
		Marian Munteanu*, Mihaela Melinte-Dobrinescu, Sarolta Lőrincz, Relu-Dumitru Roban and Mihai Ducea – *Igneous clasts in the outer nappes of the Eastern Carpathians: indicators of Late Cretaceous basin segmentation*



WILLIAM JAMES KENNEDY




Upper left: 1960: The sporting life.

Upper right: 1978: Research in Northern Aquitaine with Jake Hancock.

Middle one: 1973: Field work in the Western Interior, with Jake Hancock.

Lower one: 2010: In the office, with pre-raphaelite mural of the Mer de Glace and Mont-Blanc behind

WILLIAM JAMES KENNEDY

Biographical notes

VITA

I was an only child. My father was a postman, having serving for just under 21 years in the British Army. My mother was a typist and secretary (at one stage of a Theatrical Agent, one Miss Finnessy, with offices overlooking Oxford Circus, clients including the celebrate crooner Hutch (Leslie Hutchinson, for whom my mother claimed she was instructed to find female company), and Wilson, Keppel and Betty, of Sand Dance fame.

Oxford Circus was to loom large in later years, as I passed it several times a day en route to and from school. Passing my eleven plus examination, I was enrolled at the Quintin school, a grammar school. For my first few years the junior school was based in the middle of the Red Light district of Soho; the senior school had labs, gym and a swimming pool in Upper Regent Street. The junior and senior schools united every Monday for Morning Assembly in the Cameo Poly cinema, entertained by the chemistry master playing hymns on the cinema organ. Transfer from junior to senior school involved crocodiles of small boys in green and red blazers, accompanied by a master, walking north from Soho, turning west along Oxford Street and then north up Upper Regent Street. The 20 minute walk left numerous half periods, which were devoted to religious instruction, which I successfully passed at Ordinary Level thereafter. In later years, the school translated to the dull but respectable environment of St Johns' Wood, where it became the Quintin-Kynaston Comprehensive School, the most notorious pupil of which was the late Mohammed Emwazi (a.k.a. Jihadi John).

I was bookish, and mainly interested in insects, so my parents decided to improve my social skills by enrolling me in the Willesden Swimming Club. Obedient as ever, I devoted myself to exercise, and broke my first national (English) juvenile record (for 440 yards freestyle) in January 1969, and represented Great Britain in my first international (against Germany) at the tender age of 16. This success was recognised by my being excused school morning assembly, and spending the hour in the now defunct Finchley Road Baths (now a Sainsburys Supermarket), with a host of cockroaches and the odd rat for company.

In 1961 I applied to read geology at University, a subject that an inspiring geography master (and a school trip to Swanage) had interested me in. The critical point in my life was reached, and I am eternally grateful to the interviewing committee of University College London for rejecting my application. In contrast, I was accepted by King's College London, on the Strand. Kings had been founded by the god-fearing as a counterbalance to the godless benthamites of University College (who displayed the mummified remains of their founder on a regular basis). The largest space in Kings was the chapel. Given the nature of the foundation, there was a religious service each morning, followed by a theological lecture on Mondays. To accommodate this piety, teaching began at 11 on Mondays, and 10 on Tuesdays to Fridays, with Wednesday afternoon set aside for sporting activities. This suited me very well; I spent more time in pool and gym than in lecture room and laboratory. This led to moderate success: I reached the final of the 1,500 metres freestyle at the European Championships, and captained Great Britain in my last international (versus Italy) during my student days. More eccentric triumphs included winning the Brighton Pier-to-Pier Race, the Lake Bala event (over an hour in freezing Welsh water), the Bedford Half Mile (in the River Ouse), and the first post-war Long Distance championship over five and a half miles of a different River Ouse, beginning upstream of York, and finishing several miles downstream of the city.

The course at Kings, of Geology with subsidiary Chemistry, was not arduous. In geology there were six or eight lectures in the first year, plus two in Chemistry, and three afternoons of practical work; the lecture load was reduced in the second year. The number of students in my year and the number of staff were evenly balanced, eight as I recall. There was a certain eccentricity about some of the bachelors on the staff. I recall Jake Hancock (of whom more below), striding down the Strand in a summer jacket, grey lederhosen, field boots, and a black briefcase, and Roy Elwell, who practised putting in his office. He was a structural geologist whose trouser turn-ups caught fire during a tutorial when he stood too close to the gas fire in his office….

I graduated in the summer of 1964 (my chief memory of the examinations was writing an essay in support of the permanence of continents and ocean basins; on reflection, I suspect the answer was supposed to argue against this view). I gained a first, and was awarded a three year studentship to pursue research on the Lower Chalk of southern England under the supervision of the above Jake Hancock. As I recall, the only supervision I got was during a day trip to Eastbourne, where I led a field trip for the Geologists'

Association, and a couple of hours in a quarry in Dorset, which we abandoned as the snow overcame us. But there was more to come, as I have related elsewhere (*Proceedings of the Geologists' Association* **117**, 2006, 103-122; *Acta Geologica Polonica*, **70**, 2020, 147)), beginning with my accompanying him, as his field assistant, on a research trip to northeastern Algeria and Central Tunisia in the spring of 1965. The origins of this project began in the spring of 1959 at the *Colloque sur le Crétacé Supérieur Française*, when Jake and the late Jost Wiedmann (1931-1993) disputed on the affinities of the tiny limonitic ammonite nuclei from the Cenomanian of North Africa that had been assigned to the genus *Submantelliceras*: were they in fact nuclei of *Mantelliceras*, or *Graysonite*s? In order to investigate the subject, Hancock applied for and was awarded a grant from the then Natural Environment Research Council to purchase a long-wheel base Land Rover, and drive to northern Algeria and Central Tunisia (via Marseille and Algiers) to investigate the classic localities of Coquand, Péron, Thomas and Péron and Pervinquière , together with those in the Monts du Mellègue described Dubourdieu and Sornay that straddle the Algeria/Tunisia boundary. Our first visit to Algeria and Tunisia took place between March 31st and April 22nd 1965. The trip was not without incident not least of which was me, as a newly qualified driver, rolling over the Land Rover in northern France. We persisted, however, and arrived in Algiers. A visit to the British Consulate to seek advice on logistics led to firm advice to return to the United Kingdom forthwith. We persisted, and carried out fieldwork in the area between Berrouaghia and Sour El-Ghozlane (formerly known as Aumale), made classic by Pervinquière on the basis of material collected by Phillipe Thomas, Alphonse Péron, and others, with slight results. Continuing to the Monts du Mellège, we left Algeria to discover that the border zone, including some of Dubourdieu's localities, was a sort of no man's land several kilometres wide, bounded by barbed wire and minefields, set up during the Algerian War of Independence (1954–1962). Key outcrops were unvegetated, and strewn with tiny limonitic fossils. In contrast, when revisited in 1984, many of these outcrops were under cultivation, and fossil collecting no longer possible.

It had been Jake Hancock's intention to describe these faunas in his retirement. He handed them over to me shortly before his death in 2004, and the results were finally published in *Acta Geologica Polonica* in 2020. And the solution to the disagreement between Hancock and Wiedmann? Both were correct and wrong to a degree. Some of the limonitic nuclei are *Mantelliceras*; some are *Graysonites*, but the type species of *Submantelliceras* is a paedomorphic dwarf.

This field trip was the beginning of a collaboration that was to span more than 30 years, and a friendship that spanned forty.

In 1966, two years into my doctorate, I applied for a Departmental Demonstratorship (a fixed term post) at the Department of Geology and Mineralogy at Oxford, which I gained (curiously, Jake was visiting the department on the day of my interview...). This was translated into a tenure track lectureship in 1968, and I slowly climbed the University greasy pole, finishing up as Director of the University Museum of Natural History (and Professor of Natural History) in 2003, devoting the following years to raising funds to look after insect collections, restore the fabric, stop the roof leaking, and much else.

I return to the themes of research, and collaboration. It has been my enormous good fortune to have worked with a host of colleagues, who have provided me with opportunities to work on faunas that span the globe: from East Greenland to the Antarctic Peninsula, and from Northern Ireland eastwards across Europe and the Middle East, West Africa, southern Africa, Madagascar, South India, Pakistan, Australia, Colombia, and the United States Western Interior, Gulf Coast, and Atlantic seaboard, and plenty of other places besides. Ammonites investigated came from some unlikely palaeoenvironments, including Burmese amber, and the massive sulphide deposits of the Troodos ophiolite in what is now Cyprus, that formed as a result of hydrothermal activity at a depth of 2,500-5,000 metres. Collaboration has also brought together colleagues with disparate, but complementary skills, from nannofossils to planktonic foraminifera, inoceramid bivalves, trace elements, strontium, oxygen and carbon isotopes, cyclo– and sequence stratigraphy.

Highlights, to me, are numerous.

Field work across France with Jake Hancock and his partner Ray Parish introduced me to the wines of France (useful for a future career as college Wine Steward), and the type areas of the mid–and Upper Cretaceous stages, leading to the revision of their ammonite faunas; the type Cenomanian with Pierre Juignet, Turonian with Willy Wright and Jake, and my own contributions spanning the Coniacian to Maastrichtian. The work with Andy Gale and colleagues in the Vocontian Basin led on from this to the designation of Global Boundary Stratotype Sections and Points for the bases of the Cenomanian Stage (2004) and the Albian (2017), Later years saw work across Europe with many colleagues, including Ulrich Kaplan on the faunas of the Münsterald Basin in Westphalia, including the classic material described by Clemens Schlüter; the Gosau basins of Austria with Herbert Summesberger, and faunas from Sweden and Denmark with the late lamented Walter Kegel Christensen. A particular pleasure was to be involved, with Pierre Juignet, in the 2006 Révision Critique of the cephalopod volume of d'Orbigny's Paléontologie Française, dealing with 105 species in all. Nineteen sixty nine saw an unexpected diversion into the Pleistocene, with a summer spent mapping the raised limestone sequence of Aldabra Atoll, in the company of two colleagues, John Taylor and Colin Braithwaite graduates from King's, and 40,000 giant tortoises; I recall gazing at the night sky that July and hearing those remarkable words through the crackling radio .." one small step for a man, one giant leap for mankind".

A visit to South Africa in 1970, inspired by the material I had browsed on in the London Natural History Museum (described by Baily, Crick and Spath), led to a collaboration with Herbie Klinger, then of the South African Geological Survey, and subsequently of the South African Museum in Cape Town. We travelled to Zululand, and on this first, and several subsequent visits, amassed the most extraordinary collections of material ranging from the Upper Barremian to Upper Maastrichtian. The results have been published over the following near half-century, and we are still busy with the ammonites, and, latterly, with the associated inoceramids, thanks to the skills of Irek Walaszczyk.

I have collaborated with Irek on much else, from our completion, with Bill Cobban, of the documentation of the section at Pueblo in Colorado, recognised in 2021 as the Global Boundary Stratotype Section and Point for the base of the Turonian Stage, to making a minor contribution to the recognition of the base Coniacian GSSP. There are also integrated studies of note with Andy Gale and Irek on sections in South India, and the United States Western Interior and Gulf Coast.

Mention of the United States Western Interior means, to me, collaboration with Bill Cobban (1916-2015), and the many, many months spent with him at the U.S. Geological Survey in Denver. In 1972 I had been awarded an inaugural Lindemann Fellowship by the English Speaking Union, and spent 1973-4 in the United States. I flew to Albaquerque, and joined a caravan led by Erle Kauffman of the Smithsonian Institution. Members included Annie Dhondt, Heinz Kollmann, Jiri Kriz, Thor Hansen, Jake Hancock and Ray Parish. We stopped briefly in Denver and I met Bill, agreeing to return in due course. We had been asked, by Erle Kauffman, to write a chapter on the role of ammonites in biostratigraphy, that was ultimately published in 1977. Our original submission was rejected, and became our 1976 *Special Paper in Palaeontology* Aspects of Ammonite Biology, Biogeography, and Biostratigraphy (the 1977 article is not worth reading). The collections in Denver were extraordinary, and an extension had been built to house them. Specimens were beautifully prepared and photographed by Bill's assistant Bob Burkholder, and there was material not just from the Western Interior, but also that collected by L. W. Stevenson from the Gulf Coast and Atlantic seaboard, plus the extraordinary Texas collections of that outstanding amateur collector, James Conlin. Bill and I wrote many papers, and in our later contributions teamed up with Neil Landman of the American Museum of Natural History in New York, working together on scaphites and much else, work which continues to the present day.

I return to my thesis. After a summer's collecting, I laid out my ammonites, and began to attempt to identify them. In the 1960's, the literature on UK chalk ammonites consisted principally of the Sowerby's *Mineralogy Conchology* (1812-1846), Mantell's *Fossils of the South Downs* (1822), Sharpe's incomplete Palaeontographical Society Monograph *Description of the fossil remains of Mollusca found in the Chalk of England* (1853-57), a series of papers by Spath, published in the 1920's, in which many new names were introduced, without diagnosis or description, and the Wright brothers *A survey of the fossil Cephalopoda of the Chalk of Great Britain* (1951). Only their 1949 revision of *Discohoplites* and *Hyphoplites* included actual photographs of specimens.

The revision of the ammonites of the Chalk of the UK was to take forty years, and was the conclusion of a collaboration with Willy Wright, that most professional of amateurs, of whom I have written elsewhere (*Proceedings of the Geologists' Association*, **117**, 2006, 9-40). Wright's professional career was as a Senior Civil Servant in Whitehall, first in the War Office, and thereafter in the Department of Education. His first published contribution appeared when he was fifteen; in all almost 150 articles and monographs bear his name. Best known are his contributions on Cretaceous ammonites to the 1957 and 1996 *Treatise* volumes, together with Palaeontographical Society Monographs on ammonites, crabs (with Joe Collins), and echinoids (with Andrew Smith). I had first met Willy in 1964, but our collaboration only began in the 1970's, facilitated by his election to a Research Fellowship at my Oxford college, Wolfson. We wrote many papers together. Our first Palaeontographical Society Monograph, dealing with the ammonites of the Plenus Marls and Middle Chalk appeared in 1981; that on the Lower Chalk saw parts appearing in 1983, 1985, 1990, 1995, and 1996; following his death in 2010, I completed part 6 in 2015, and the concluding part, co-authored with Andy Gale, appeared in 2017. The third monograph, on the ammonites of the Upper Chalk, published in two parts, appeared in 2019 and 2020, forty years on from when it all began.

The sedimentology of the Lower Chalk was part and parcel of my thesis. I described the trace fossils, and recognised the clay-rich and clay-poor cycles as in part at least primary in origin. Although I had read Zeuner's (1952) Dating the Past, I never made the critical link to Milankovitch cycles. More successful was collaboration with Bob Garrison of Santa Cruz in the 1970's during his sabbatical leave in Oxford, leading to publications on early diagenetic nodular chalks and hardgrounds, and late diagenetic solution seams and flaser structures, published in 1975 and 1977 respectively. Field work in connection with the latter contribution was not without incident. We visited the cliff sections east of Dover Harbour. This involved descending the vertical rock-cut zig-zag path of Langdon Stairs, the final few metres descended by rope. The unobserved rising tide left us stranded on a major landslip, with plenty of time for detailed observations until dusk, when the tide fell enough for us to wade, waist deep, back to a very wet rope.

Exploration Manager Richard Hardman, at that time based in Stavanger, recognised similar structures in the Maastrichtian and Paleocene chalks of wells in the Norwegian and Danish sectors of the Greater Ekofisk area of the North Sea Central Graben, and this led to my logging cores from dozens of wells, and developing depositional models that recognised autochthonous facies comparable to the rhythmically bedded Lower Chalk of southern England, and allochthonous facies including laminated chalks (interpreted as contourites), turbidites, and debris flows, together with widespread evidence of large – and small-scale slumping and down-slope movement, including the re-deposition of reservoir quality chalks into poorer quality autochthonous sequences.

In conclusion, the Cretaceous has served me well, as has the rock that gave its name to the system. I hope I have repaid my debt in documenting its record.

EDUCATION:

1954-61:	Quintin School, Regent Street and St. John's Wood, London.
1961-64:	King's College, London, graduated with First Class Honours degree in Geology.
1964-66:	Research at King's College, London; Ph.D. accepted 1968. Title: "The Lower Chalk of South-East England with particular reference to the depositional diagenetic and stratigraphic features".

CAREER:

1967	Departmental Demonstrator in the Department of Geology and Mineralogy (now Earth Sciences), Oxford
1968	University Lecturer, Oxford
1970	Elected Fellow of Wolfson College, Oxford
1976	Curator of Geological Collections in the Oxford University Museum of Natural History (jointly with full University Lecturer's duties)
1978-1981, 1986-1989,	Principal Curator of University Museum (jointly with full University Lecturer's duties and Curatorship of Geological Collections)
1996	Awarded title of Professor Earth Sciences
2003	Elected Emeritus Fellow, Wolfson College, Oxford
2003	Elected Fellow of Kellogg College, Oxford
2003	(October) to ***2010*** (September) Director of the Oxford University Museum of Natural History
2010	Elected Emeritus Fellow of Kellogg College, Oxford

AWARDS

Tennant Medal (1964), King's College London
Daniel Pigeon Fund (1970), Geological Society of London
Henry Strakosh Bequest 1969 (to South Africa)
Hobson Bequest, 1972 (British Association)
First Lindemann Fellow (English Speaking Union) to the U.S.A., 1973-1974
D.Sc. (Oxford), 1987
Prestwich Medal of the Geological Society, 1990
Neville George Medal of the Glasgow Geological Society, 1992
Gold Medal for Zoology of the Linnean Society, 2002

PUBLICATION LIST OF WILLIAM J. KENNEDY

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THE GIANTS OF THE CRETACEOUS:

THE STORY OF IDEAS

by William James Kennedy

THE SOWERBYS: JAMES (1757–1822) AND JAMES DE CARLE (1787–1871)

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Trained at the Royal Academy, James Sowerby is best-known for his botanical illustrations in works such as *Flora Londiniensis* (1777-1798), Sibthorp's *Flora Graeca* (10 volumes, 1806-1840), *English Botany, or coloured figures of British Plants*… (1790-1813, 96 volumes, with 2,592 coloured plates), and *A Specimen of the Botany of New Holland* (1793-1795), the first monograph of the flora of Australia. There were also exquisitely illustrated works on fungi, animals, minerals, and fossils. Chief amongst the last, both written and illustrated by Sowerby, was *The Mineralogy and Conchology of Great Britain; or coloured figures and descriptions of the remains of testaceous animals or shells, which have been preserved at various times and depths in the earth*. Following his death, the project was completed by his son James de Carle Sowerby, who was also a distinguished botanist, mineralogist and illustrator, co-founder, and, for 30 years, secretary of the Royal Botanic Gardens at Kew. This work was published between 1812 and 1845 in seven volumes, with 648 hand-coloured plates, issued in 113 parts. The illustrations record the specimens with an exacting attention to accuracy and detail not matched until the introduction of photographic illustrations. Examples of some of the plates together with photographs of the specimens are displayed here.

James de Carle Sowerby was also the illustrator of a number of other key geological publications: Fitton's *Observations on the strata between the Chalk and the Oxford Oolite, in the south-east of England*, published in the *Transactions of the Geological Society* for 1836, and Dixon's *The geology and fossils of the Tertiary and Cretaceous Formations of Sussex* (1850).

HANNS BRUNO GEINITZ (1814–1900)

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Born in Altenburg (Thuringia, Germany), Geinitz started his geological education in 1834 at the Friedrich-Wilhelms University of Berlin (today the Humboldt University). Among his teachers was Professor Friedrich August Quenstedt who aroused his interest in 'Geognosie and Petrefaktenkunde' (geology and palaeontology). Three years later, Geinitz moved to Jena where he completed a PhD thesis on the Thuringian Muschelkalk (Middle Triassic) at the Friedrich-Schiller University in August 1837, supervised by Prof. Johann Wolfgang Döbereiner. In 1838, Geinitz moved to Dresden and accepted a position as a lecturer at the Technische Bildungsanstalt, the precursor institution of the Technical University of Dresden. He immediately began geological and palaeontological investigations on the Cretaceous strata in and around Dresden, and started to work on his first major monographic publication, the quadripartite *Charakteristik der Schichten und Petrefacten des sächsischen Kreidegebirges* (Geinitz 1839–1843). In 1847, Geinitz was appointed Inspector of the Königliches Naturalienkabinett (the Royal Natural History Cabinet), located in the famous Dresden Zwinger. Four years later (1851), the Technische Bildungsanstalt offered him a chair in Geology and Mineralogy, and he continued to lecture at the institution until 1894. Geinitz also held his leading position in the Natural History Cabinet and one of his main achievements was the separation of the 'Mineralienkabinett' (Mineral Cabinet) from the host institution as the new Royal Mineralogical Museum in 1857. Until his retirement in 1898, he was the first director of this museum (today the Museum of Mineralogy and Geology of the Senckenberg Natural History Collections Dresden). During his directorate, the geological and palaeontological collections were continuously enlarged, completely restructured and carefully catalogued; Geinitz developed the museum into one of the leading geoscientific institutions of the second half of the 19th century. Geinitz died on 28th of January 1900 in Dresden.

Geinitz was – as we would say today – a workaholic, and produced, alongside his teaching commitments at the university and his administrative duties as head of the Royal Mineralogical Museum, about 300 scientific publications related to various geological, mineralogical and palaeontological topics such as middle Palaeozoic fossils from the 'Sächsische Grauwackenformation', and the stone coals in Germany, and his famous monograph on the Permian System (Geinitz 1861–1884: *Dyas oder die Zechsteinformation und das Rothliegende*). However, his main preference was the Cretaceous System and his best-known works are, beside his early *Charakteristik* (Geinitz 1839–1843), the *Quadersandsteingebirge oder Kreidegebirge in Deutschland* (Geinitz 1849) and his *Das Elbthalgebirge in Sachsen* in two volumes (part 1: Geinitz 1871–1875; part 2: Geinitz 1872–1875). These major monographs remain benchmark publications, and Geinitz described and illustrated numerous Cretaceous fossils on beautiful and scientifically accurate folio plates in them, also introducing many new species. A complete list of Geinitz's published works can be found in Kühne (2014) while Niebuhr (2014) compiled a list of his publications on the Cretaceous.

Geinitz was very progressive in his scientific views and he received several important awards for his scientific achievements: the Murchison Medal of the Geological Society of London in 1878 and the Cothenius Medal of the Academia Leopoldina in 1894. He was also was in regular scientific exchanges with many internationally renowned colleagues from many different countries, such as Leopold von Buch, Alcide d'Orbigny, Joachim Barrande, Roderick Impey Murchison, and *James Dwight Dana*. Nevertheless, in a bout of national pride Geinitz also coined the famous dictum: "Science is international, but Mineralogy is Saxonian".

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ALCIDE DESSALINES D'ORBIGNY (1802-1857)

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Alcide d'Orbigny was born in Couëron (Loire-Atlantique). He inherited a passion for natural history from his father, who practiced medicine there.

His first major contribution came in 1826, with the publication of his *Tableau mëthodique de la classe des céphalopodes*, published in the *Annales des Sciences.* He introduced the term foraminifera for these minute organisms; their true nature being recognised by Dujardin in 1835. In June 1826 he boarded the corvette *La Meuse,* and for seven years and seven months made observations on the fauna and flora of South America. The results were published in his *Voyage en Amérique Méridionale* in ten volumes with 500 plates.

Three of his key works are relevant in the present context.

Paléontologie française: Terrains crétacés. 1. Céphalopodes (1840-1842) is a benchmark paper for all working on Cretaceous ammonites, describing, in all, 250 species of belemnites, nautiloids, and ammonites. Examples of his figures, and the sometimes fragmentary material his reconstructions were based on are shown here.

Volume 2 of his *Prodrome de Paléontologie stratigraphique universelle des animaux Mollusques & rayonnés faisant suite au cours élémentaire de Paléontologie et de Géologie stratigraphiques,* published in 1850, is a comprehensive listing, by stages, of Jurassic, Cretaceous, and Tertiary fossils.

His *Cours Elementaire de Paléontologie et de Géologie Stratigraphiques,* published between 1849 and1852, sets these works in the overall context of his view of earth history.

And d'Orbigny gave us that fundamental unit of geology, the étage (stage), the Aptien in 1840, Albien in 1842, Cénomanien in 1847, the Turonien and 1842, and the Sénonien, also in 1842. We owe him a considerable debt, and continue to debate their definition.

DANIEL SHARPE (1806–1856)

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Daniel Sharpe was born in Nottingham Place, Marylebone, in north London on April 6th, 1806 – less than six months after the battle of Trafalgar. His mother died two weeks after his birth, and his father, a brewer, just over six months later. He and his five siblings were brought up by his half-sister in Stoke Newington, where he attended school. He moved to Mr Coogan's school in Walthamstow, where he acquired a good knowledge of the classics. He entered the counting house of Van Zeller, a Portuguese merchant in London, at the age of sixteen, where he remained for eight years, spending a year in Portugal in 1825. On his return, he joined his elder brother Henry, and developed a career in the trade with Portugal, where he made numerous visits, and lived there between 1835 and 1838.

Sharpe was elected to the Geological Society in 1827 at the age of 21, and published across a wide range of geological topics: from the geology of Portugal; the structure of the Alps; the Lower Palaeozoic rocks of Westmorland and north Wales; to the study of foliation and cleavage, recognizing that deformed fossils recorded the deformation of the rocks they were found in. His contributions to palaeontology were substantial: in his first paper he described a Jurassic ichthyosaur. His contributions on the geology of Portugal were extensive, and included a description of the ubiquitous Tethyan oyster *Exogyra olisiponensis*. He described Charles Lyell's Palaeozoic molluscs and brachiopods from the United States, and Charles Darwin's Falkland shells.

Sharpe's last work was the Palaeontographical Society Monograph *Description of the fossil remains of Mollusca found in the Chalk of England. Cephalopoda*, published in three parts (1853, 1855, 1857) (the title page and index were added in December 1909). Sharpe clearly intended to continue with the project and deal with other molluscan groups found in the Chalk. This was not to be. He died on May 31st 1856, having fractured his skull when thrown from his horse while out riding near Norwood in south London, within months of being elected President of the Geological Society. His collections are now to be found in the Natural History Museum in London, and the British Geological Survey at Keyworth, Nottinghamshire.

Apart from his geological expertise, he was a respected philologist in his day, publishing appendices on Lycian coins and inscriptions to Sir Charles Fellows's second account of his researches at Xanthus in south-western Turkey, and Spratt and Forbes' travels in Lycia, Milyas, and the Cibyratis, in the same region.

FERDINAND STOLICZKA (1838–1874)

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All work on the fossil invertebrate faunas of south India is founded on the extraordinary contribution of Ferdinand Stoliczka, a summary of whose life and work is set out below. Stoliczka was born near Kromeriz in the Slin region of Moravia, in what is now the Czech Republic, on June 7th 1838. His father was a forester in the employ of the Archbishop of Olomouc. He studied geology in Prague and Vienna under Eduard Suess and Rudolf Hoernes, and graduated with a doctorate from the University of Tübingen in November 1861. He joined the Imperial Geological Institute of Austria and published on recent and fossil bryozoans, as well as the fauna of the Gosau Group. Stoliczka joined the Geological Survey of India in 1862, and was tasked with describing the Cretaceous faunas of south India, publishing monographs on the Cephalopoda, Gasteropoda, Brachiopoda, Bivalvia, Echinodermata and other invertebrateand vertebrate goups in *Palaeontologica Indica* between 1870 and 1873. As his obituary notes, this extends to around 1500 pages, illustrated by 178 plates, an extraordinary contribution from a man in his twenties and early thirties. Palaeontology apart, there were also publications on Indian mammals, birds, reptiles, molluscs, bryozoans, arachnids, coleoptera, and corals, and there are bats, birds, butterflies, fish, lizards, mammals and snakes that bear his name. Added to this, he lent his name to Stoliczka Island, the northernmost island of the Franz Joseph Archipelago (81° 11', 58° 16') in the Arkhangelsky Oblast of the Russian Federation.

Stoliczka took part in a series of expeditions visiting Burma, Malaya, the Andaman and Nicobar Islands, Kutch, and the Ladakh Valley, on which he contributed numerous publications. His final expedition was to Turkestan, as part of the Second Yarkan Mission. He suffered severe headaches as the expedition crossed the Karakorum Pass (altitude 5580 m); on the 18th of June he set off to examine a sequence of dolomitic limestones and shales, in spite of deteriorating health. He died (of chronic mountain sickness) at Moorghi in Ladakh on June 19th 1874, ten days after his 36th birthday. There is a monument to his memory in the Moravian Mission Cemetery in Leh, in Jammu and Kashmir.

ÉDOUARD GUERANGÉR 1801–1895

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Édouard Guerangér was born in Sable-sur-Sarthe. He moved to Lemans, and was a practicing pharmacist until ill-health forced him to retire in 1843, at the age of 42. He was a typical naturalist of his time, with a range of interests spanning botany, zoology, chemistry, and geology. An outstanding collector, his collecting began in the quarries near his home in the quartier Sainte-Croix in Le Mans. He was a friend and correspondent of Alcide d'Orbigny, and sent him many specimens that were figured and described in the formers' *Paléontologie Française*. His *Répetoire paléontologique de la Sarthe* was published in 1853, and his *Album paléontologique de la Sarthe* in 1867. The latter included 25 photographic plates of several hundred fossils from his own collection, and is one of the earliest palaeontological publications illustrated by photographs. A second publication on the Turonian fossils of Sarthe was produced in a small number of folio copies, and a miniature, pocket edition, but never reached publication.

Guéranger's collections are preserved in the Musée Vert in Le Mans, but of the eight plates of ammonites, illustrated here, only those illustrated in plate eight survive. Gueranger's work was little known in later years, until L.F. Spath came across a copy in the library of the Natural History Museum in London, and in 1926 used Guerangér's figures as the basis for a series of new species, introduced without diagnosis or description, some of them lost, and others of problematic affinities:

– "*Mantelliceras rowei* nom. nov. = *Amm. couloni*? Gueranger (non d'Orbigny), Album Paléontologique, Le Mans, 1867, pl. v., fig. 1" ..... This is an upper Cenomanian *Eucalycoceras*;
– "*Metacalycoceras boehmi*, nom. nov. = *Ammonites navicularis* Guéranger, non Mantell, *loc. cit.*. 1867, pl. v., fig. 5." ..... Affinities uncertain;
– "*Metacalycoceras guerangeri*, nom. nov. = *Am. rhotomagensis* (?Lamarck) in Guerangér, *loc. cit*., 1867, pl. 1v., fig. 4" ..... The specimen survives. It is a *Calycoceras* (*Proeucalycoceras*), and a lower upper Cenomanian zonal index;
– "*Metacalycoceras* (?*Paracalycoceras*) *subwiesti* nom. nov. = *Am. mantelli*, Guéranger (non Sowerby), pars, pl. vi., fig. 2 only" ..... The specimen is from "Saint Calais, ou elle occupe un niveau inférieur à celui de *Trigonia crenulata*." It may be a *Calycoceras* (*Proeucalycoceras*);
– *Acompsoceras pseudorenevieri* nom. nov. = *Am. renevieri* Guéranger non Sharpe, loc. cit., 1867, pl. vii, fig. 4." ..... A species of *Acanthoceras.*

CLEMENS AUGUST SCHLÜTER (1835–1906)

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Clemens Schlüter was born in Coesfeld, Westphalia. He joined the staff of Bonn University in 1873, and rose to the position of Professor and Director of the Geologisch-Paläontologisches Institut in 1882, a post he held until his death in 1906. He was the author of more than 160 publications, the overwhelming majority on the Cretaceous of Westphalia. The first, published in 1859, dealt with fossil fish from Baumberg; his last palaeontological contribution, published in 1902, dealt with holasteroid echinoids. In the intervening years there were publications on Cretaceous sponges, corals, bivalves, gastropods, ammonites, nautiloids, belemnites, echinoids, crinoids, crustaceans, fish, and reptiles, regional stratigraphy, and biostratigraphy.

There were two major contributions on cephalopods: *Beitrag zur Kenntniss der jüngsten Ammoneen Norddeutschlands* (1867) and *Cephalopoden der oberen deutschen Kreide* (1871-1876). In the former the illustrations are idealised; in the latter specimens are illustrated with judicious restoration. Examples of plates from both publications, and photographs of the specimens figured, are set out here. In both works, all planispirally coiled species are referred to a single genus: *Ammonites*.

The concluding section of Schlüter's *Cephalpoden* sets out the sequence of Upper Cretaceous ammonite faunas in Germany, with zones recognised that are still in use today. These include those of *Ammonites Rotomagensis* and *Holaster subglobosus* in the Cenomanian; *Inoceramus Brogniarti* and *Ammonites Woollgari* in the Turonian; *Ammonites margae* and *Inoceramus digitatus* in the 'Emscherian' (a term introduced by Schlüter), and *Heteroceras polyplocum*, *Ammonites Wittekindi* and *Scaphites pulcherrimus* in the 'Ober-Senon'.

FRANZ KOSSMAT (1871–1938)

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Kossmat was born in Vienna, and began his geological education at the University of Vienna in 1890. Under the direction of Professor Wilhelm Waagen, he began the systematic revision of a large collection of Cretaceous cephalopods from the Trichinopoly district in south India. These had been collected in 1892–1893 by Dr. H. Warth, at that time deputy superintendent at the Geological Survey of India and temporary director of the Madras Museum, and sent to Waagen for further study. Additional material came from William King, then Director of the Geological Survey of India in Calcutta, at the request of Waagen, as did material from the Pondicherry district, collected by Warth in 1893–1894.

Kossmat finished his doctoral thesis on this material in 1894, and, based on his systematic and stratigraphic studies, produced two major contributions: *Untersuchungen* über *die Südindische Kreide-Formation*, published in *Beiträge zur Paläontologie und Geologie Österreich-Ungarns und des Orients* (1895-1898), and *The Cretaceous deposits of Pondicherri*, published in *Records of the Geological Survey of India* (1897).

Ferdinand Stoliczka, writing 30 years earlier, had referred all of his normally coiled ammonites to the genus *Ammonites*. In contrast, Kossmat's publications have a more contemporary feel, the result of the introduction of a host of ammonite genera, notably by Melchior Neumayr in his 1875 publication *Die Ammonitiden der Kreide und die Systematik der Ammonitiden*. Kossmat was also able to correlate the Indian material he studied to the European sequence and stages. He produced the correlation table shown here in the *Records* in 1897 and published an extensive discussion in the *Beiträge* in 1898.

Kossmat's later career followed a very different course. As a geologist at the Kaiserlich-Königliche Geologische Reichsanstalt (today the Geological Survey of Austria) he was heavily involved in mapping projects between

1895 and 1909. He qualified for office at the University of Vienna, under the supervision of Eduard Suess, and was appointed Professor of Mineralogy and Geology at the Technische Hochschule in Graz in 1911. In 1913, he was appointed Professor of Geology and Palaeontology at the University of Leipzig, a position that included the directorates of both the Geological-Palaeontological Institute and the Sächsische Geologische Landesanstalt (the Geological Survey of Saxony), posts he held until his retirement in 1934. His researches extended from eustasy to tectonics and palaeogeography, and he was a firm opponent of Alfred Wegner's theory of continental drift.

ALBERT DE GROSSOUVRE (1849–1932)

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Marie Félix Albert Durand de Grossouvre was born in Bourges (Cher). He attended the École Polytechnique and the École des Mines in Paris, and was employed as a mining engineer in his home town, and appointed Ingénieur et chef des mines in 1889. His work and publications spanned hydrogeology, studies on phosphates (1885), iron ores (1886), and cartography (the geological map sheets Issoudun, Châteauroux, and Valencay). There were regional and stratigraphic studies on both the Jurassic and Cretaceous of France. The latter dealt with Touraine and Maine (1899, 1900), the Pyrénées (1892), Loire-Inférieur and the Vendée (1912), and elsewhere. A revision of the ammonite faunas of the type area of the Maastrichtian, including the Binkhorst Collection, was published in 1908.

De Grossouvre's outstanding contribution was his *Recherches sur la Craie Supérieur.* Part 2, *Paléontologie. Les ammonites de la Craie Supérieur,* was published in 1894 (but misdated 1893); parts 1, *Stratigraphie générale*, in 1901. The latter is a comprehensive review of post-Turonian stratigraphy; the adjacent figure (from Séronie-Vivien 1972) traces the progression from the original definition of the Santonian, Campanian, and Dordonian by Coquand in 1857 to his own results. Part 1 provides a comprehensive review of French post-Turonian ammonite faunas, and provided, for the first time, a well-documented and illustrated account of the ammonites of the type areas of the Coniacian to Campanian in northern Aquitaine.

De Grossouvre was an officer of the Légion d'honneur, awarded the Prix Fontaine of the Académie des Sciences, and elected a correspondent of the section minéralogie of the Academy in 1913.

His history of his birthplace, *La vieux Bourges*, was published in 1911.

ALPHEAS HYATT (1838–1902)

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Hyatt was born in Washington D.C., and at various times attended the Maryland Military Academy, Yale and Harvard universities, coming under the influence of Louis Agassiz at the latter. After graduating in 1862, he joined the Massachusetts Volunteer Infantry, and rose to the rank of captain. The civil war ended in 1865, and by 1870 he had been appointed Professor of Palaeontology and Zoology at Massachusetts Institute of Technology, a post he held until 1888. He was Professor of Biology and Zoology at Boston University from 1877, and was attached, as palaeontologist, to the United States Geological Survey from 1889. He played a leading part in the Establishment of the marine Biological Laboratory at Woods Hole.

His principal publications on fossil cephalopods include *Genera of fossil cephalopods* (1883-1884), *Genesis of the Arietidae* (1889), *Cephalopoda* in K.A. Von Zittel's *Textbook of Palaeontology* (1900), a page of which is reproduced here, *Pseudoceratites of the Cretaceous* (1902), *and The Triassic cephalopod genera of North America* (1905).

Hyatt was the author of a host of cephalopod genera; of the Upper Cretaceous Acanthoceratoidea alone, these are *Mantelliceras* Hyatt, 1903, *Sharpeiceras* Hyatt, 1903, *Acompsoceras* Hyatt, 1903, *Calycoceras* Hyatt, 1900, *Pseudaspidoceras* Hyatt, 1903, *Metoicoceras* Hyatt, 1903, *Buchiceras* Hyatt, 1903, *Metasigaloceras* Hyatt, 1903, *Choffaticeras* Hyatt, 1903, *Metatissotia* Hyatt, 1903, and *Coilopoceras* Hyatt, 1903.

A disciple of Neo-Lamarckism, Hyatt was the major proponent of the theory of recapitulation. The adjacent quote from W.J. Arkell in the 1957 *Treatise* volume gave the concept a decent burial…. (but then, the present author, in his final examinations in 1964, wrote an essay in defence of the permanence of continents and ocean basins….).

LÉON PERVINQUIÈRE (1873–1913)

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Léon Pervinquière was born in La Roche-sur-Yonne in the Vendée. He studied at the Sorbonne in Paris, under the direction of Ernest Munier-Chalmas and Émile Haug, and gained the position of Chef des Travaux Practiques de Géologie. He was the leading authority of his day on the geology and geography of Tunisia, based on years of field work in that country, beginning in 1896; in 1911 he was a member of the expedition that defined the boundary between Tunisia and Tripolitania. His thesis for the grade of Docteur-ès-Sciences naturelles, *Étude Géologique de la Tunisie Centrale*, was published in 1903. It involved a detailed survey of some 20,000 km2, and provided the material for two major monographs: *Études de paléontologie tunisienne*. I. *Céphalopodes des terrains secondaires*, was published in 1907, with 438 pages and 27 plates, and *Études de paléontologie tunisienne*. II. *Gastropodes et Lamellibranches des terrains crétacés*, with 352 pages and 23 plates, was published in 1912.

Cretaceous ammonites from the marl facies of the Cretaceous of north-eastern Algeria, most of them tiny limonitic nuclei, had been described (but for the most part not figured) in a series of monographs by Henri Coquand between 1852 and 1880. His collections were subsequently purchased by Count Andor Semsey and presented to what Pervinquière described as the 'Musée de Budapesth'. On the basis of photographs of this material, and comparable specimens collected by the soldiers and amateur geologists Philippe Thomas and Alphonse Pèron, Pervinquière produced his third major contribution, published in 1910*: Sur quelques ammonites du Crétacé algérien* (*Mémoires de la Société Geologique de France*. Paleontologie, 17, (2-3), 86 pp., 7 pls).

There is an excellent recent biography of Pervinquiére:

Castor Godard and Jean-Marc Viaud (2007) – *De la Vendée au Sahara; l'aventure tunisienne du géologue Léon Pervinquière* (1873-1913). ISBN 2-911253-33-7.

LEONARD FRANK SPATH (1882-1957)

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Leonard Frank Spath was a dominant figure in ammonitology in the first half of the twentieth century, and was regarded as a key worker in the 'English school', as opposed to the 'German school' of Otto Schindewolf and his followers, about whom his comments were generally negative. Spath was not, in fact English, but German by birth; his birthplace was Munich, a fact he concealed throughout his life. His parents died when he was seven or eight, and he was brought up by an aunt in Croydon, in south London. His early career appears to have been as a commercial artist, living in Chelsea. He registered for a geology degree at Birkbeck Colllege, London, in 1908-9, and graduated with a first class degree, specialising in petrology, in 1912. In that same year he joined an expedition to Tunisia; his collections, including Cretaceous ammonites, are in the London Natural History Museum. Beginning in 1912 (in which year he took out naturalisation papers), Spath was employed on a temporary basis by that museum, curating brachiopods. He was offered, and refused, a permanent post at the Museum when the left the British army in 1919. For the rest of his active career, Spath combined work at the Museum with part-time teaching at Birkbeck College. His refusal to accept a permanent position is perhaps a reflection of his unwillingness to reveal his family background, and he remained classified as an 'Unofficial Scientific Worker', remembered by his personal assistant of more than 30 years as "A very, *very* nice man. Everyone at the Museum liked him."

Spath's publications record spanned more than 40 years, with major contributions on the Triassic faunas of Greenland, and Jurassic faunas from Kutch. His major benchmark Cretaceous publication was the Palaeontographical Society *A Monograph of the Ammonoidea of the Gault*, published between 1923 and 1943, in two volumes, in all 787 pages and 72 plates. Cretaceous ammonites from around the world came to his desk in the museum for study, and there are contributions by him on faunas from South Africa, Angola, Australia, Burma (Myanmar), Grahamland in the Antarctic Peninsula, Greenland, India, Jamaica, Mozambique, and Pakistan.

Dealing with Spath's works is not without problems. For his Gault monograph he provided a list of more than fifty descriptive terms, some still in use, others (serpental, subangustumbilicate, subconcavumbilicate) now abandoned, their use in his works producing dense, challenging descriptions. As his obituarist, L.R. Cox, writing in November 1957 noted: "No author had previously founded so many new genera and species in so few words. Unfortunately this procedure gave rise to protests in some quarters, and Spath could claim to be largely responsible for the clause which was eventually added to article 27 of the Rules of Zoological Nomenclature, requiring, from 1931 onwards, the validation of any new genus or species by a verbal diagnosis."

MAURICE COLLIGNON (1893-1978)

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Maurice Collignon was born in Saint-Malo (Île-et-Villaine). He gained his baccalauréat in Paris in 1910; there he met the palaeontologist Marcellin Boule, professor at the Muséum national d'Histoire Naturelle. This contact was to set him on a voyage of research that paralleled, and then succeeded, his career as a military officer; he received his diploma from the école Spéciale Militaire de Saint Cyr in 1914, and retired in 1959 with the rank of Major General, having been appointed Commanding Officer of the Sub-Division Chambéry in 1945. In 1950 he joined the Service Géolgique d'Outre Mer as a palaeontologist, and carried out four expeditions to Madagascar, in 1952, 1953, 1954, and 1957. A copy of a page of his field notes on Maastrichtian sections in the environs of Manera is reproduced here.

Collignon's publications were chiefly on faunas from Madagascar, but there are also contributions on material from Algeria, France, Morocco, New Caledonia, Spain, and elsewhere. It was appropriate, given his military background, that his first publication in 1928-9, was on fossils from the rifle range at Diègo-Suarez in Madagascar. Other, key publications include those on the Campanian of Menabe (1948-1956), the eighteen volume *Atlas des fossils caractéristiques de Madagascar* (*Ammonites*) (1958-1971), with 658 plates and 2423 figures, ten of the volumes devoted to the Cretaceous, and his contributions to Henri Besairie's *Gélogie de* Madagascar I *les terrains sédimentaires* (1971). Collignon published on a range of groups in addition to ammonites, including corals, serpulids polychaetes, bivalves and gastropods.

The ammonite biostratigraphy of the Madagascan Cretaceous sequences and correlation with those in Europe were reviewed in 1959 at the Dijon *Colloque sur le Crétacé supérieur française*, published in 1960, and reproduced in part here.

TATSURO MATSUMOTO (1913-2009)

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Tatsuro Matsumoto was born in central Tokyo and attended the National Shizuoka High School (now Shizuoka University). His undergraduate and graduate studies were undertaken at the Department of Geology of the Faculty of Science at Tokyo University. He published his first paper whilst still an undergraduate. Graduate studies, nominally under the direction of Teiichi Kobayashi were supervised by Hisakatsu Yabe. Matsumoto joined the staff of the newly founded Department of Geology of Kyushu University in 1939 and remained there until his retirement in 1977.

Matsumoto was the author of 246 papers in English, 159 in Japanese, and 22 book chapters, on Cretaceous stratigraphy and palaeobiogeography, and the systematics and evolution of ammonites, nautiloids, and inoceramid bivalves. His researches centred on the Japanese islands, including *Fundamentals in the Cretaceous Stratigraphy of Japan* (1942-1944), monographs on Japanese representatives of the Puzosiidae (1954), Kossmaticeratidae (1955), Baculitidae (1963), Collignoniceratidae (1965-71), Nostoceratidae (1967, 1977), and Acanthoceratidae (1957-1975). There was a major contribution of the Upper Cretaceous of California (1959), and contributions on species from France, Germany, Madagascar, south India, New Guinea, Texas, and elsewhere. A key early publication entitled *Some doubtful Cretaceous ammonite genera from Japan and Saghalien*, co-authored with C.W. Wright, was published in 1954. Wright and Matsumoto corresponded over the succeeding years, as the latter's acknowledgements reveal.

Matsumoto studied ammonite collections in museums in both Europe and North America. Beneath many specimens he left brief neatly handwritten notes in English on their affinities and status, notes that saved those of us who followed him from error.

CLAUD WILLIAM WRIGHT (1917-2010)

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Claud to his contemporaries, and Willy to the rest of his friends and acquaintances, it is probably impossible to write a paper on Cretaceous ammonites without at least one Wright, C.W. reference in the bibliography, for he was the author of the Cretaceous ammonite part of the 1957 *Treatise on Invertebrate Paleontology Part L Mollusca 4 Cephalopoda Ammonoidea* (the authors arranged alphabetically, beginning with W.J. Arkell, and ending with C.W. Wright), and principal author of the 1996 *Part L Mollusca 4 revised: Volume 4: Cretaceous Ammonoidea*. But he was not a geologist by training, rather a most professional amateur, publishing his first paper, on the Yorkshire Chalk, at the age of 15. Born in Yorkshire, he attended Charterhouse, a Public (that is to say private) School in Surrey, and read 'Greats' (Latin, Greek, and ancient philosophy) at Oxford, where he encountered W.J. Arkell. Impressed by his knowledge of Dorset geology, Arkell asked him to write the Gault, Upper Greensand, and Chalk chapters of the Geological Survey of Great Britain *Geology of the Country around Weymouth, Swanage, Corfe and Lulworth* (1947) whilst he was still an undergraduate; it was at corrected proof stage in November 1939.

Graduating in 1939, he joined the War Office as Assistant Private Secretary, two weeks before war broke out, and did military service. He returned to the War Office where he rose to the rank of Assistant Secretary of State, transferring to the Department of Education as Deputy Secretary in 1971, and retired in 1977. Throughout this exacting career, he wrote about ammonites and much else, and co-authored Palaeontographical Society monographs on Cretaceous crabs (1972: with J.S.H. Collins), echinoids 1989-2012 with A.B. Smith), and Chalk ammonites (1981-1996 with W.J. Kennedy); in all, over 150 publications bear his name.

And the *Treatise*? It was banged out on an ancient manual typewriter, with carbon copies retained, the originals sent off to the States. Wright regarded it as a text-book, and took the view that genera were things that should be "about the same size….."

For a fuller account of this remarkable man, see: Kennedy, W.J. (2006) C. W. Wright: a most professional amateur. *Proceedings of the Geologist's Association*, 117, 9-40.

WILLIAM AUBREY "BILL" COBBAN (1916–2015)

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Bill Cobban was born in Anaconda, Montana, and brought up in nearby Great Falls. He graduated from the University of Montana in 1940, and began working for the Carter Oil Company (now Exxon Mobile). He enrolled for a doctorate at Johns Hopkins University in 1946, and gained his doctorate in 1949. He joined the United States Geological Survey in 1948, and was initially based in Washington D.C., before moving to Denver in the early1950's, where he remained for the rest of his career.

This poster illustrates three examples of his researches on the Cretaceous of the United States Western Interior. The first is the joint 1960 publication with J.B. Reeside on the Ammonites of the Mowry Shale, and the recognition of intraspecific variation in *Neogastroplites*. The second is his work on scaphites. His 1951 *USGS Professional Paper* (based on his Ph.D. thesis) recognised their stratigraphic value in the Turonian to Santonian Colorado Group, whilst the 1969 *Professional Paper* 619 described the evolution of, and dimorphism in, members of the upper Santonian-lower Campanian *Scaphites leei-Scaphites hippocrepis* lineage. The third is his work on the Pierre Shale, and the construction of a refined biostratigraphic framework based on the morphologically diverse heteromorphs, many of them unique to the sequence. This last area of research provides the basis for the reconstruction of sea level and shoreline fluctuations in the United States Western Interior, and the linking of numerical ages from bentonites to the faunal sequence. In all, his work identified 60 ammonite zones in the interval extending from the middle Cenomanian to the Campanian/Maastrichtian boundary .

A biography of Cobban, and his reminiscences can be found in *Acta Geologica Polonica*, volume 66 (2016), and a complete list of his more than 300 publications in *The Journal of Paleontological Sciences*: JPS.H.07.001.

ABSTRACTS

TIMING AND TEMPO OF DECCAN VOLCANISM RELATIVE TO THE K/PG EXTINCTION REVEALED BY MERCURY AND TELLURIUM ANOMALIES

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Mercury (Hg) and, more recently, tellurium (Te) are indicators of large-scale volcanism in marine sediments and provide new insights into relative timing between biological and environmental changes, mass extinctions and delayed recovery (Grasby et al. 2019; Regelous et al. 2020). Several studies have evaluated the relationship between Hg anomalies in sediments and LIP activity across mass extinction horizons. The bulk (80%) of Deccan Trap eruptions occurred over a relatively short time interval in magnetic polarity C29r. U-Pb zircon geochronology reveals the onset of this main eruption phase 350 kyr before the Cretaceous-Paleogene (K/Pg) mass extinction (Schoene et al. 2019). Maximum eruption rates occurred before and after the K/Pg extinction, with one such pulse initiating tens of thousands of years prior to both the bolide impact and extinction, suggesting a cause-and-effect relationship (Keller et al. 2020). We present a comprehensive high-resolution analysis of Deccan Traps Hg loading, climate change and end-Cretaceous (KPB) mass extinction from a transect, which includes 30 sections deposited in both shallow and deep environments. In all sections, results show that Hg concentrations are more than two orders of magnitude greater during the last 100 kyr of the Maastrichtian up to the Early Danian P1a zone (i.e., the first 380 kyr of the Paleocene). Hg anomalies generally show no correlation with clay or total organic carbon contents, suggesting that the mercury enrichments resulted from higher input of atmospheric Hg species into the marine realm, rather than organic matter scavenging and/or increased run-off. Significant and coeval Hg enrichments are observed in multiples basins characterised by proximal and distal, as well as shallow – and deep-water settings, supporting a direct fallout from volcanic aerosols. Hg isotope data from Bidart confirm a direct Hg fallout from volcanic aerosols. Te/Th ratios measured in both the Goniuk (Turkey) and Elles (Tunisia) sections show the same trend as Hg/TOC and are consistent with a volcanic origin, albeit a minor extraterrestrial contribution of Hg to the boundary cannot be excluded. Te and Hg are, however, not correlated with iridium contents in the K/Pg interval and are consequently not related with impact and maximum eruption rates occurred before and after the K/Pg extinction, with one such pulse initiating tens of thousands of years prior to both the bolide impact and extinction.

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GEOCHEMICAL AND CALCAREOUS NANNOFOSSIL EVIDENCE OF TWO LATE BARREMIAN EPISODES OF ENVIRONMENTAL CHANGE IN SOUTH-EAST SPAIN

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Several episodes of environmental change (EECs), corresponding to reinforced greenhouse conditions and characterized by shifts in the C-isotope record and occasional deposition of organic mud, occurred during the Early Cretaceous (Föllmi 2012). Here we present geochemical and biotic evidence for two Late Barremian EECs recorded from pelagic successions of argillaceous limestones and marlstones of the Subbetic Domain (Betic Cordillera). New C – and O-isotope data are provided for the Barranco de Cavila, Río Argos, Cortijodel Hielo and La Frontera sections. These data cover the interval comprised between the *Gerhardtia sartousiana* and *Deshayesites forbesi* ammonite zones (Upper Barremian–Lower Aptian). C – and O-isotope data record pronounced negative excursions within the *Hemihoplites feraudianus* ammonite subzone (intra-Feraudianus negative excursion, IFeNE) and *Martelites sarasini* ammonite zone (intra-Sarasini negative excursion, ISNE). The IFeNE would represent a new EEC to be recorded in the pelagic basin of the Southern Iberian Palaeomargin (Western Tethys). Whether this EEC had only regional or more widespread effects remains unclear. High-resolution quantitative studies of calcareous nannofossil assemblages have allowed the application of a refined biostratigraphy and identification of the nannoconid decline (ND) and the wide canal>narrow canal (wc>nc) Event (Aguado et al. 2022). Both bioevents are directly correlated to the standard Mediterranean ammonite zonation for the first time, and to the geochronological time scale by using astrochronologically tuned cyclostratigraphic data (Martinez et al. 2020). The ND

(122.4 Ma) is located within the *H. feraudianus* ammonite subzone and the wc>nc Event (122.0 Ma) within the lower part of the *M. sarasini* ammonite zone. A quantitative analysis of calcareous nannofossil assemblages has revealed significant variations in environmental conditions during deposition of the interval studied. The recorded increases in absolute and relative abundances of *Rhagodiscus asper*, concomitant with inceptions of the ND and the wc>nc Event and with the two observed negative C-isotope excursions, point to oceanic surface-waters warmings. These episodes of rising abundances of *R. asper* coincide with increases in *Biscutum* spp., *Discorhabdus ignotus* and *Zeugrhabdotus noeliae*, suggesting surface-water eutrophication. Elemental and organic geochemistry evidence suggests coeval environmental, sedimentary and biotic changes.

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ASTROCHRONOLOGY OF THE APTIAN –ALBIAN TRANSITION: A CASE STUDY FROM THE VOCONTIAN BASIN, FRANCE

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The OAE 1b at the Aptian–Albian transition is characterised by a cluster of black shale layers which seem to be rhythmically paced. In order to determine to which extent orbital forcing was at the origin of this pacing, our study provides an astronomical sequencing of the OAE 1b from the Jacob to the Leenhardt events, at the Col de Pré Guittard section (Albian GSSP, Vocontian Basin, south-east France; Kennedy et al. 2017). The section belongs to the Blue Marls Formation and consists of a thick marl series interrupted by thin limestone and dark, organic-rich layers, which constitute marker beds that are identified throughout the basin. We sampled bulk rock every 5 cm and measured mass-normalised magnetic susceptibility using a Kappabridge KLY-3S. Rock-Eval and carbon-isotope analyses on organic carbon were also done to locate these events precisely in the sections studied. Spectral analyses register the imprint of an orbitally driven forcing according to Milankovitch cycles ratio (eccentricity, obliquity and precession cycles). The interval starting from the Jacob level and ending in the Leenhardt level contains 41 repetitions of the 100-kyr eccentricity in magnetic susceptibility data, leading to a duration of c. 4.1 myr. This duration is consistent with that of 4.1 myr provided by the current geologic time scale (Gale et al. 2020). From our sequencing, we calculated the duration between the Jacob and Kilian events at 1.6 myr, the duration between the Kilian and Paquier events at 1.3 myr, and the duration between the Paquier and Leenhardt events at 0.9 myr. Thus, the long orbital cycles are not responsible for the pacing of the anoxic events at the Aptian–Albian boundary and other causes (volcanism, palaeobathymetry, local changes in productivity) must be found. However, the anoxic events always occur 100-kyr prior to maxima in the 405 kyr eccentricity, meaning that the change in seasonality linked to the 405-kyr eccentricity forced the inception of anoxic conditions, within a specific tectonic or geodynamic setting.

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BENTHIC FORAMINIFERAL ASSEMBLAGES AND PALAEOENVIRONMENTS ACROSS THE CENOMANIAN–TURONIAN BOUNDARY INTERVAL AND THE OAE 2 AT CLOT CHEVALIER (VOCONTIAN BASIN, SOUTH-EAST FRANCE)

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The Cenomanian–Turonian boundary interval is characterized by environmental perturbations related to the global Oceanic Anoxic Event 2 (OAE 2) that severely affected the marine biota, including benthic and planktic foraminifera. We present a continuous high-resolution benthic foraminiferal record in combination with published planktic foraminiferal (Falzoni et al. 2016) and geochemical data (Gale et al. 2019), with the aim to define benthic foraminiferal biozones and to compare palaeoceanographical changes in surface and bottom waters across the Cenomanian–Turonian boundary interval in the Vocontian Basin. Samples were processed using acetic acid according to the standard laboratory procedure to obtain washed residues for micropalaeontological studies. In general, the benthic foraminiferal assemblages are characterized by low diversity and by marked changes in abundance throughout the stratigraphical section. In the Middle Cenomanian interval below the OAE 2, the benthic foraminiferal assemblages show the highest diversity and abundance of infaunal (e.g., *Textularia chapmani*, *Gaudryina pyramidata*, *Spiroplectinata compressiuscula*, *Spiroplectammina* sp., *Ammobaculites* sp.) and epifaunal (e.g., *Glomospira charoides*, *Ammodiscus cretaceus*, *Trochammina* sp.) agglutinated taxa, suggesting an upper-middle bathyal environment with relatively oxic conditions at the seafloor. The calcareous benthic foraminiferal assemblages are composed of cosmopolitan taxa including *Lingulogavelinella turonica*, *Gavelinella intermedia*, *Lenticulina rotulata* and gyroidinids. In contrast, the microfossil assemblages in the Upper Cenomanian interval within

the OAE 2 are dominated by Radiolaria (> 50%), and characterized by the presence of benthic calcareous epifaunal forms such as *Lingulogavelinella asterigerinoides*, *Gyroidinoides* sp., and of few infaunal agglutinated forms (e.g., *Ammobaculites* sp., *Bulbobaculites problematicus*). These assemblages suggest intense eutrophication and near-anoxic conditions at the seafloor in agreement with the highest values of Total Organic Carbon registered over this interval. In the lowermost Turonian, in the interval within the OAE 2 where the $\delta^{13}C$ curve begins to decrease to pre-excursion values, the assemblages show the re-occurrence of the pre-anoxia fauna. The progressive decrease of agglutinated forms and increase of lingulogavelinellids, laevidentalinids and gyroidinids typical of suboxic environments, indicate a relatively rapid re-oxygenation of bottom waters. Our results show that the distribution of benthic foraminifera strongly follows oxygenation and carbon export flux fluctuations at the seafloor during the OAE 2, delineating an interval with severe dysoxic conditions that reflect a strengthening of the Oxygen Minimum Zone, likely related to increased primary production at the ocean surface.

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NO EVIDENCE FOR LONG-TERM BOTTOM ANOXIA DURING OCEANIC ANOXIC EVENT 1D IN DEEP ENVIRONMENTS OF THE WESTERN TETHYS: A RECORD OF BENTHIC FORAMINIFERAL ASSEMBLAGES AND CHEMICAL INDICES

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The Alternans Level, a 2.2-m-thick succession containing black non-calcareous shales in the Silesian Nappe, Western Outer Carpathians (Barnasiówka-Jasienica section) correlates with the lower part of the latest Albian–earliest Cenomanian positive carbon isotopic excursion coinciding with the Oceanic Anoxic Event (OAE) 1d. These sediments belong to a deep-water flysch succession deposited below the calcium compensation depth which contains numerous hemipelagic claystones, accumulated during 3rd order sea level rise of the KAl8 eustatic cycle (Bąk et al. 2022). We present the results of micropalaeontological and chemical analyses of both organic-rich and gray/green non-calcareous shales based on deep-water agglutinated foraminiferal (DWAF) assemblages, total organic carbon (TOC) content and selected chemical indices, which are integrated with the organic carbon isotope curve. The hemipelagic non-calcareous shales contain moderately diversified DWAF assemblages. The limited variation in their composition and relative abundance points to a conclusion about no dramatic changes in the conditions at sea floor during the OAE 1d interval. Dominance of surficial epifauna including forms with tolerance to fluctuating oxygen in the bottom water, and significant decrease in number of tubular forms within the Alternans Level suggest that organic-rich shales (TOC <1.5%) may represent temporary dysoxia. There is also no dominance of disaster opportunists among the DWAF assemblages in the overlying oxidized (green) sediments, which contradicts anoxia at that time. The combination of selected elemental redox proxies (U/Th, V/Cr, Ni/Co)

do not reflect significant changes during the Albian–Cenomanian boundary (carbon isotope) interval including the OAE 1d.

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WILL THE CRETACEOUS FOSSIL RECORD HELP US PREDICT THE FUTURE OF MARINE BIOTA IN THE FACE OF MODERN CLIMATE CHANGE?

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The contemporary trend of global warming has great potential to replace modern marine biological ecosystems with ones that lack modern analogues, leaving ecologists with no observational basis to predict likely biotic effects. The fossil record has the significant advantage of containing long time series of environmental changes that can help predict future environmental responses to present-day changes. Studies of the fossil record can also provide detailed information on the rate of ecological change and pinpoint the factors behind these changes. Meanwhile, answers to the question of how modern ecosystems will react to climate change can be found through the analysis of fossil biotic assemblages performed with the appropriate data resolution and by selecting the appropriate geological formations. Taking into account these assumptions, our study on radiolarians, foraminifera and calcareous dinocysts refers to contemporary climate change, taking up the problem of the microfossil record and its relationship with climatic oscillations leading to the 'greenhouse' conditions during the Cretaceous. The background for such a research is the current rapid global warming trend as a result of human activity since the mid-20th century, proceeding at a rate that is unprecedented over decades and could well be analogous to rapid climatic changes that affected marine ecosystems during the Cretaceous. A crucial role is played by the physical interaction between ocean and atmosphere which is taking place in the tropical and subtropical zones. A recent oceanographical study emphasises the important role of the Indian Ocean in this process and demonstrates its much larger impact on climate variability than previously thought (e.g., Schott et al. 2009). Recent discoveries of a strong increase of Indian Ocean sea surface temperatures over the past decades and its relation to the increase of heat storage indicate the significant roles of the El Niño-Southern Oscillation and the recently identified Indian Ocean Dipole as important global climate drivers (e.g., Saji et al. 1999). The microfossil record from deep-marine settings in the ancient Tethys might help to study the above-mentioned global processes. The Cretaceous was a period of repeated episodes of high sea water temperatures, associated with a high sea level. Similar to the present-day Indian Ocean, the Tethys Ocean during the Cretaceous was situated along the equatorial and sub-equatorial zones. Because of this position it could then have been the main global heat storage and transfer, comparable to the Indian Ocean today (Levitus et al. 2017). In the equatorial part of the Tethys, like in the Indian Ocean today, sustained changes in the difference between surface temperatures of the tropical western and eastern part probably took place during the Cretaceous, caused by the planetary pattern of ocean-atmosphere circulation.

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FROM SHALLOW PERI-TETHYAN PLATFORM TO DEEP SILESIAN BASIN – HOW DID BIOTIC MICRO-CONSTITUENTS RESPOND TO GLOBAL SEA LEVEL AND CRETACEOUS OAE'S DURING THE LATEST ALBIAN THROUGH MIDDLE CENOMANIAN

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Our study presents an interpretation of changes in marine planktic and benthic communities (spicules of sponges, foraminifers, radiolarians) which, during the mid-Cretaceous (latest Albian–Middle Cenomanian), were intensively redeposited with carbonate mud by gravity currents from the peri-Tethyan shelf to the northern, marginal Silesian Basin of the Western Tethys (Górny et al. 2022). Quantity and composition of these microfossil constituents identified both in gravity sediments and in hemipelagic shales were modified by eustatic sea level changes and OAEs during this time interval (Bąk et al. 2022). The onset of mass redeposition of biogenic material from peri-Tethyan shelves to the Silesian Basin corresponds to the top of OAE 1d, which records a global regressive event (KAl8). Periods of intensive redeposition of sponge spicules were the result of a relative sea level fall (regressive phase of T-R cycles) corresponding to third-order eustatic sea level cycles distinguished by Haq (2014) as KAl8, KCe1, KCe2 and KCe3. Gradual reduction of this process started after the MCE Ib in relation to a drop in sea level of up to 25 m (uppermost part of the *Cunningtoniceras inerme* ammonite Zone and lower part of the *Acanthoceras rhotomagense* ammonite Zone). The record of increased content of small, globular planktic foraminifera, in turbidite sediments, during the OAE 1d corresponds to the maximum of transgression during the 3rd order KAl8 cycle. The near-complete lack of redeposited planktic foraminifera with the lowest content of biomicrite microfacies reflects regressive cycles of KAl8 and KCe1. Intensive redeposition of calcareous benthic foraminifera took place during the KCe1 and KCe2 highstand and the transgressive cycle of KCe3. The generally low diversity of radiolarian assemblages derived from suspension in the Silesian Basin and redeposited from shelf environment indicates much cooler water conditions than in the region located further south in the Tethys Ocean. The high frequency of taxa that lived below the thermocline and preferred nutrient-rich waters might point to a period of high nutrient content in the water column.

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INTEGRATED BIOSTRATIGRAPHY OF UPPER CRETACEOUS DEPOSITS IN AN EXCEPTIONAL CONTINENTAL VERTEBRATE-BEARING MARINE SECTION (TRANSYLVANIAN BASIN, ROMANIA)

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The current study focuses on the biostratigraphy and palaeoenvironmental conditions represented in a key Upper Cretaceous marine-to-continental section in the south-western Transylvanian Basin, Romania. Its importance lies in its content of fossil vertebrates belonging to the dwarf dinosaur fauna that inhabited the ‘Hațeg Island’, the best evidence yet for the advent of this unique island fauna. Our study improves the constraints on end-Cretaceous events that controlled the emergence of the dinosaur-bearing Hațeg Island. An integrated analysis of assemblages of calcareous nannoplankton, planktic/benthic foraminifera, as well as palynological material has yielded better constraints of both age and palaeoenvironmental conditions and changes occurring during deposition of the Upper Cretaceous marine-transitional

Bozeș Formation. Based on the presence of *Ceratolithoides aculeus*, these deposits are not older than the late Early Campanian, while the presence of *Reinhardtites anthophorus* and *Eiffelithus eximius* restricts their age as no younger than the late Late Campanian. The same date is also supported by the presence of the foraminifera *Contusotruncana plummerae* and *Bolivinoides decoratus* as well as of palynomorphs such as *Samlandia* cf. *vermicularia* and *Krutzschipollis crassis*. The abundance pattern of planktic foraminifera (heterohelicids, globular hedbergellids and rugoglobigerinids, as well as keeled globotruncanids) and that of *Watznaueria barnesiae* point to eutrophic cold surface/subsurface, open-marine conditions interrupted by mesotrophic to oligotrophic episodes with warm-water influxes. The composition, abundance and distribution of the benthic foraminiferal assemblages together with the calculated benthic foraminifera oxygen index suggest suboxic conditions with two short oxic intervals and fluctuations in the nutrient supply to the sea floor. The composition of planktic foraminiferal assemblages and the ratio of planktic/benthic foraminifera throughout the section point to deposition on a continental shelf with palaeoenvironments that fluctuated from inner to outer shelf. Our micropalaeontological study once again supports the need for integrated stratigraphical analyses for better, more accurate age and environmental interpretations, while our new data demonstrate the importance of the section studied for basinal and regional correlations.

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HOW PROBLEMATIC IS IT TO DEVELOP AN AMMONITE ZONATION FOR THE LOWER TO MIDDLE PART OF THE LOWER APTIAN IN AMERICA?

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As shown in another contribution by us, an Aptian ammonite zonation for the southern part of North America and Central America is being developed. We call this zonation the Aptian standard ammonite zonation for the Central Atlantic Province (= CAP) which is based on, essentially, a study of the Mexican ammonoid record. The CAP ammonite zonation has no age-diagnostic intervals for the majority of the Lower Aptian, with the exception of its uppermost part. In essence, the standard Aptian ammonite zonation for the Mediterranean Province uses, as do the Boreal and Russian zonations, the ranges of some species of the genus *Deshayesites* as index for this age interval. However, America (New World) lacks a reliable record of *Deshayesites* (Reboulet et al. 2018). This genus has been noted from Colombia and Mexico, but none of these reports is convincing and most of them certainly are incorrectly identified. This is the case for the Early Albian genus *Neodeshayesites* which resembles *Deshayesites* and, in fact, originally was listed as *Deshayesites* in Colombia. In Mexico, some Late Aptian ammonoids have been assigned to *Deshayesites*, but all of these are incorrect. In Mexico, shallow-marine carbonate facies predominated during the earliest and middle Early Aptian, and basinal facies were present only in depocentre areas of some basins where outcrops contain very poor ammonite records comprising desmoceratids of the genus *Pseudohaploceras* with no age-diagnostic value. Early Aptian ammonoid diversity in America (Colombia, Mexico, USA, Venezuela), as far as we know, seems to increase suddenly with the arrival from the Old World of the first Aptian deshayesitid, the genus *Dufrenoyia*. This important ammonite migration event is related to a marked transgression that occurred during the latest Early Aptian (e.g., Moreno-Bedmar et al. 2012 and references therein). The American ammonite record in the uppermost Lower Aptian is rich and diverse and contains several age-diagnostic taxa, standing out among them are cheloniceratids, but the most important age-diagnostic are those of the genus

Dufrenoyia. The very poor ammonite record and the apparent total absence of age-diagnostic ammonites during the lowermost to middle Lower Aptian make developing an ammonite zonation for this interval in America completely non-viable.

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UPPER ALBIAN CARBONATE FACIES AND DIAGENESIS IN THE WESTERN ISTRIAN ANTICLINE (WIA), CROATIA

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Regional unconformities and events in the shallow-marine carbonate successions of the Western Istrian Anticline (WIA) in the north-western part of the Adriatic Carbonate Platform (AdCP) (Vlahović et al. 2005) were studied within the WIAnLab project. Although shallow-marine carbonate deposits predominated on the AdCP during the Albian, as it did most of the time during the Mesozoic when the AdCP migrated and developed in the Tethyan Ocean, occasional emergences occurred (Durn et al. 2003). Upper Albian deposits document a facies shift from shallow-marine limestone with predominant benthic foraminiferal communities (including *Pseudonummoloculina heimi*, *Nezzazata* sp. and *Cuneolina* sp.) to nearly terrestrial and lagoonal environments (with charophytes and ostracods). Their characteristics and facies architecture indicate the influence of processes that occurred in variable depositional and diagenetic environments. Silicified limestones and diagenetic quartz-rich sediments accompanied by dolomites and clays have been documented. Global data on silicification of continental and near-terrestrial carbonates are generally sparser than in marine environments (Bustillo 2010). Important clues to the Late Albian palaeoenvironment, palaeoclimate and provenance have been obtained from these deposits associated with the WIA, an ideal natural laboratory for studying regional unconformities in carbonate rocks.

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ALBIAN–CENOMANIAN FAUNAL DIVERSITY OF THE EL MIZAB FORMATION (TALERHZA BASIN, NORTH-WESTERN MOROCCO)

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The Talerhza Basin is a small Cretaceous basin located in the eastern part of the South Riffian Ridges. Its stratigraphical sequence (Albian–Paleogene, 300 m thick) unconformably overlies Middle Bajocian silty marls through a polygenic conglomerate level of rounded lithoclasts from various Jurassic formations of the South Riffian Ridges. Faugères (1978) identified in this sequence ten formations. The third, the El Mizab Formation (70–120 m thick), consists of a marlstone and shelly limestone alternation, rich in oysters and containing other macrofauna. Its lower part has yielded ammonites of Late Albian age (Benzaggagh et al. 2017), including: a new species of the genus *Hypengonoceras*, *Mortoniceras* (*Deiradoceras*) aff. *albense*, *Mortoniceras* (*Deiradoceras*) *bipunctatum*, *Mortoniceras* (*Deiradoceras*) *cunningtoni*, *Mortoniceras* (*Mortoniceras*) *pricei*, *Mortoniceras* (*Mortoniceras*) *inflatum*, *Mortoniceras* (*Mortoniceras*) *fallax*, *Mortoniceras* (*Mortoniceras*) *pachys* and *Oxytropidoceras* (*Tarfayites*) cf. *bituberculatum*. Associated are irregular echinoids (*Coenholectypus neocomiensis*, *Coenholectypus* sp. and *Macraster* aff. *vatonnei*; Benzaggagh et al. 2018), gastropods (*Ampullina* aff. *uchauxiensis*, *Calliomphalus* cf. *orientalis*, Neogastropoda indet., *Pleurotomaria* indet., *Pseudamaura subbulbiformis*, *Tylostoma* aff. *globosum*, *Nerineopsis* aff. *excavata* and *Turritella* indet.; Benzaggagh 2017), plus a rich bivalve fauna (Benzaggagh 2016) composed of 28 species belonging to eighteen genera, such as *Amphidonte conica*, *Aphrodina* (*Aphrodina*) *dutrugei*, *Cucullaea* (*Idonearca*) *thevestensis*, *Cucullaea* (*Idonearca*) *trigona*, *Lopha syphax* and *Protocardia hillana*. The upper part (Lower Cenomanian) of the formation studied consists of a monospecific shelly marl and limestone alternation rich in *Rhynchostreon suborbiculatum*. Most of the taxa listed are common to several Cretaceous epicontinental basins of northern Gondwana (North Africa and Middle East), the trans-Saharan Cretaceous corridor, western Africa and the eastern South America margin.

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STRATIGRAPHY AND PALAEOENVIRONMENTS IN THE UPPER TURONIAN TO LOWER CONIACIAN OF THE SAXONIAN CRETACEOUS BASIN (GERMANY) – INSIGHTS FROM CALCAREOUS AND AGGLUTINATED FORAMINIFERA

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Upper Turonian to Lower Coniacian marls of the Strehlen Formation in the Graupa 60/1 core (Saxony, Germany) were investigated for their foraminiferal content to add stratigraphical and palaeoenvironmental information on the transitional facies zone of the Saxonian Cretaceous Basin. Further comparison with the foraminiferal fauna of the Brausnitzbach Marl (Schrammstein Formation) were carried out so as to clarify its relationship to the marls of the Graupa 60/1 core. Tethyan agglutinated marker species for the Late Turonian to Early Coniacian confirm the proposed age of the marls of the Graupa 60/1 core and the Brausnitzbach Marl. The reconstructed palaeoenvironment of the marls reflects middle to outer shelf conditions. The maximum flooding zones of genetic sequences TUR6, TUR7 and CON1 could be linked to changes in the distribution of foraminiferal morphogroups and to acmes of agglutinated foraminifera, such as *Ataxophragmium depressum*, *Dorothia conula* and *Psammosphaera fusca*. In general, a rise of relative sea level can be recognized

from the base to the top of the marls in the Graupa 60/1 core, as indicated by the planktic/benthic ratio and the agglutinated foraminiferal assemblage composition. While agglutinated foraminiferal assemblages suggest a generally high organic matter influx and variable, but high, productivity for the Graupa 60/1 core, the depositional environment of the Brausnitzbach Marl was characterized by moderate productivity and a generally shallower water depth.

CONIACIAN–SANTONIAN BOUNDARY DIACHRONISM: EXAMPLES FROM THE GSSP OF OLAZAGUTIA (SPAIN) AND TEN MILE CREEK-ARBOR PARK (USA)

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The Coniacian–Santonian OAE 3 is the last oceanic anoxic event of the Cretaceous (e.g., Wagreich 2012). The mechanisms and palaeoenvironmental conditions leading to and through this event are poorly known, more particularly the marine phosphorus cycle and changes therein, and climate conditions. The present study focuses on bulk rock and clay mineralogy, phosphorus and carbon isotope geochemistry and high-resolution biostratigraphy, to decipher changes in climate and primary productivity. Two sections from different palaeogeographical areas characterised by different palaeodepths were studied. These investigated sections were proposed as candidates for the base of the Santonian global boundary stratotype section and point (GSSP): Olazagutia (north-west Spain) and Ten Mile Creek-Arbor Park (Texas, USA) (Lamolda and Hancock 1996). The first one was finally ratified in 2013, and the base of the Santonian Stage was defined by the first occurrence of the inoceramid *Cladoceramus undulatoplicatus* (Lamolda et al. 2014). However, in the Olazagutia section, a strong diachronism is observed between the inoceramid *C. undulatoplicatus* and the nannofossils *Amphizygus minimus*, *Calculites obscurus* and *Lucianorhabdus cayeuxii*, suggesting that the occurrence of *C. undulatoplicatus* appears to occur significantly above the Coniacian–Santonian boundary, and its first occurrence appears to be environmentally controlled. Indeed, in both sections, the first occurrence of *C. undulatoplicatus* is coeval with phosphorus increase indicative of more mesotrophic conditions. However, contrary to the Olazagutia section, the first occurrence of C. *undulatoplicatus* is synchronous with the first occurrence of *A. minimus* in the Ten Mile Creek section. Furthermore, several bentonite layers are present close to the proposed Coniacian–Santonian boundary, but only one provided sufficient well-preserved zircon minerals to allow accurate age dating of the base of Santonian (82.236 Ma ± 0.063). Based on weathering index and clay mineralogy, quite similar climate changes are observed in these sections. The climate shifted synchronously from humid to relatively drier conditions near the Coniacian–Santonian boundary, followed by a return to more humid conditions during the Santonian. Fluctuations in total phosphorus contents appear mainly to have been driven by changes in detrital input and consequently by climate in both sections (Spain and Texas).

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A NEW BERRIASIAN TO CONIACIAN COMPOSITE CARBON ISOTOPE RECORD FOR THE BOREAL REALM

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High-amplitude shifts in sedimentary $\delta^{13}C$ characterize the Cretaceous System and have been proved to be of great use for supraregional chemostratigraphical correlation. Here we present an Upper Berriasian to Lower Coniacian (c. 142–88 Ma) composite carbon isotope record based on 14 drill cores, two outcrops and almost 5,000 samples. The total record comprises a composite thickness of about 1,500 m. All cores and successions are located in the larger Hannover area, which represents the depocentre of the North German Lower Saxony Basin (LSB) in Early to mid-Cretaceous times. In northern Germany, Boreal Lower Cretaceous sediments are predominantly represented by $CaCO_3$-poor mud – and siltstones of up to 2,000 m in thickness, which become carbonate richer during the Albian–Cenomanian transition and even chalkier in the Upper Cenomanian to Coniacian interval. The carbon isotope record reveals a number of global key events including the Valanginian Weissert Event, the OAEs 1a and d, as well as the Kilian Event (Aptian–Albian). For the early Late Cretaceous, the Mid-Cenomanian Event (MCE), OAE 2 (Cenomanian–Turonian Boundary Event) and the Navigation Event, among others, have been identified. All these events allow for a detailed comparison with Tethyan and other Boreal records. Thus, this new detailed chemostratigraphy provides a unique opportunity to potentially overcome many still existing Boreal–Tethyan correlation issues. The record presented here can be considered to be almost complete; however, a gap in the Lower Albian cannot be ruled out.

SHALLOW – TO DEEP - MARINE CRETACEOUS PALAEOSETTING IN THE NORTH - WESTERN BLACK SEA ONSHORE AND OFFSHORE

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In the north-western Black Sea onshore of southern Romania, within the South Dobrogea region (part of the Moesian Platform bordering on the Black Sea in the east), the Cretaceous sequence is characterized predominantly by marine sedimentation. Several palaeosetting changes, from shallow – to deep-marine deposition, are indicated, based on a study of outcrops and boreholes, some of them located offshore. During the Early Cretaceous, the area was enclosed in a carbonate platform. The sediments of the Berriasian–lowermost Aptian interval are marly limestones, oosparites, sandy clays, limestones and reef buildups of patch-reef type, with rich macrofaunas, i.e., ammonites, bivalves and brachiopods (Avram et al. 1993). Very scarce assemblages of benthic foraminifera and nannofossils are also present. Within the Lower Cretaceous, a modification is marked by the transgressive Upper Valanginian, when a deepening event took place, expressed by the occurrence of marls, clays and limestones, containing calcareous nannofossils of Tethyan and Boreal origin (Melinte and Mutterlose 2001) and planktic foraminifera. In the Lower Aptian, a fluvial-lacustrine palaeoenvironment was observed in several outcrops largely exposed along the Danube-Black Sea Channel and in boreholes from onshore and offshore the north-western Black Sea. A coarse-grained channel deposition is present (pebblestones, sandstones), along with alluvial plain deposits, mainly claystones and sandstones with charophytes and ostracods (Avram et al. 1993; Stoica 1997). During the Cenomanian, a transgression took place, leading to the occurrence of marls, clays and glauconite-rich chalk. These facies, which frequently include bioturbated mudstone chalk, extending to the Maastrichtian, were interpreted to represent deep-water environmental conditions. The Cretaceous palaeosetting modification pointed out in the onshore and offshore north-western Black Sea mirrored the eustatic fluctuation of those times (Haq 2014) that led to palaeogeographical modifications. The effect of eustatic changes is modulated by eurybathic ones.

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THE MID-CRETACEOUS WESTERN INTERIOR SEAWAY: OCEAN GATEWAYS AND THE ONSET OF OCEANIC ANOXIC EVENT 2

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At sites across the US Western Interior Basin, abrupt changes in foraminiferal assemblages (bio-events), lithology and geochemical records have been widely recorded at or near the boundary between the Hartland Shale and Bridge Creek Limestone members of the Cretaceous Greenhorn Formation in Colorado (and their stratigraphical equivalents throughout the basin) (Eicher and Diner 1985; Leckie et al. 1998; Elderbak and Leckie 2016; Jones et al. 2019; Bryant et al. 2021). These regional changes coincide with global sea level rise and the onset of Oceanic Anoxic Event 2 (OAE 2) (Arthur and Sageman 2005; Elderbak and Leckie 2016; Jones et al. 2020). Here we compare foraminiferal and geochemical records from six sites across the basin (Texas, New Mexico, Utah, Colorado, Kansas and Montana) to understand the timing of Western Interior Seaway (WIS) bio-events in the context of the development of OAE 2. Our results show that the WIS Benthonic Zone (BZ), first described by Eicher and Worstell in 1970 across the US Great Plains, and its ecological equivalents were a virtually isochronous but spatially heterogeneous change in benthic foraminiferal assemblages spanning >1,400 miles (2,250 km). Late Cenomanian sea level rise caused water mass mixing, high pulsed productivity, and deoxygenation along the WIS margins, and ventilation of the deep central axis of the seaway. We find that at all sites, the BZ interval leads the largest and most rapid positive carbon isotope excursion that marks an early phase of OAE 2. Based on this temporal relationship, we hypothesize that sea level rise in the WIS reached a tipping point, connecting the WIS to the global ocean and facilitating surface ocean circulation across the Northern Hemisphere. This relatively shallow ocean gateway revitalized sluggish circulation and established upwelling regimes that enhanced export of organic matter to the seafloor in the WIS and elsewhere, perhaps triggering anoxic conditions and black shale deposition at other localities beyond the WIS. It may have also impacted water mass circulation across north-west Europe as evidenced by short-lived cooling (Plenus Cold Event), which is not evident in the WIS. The '*Heterohelix* shift' records a nearly isochronous change in planktic foraminiferal assemblages across the WIS related to elevated productivity and the development of photic zone euxinia. Continued sea level rise initiated downwelling (cabbeling) in the WIS as the interaction between northern Boreal and southern Tethyan waters increased. This palaeoceanographical change is recorded by the expression of the *Gavelinella* acme and then followed by *Neobulimina* dominance in WIS benthic foraminiferal assemblages. These later benthic bio-events represent contrasting modes of cabbeling-driven bottom water formation and stratification, respectively, in contrast to the transgressive ventilation that caused the BZ.

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THE SEDIMENTARY AND GEOCHEMICAL RECORD OF THE OCEANIC ANOXIC EVENT 2 IN THE SHALLOW-WATER CARBONATES OF THE FRIULI REGION (NORTH-EAST ITALY)

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The Cenomanian–Turonian Oceanic Anoxic Event 2 (OAE 2) represents one of the major palaeoclimatic and palaeoceanographical perturbations of the entire Phanerozoic (Gangl et al. 2019). This event has been associated with a widespread occurrence of marine anoxia and deposition of organic-carbon rich sediments (black shales) in oceanic basins and with severe alteration of geochemical cycles. It has been suggested that the potential trigger mechanism of OAE 2 was the emission of large quantities of CO_2 by volcanic activity which stimulated a series of complex geochemical and biotic feedbacks (e.g., Schlanger and Jenkyns 1976; Tsikos et al. 2004; Jarvis et al. 2011). Most of the geochemical, sedimentological and palaeontological data dealing with OAE 2 come from deep-water carbonate successions, whereas the shallow-water counterparts have been much less studied. The few available data, however, suggest that such an anoxic event strongly impacted shallow-water ecosystems as well. In the present work we discuss the results of a detailed facies and petrographic analysis, along with high-resolution geochemical and mineralogical data across OAE 2. The data set is obtained by analysing both bivalve shells (mainly rudists) and bulk rock samples from well-exposed Upper Cenomanian–Lower Turonian sections cropping out in the Friuli region of Italy that belongs to the so-called Adriatic Carbonate Platform (AdCP). These outcrops represent a reliable record of shallow-water carbonates, offering for the first time the opportunity to depict the palaeoenvironmental changes through OAE 2 in the AdCP. Biostratigraphy and carbon-isotope stratigraphy have been used to constrain the OAE 2 interval precisely, whereas other geochemical and mineralogical proxies to evaluate palaeoenvironmental changes before, during and after OAE 2. Preliminary results show several environmental fluctuations which have been recognised both in all the studied successions and in other coeval Tethyan Carbonate Platforms (e.g., Apennine Carbonate Platform). These findings provide important insights into understanding how the severe environmental and oceanographic perturbations caused by OAE 2 affected shallow-water settings, allowing to discriminate local from global processes and their effects.

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EVIDENCE FROM XRF SCANNER-DERIVED ELEMENTAL RECORDS AND BULK CARBONATE STABLE ISOTOPES: EXAMPLE OF THE DEPOSITIONAL AND SEA LEVEL HISTORY OF THE TARFAYA ATLANTIC COASTAL BASIN, SOUTH-WEST MOROCCO

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The Upper Cretaceous organic-rich successions deposited in the Tarfaya Atlantic coastal basin of south-west Morocco permit to track closely reconstructions of depositional environments at the upper margin of an oceanic oxygen minimum zone impinging on a broad continental shelf. We present high-resolution X-Ray fluorescence (XRF) scanning, bulk carbon and oxygen isotopes and natural gamma-ray (NGR) records from sedimentary cores in the Tarfaya Basin. These cores recovered a sedimentary succession of more than 600 m in thickness. A negative carbon isotope excursion at the Cenomanian–Turonian boundary event corresponds to the onset of the Oceanic Anoxic Event (OAE) 2 and can be related to intense emissions of mantle CO_2 into the atmosphere. The following positive excursion leads to increased marine productivity and carbon burial; it was accompanied by transient climate cooling. In the Tarfaya succession, five sequences are identifiable in the cores and can be correlated to the global eustatic sequences adopted in the New Jersey Margin and in European shelf basins. The Lower Campanian sequence located within the positive carbon isotope excursion of the Santonian–Campanian Boundary Event, is associated with a long-term cooling trend, expressed in the ^{18}O record, and with major changes in the amount and composition of terrigenous input. These changes indicate cooler and wetter climate conditions in the source area.

GEOCHEMICAL SIGNATURE OF CRETACEOUS DINOSAUR EGGSHELLS: FINGERPRINTS OF TIME AND/OR PLACE?

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Dinosaur eggshells are made of calcium carbonate in the form of calcite crystals (Hirsch 1994). They are abundant in Cretaceous continental deposits and their stable isotopic composition has been used to infer palaeoenvironmental and palaeoecological conditions of past ecosystems, as well as the paleobiology of the egg-laying organisms (e.g., Cojan et al. 2003; Riera et al. 2013; Montanari et al. 2018). Most studies are limited to samples from a single locality or rely on comparison between distantly related taxa/ootaxa. We sampled the ootaxon *Guegoolithus turolensis*, related to iguanodontian ornithopod dinosaurs, from four coeval localities in different palaeoenvironments from the Barremian (Lower Cretaceous) Maestrazgo Basin (north-eastern Spain): Cuesta Corrales 2 and Escarpe Pelejón (grey lacustrine marly limestones, El Castellar Formation, Galve Sub-basin); Collado del Cuchillo (grey coastal plain marls, Mirambel Formation, Morella Sub-basin) and La Cantalera 1 (grey, bioturbated palustrine clays, Blesa Formation, Oliete Sub-basin). Bulk rock samples were screen-washed and eggshells were picked from concentrates. In total, 42 eggshell fragments were selected. Powdered eggshell samples were measured for their C and O-isotope ratios and major to trace elemental content (Ca, Mg, Sr, Fe and Mn) using mass spectrometry and ICP-AES. Diagnostic diagenetic evaluation is based on geochemical evidence and complementary petrographic inspection. Considerable alteration of the studied material can be discarded based on the fact 85% of the samples show low Mn and Fe abundance (lower than 100 and 400 ppm, respectively). Interestingly, Sr content is highly variable from c. 500 ppm up to severely enriched at 7,000 ppm in the samples from the Galve

Sub-basin, without significant linear correlation to other measured proxies. This unusual enrichment may be related to the genesis of the sub-basin, related to normal faults that capture the regional detachment level of the evaporite-rich Keuper facies, with circulating fluids which dissolved evaporites. The isotope composition of eggshells was thus not influenced by the process leading to the incorporation of sedimentary Sr. In respect to C and O-isotope ratios, values obtained for the only coastal plain setting largely overlap with the range of values reported by other authors for Cretaceous eggshells. In contrast, the remaining locations corresponding to marsh/lacustrine environments depart from this range towards heavier C and O-isotope composition (1 to 2‰ offset). Differences in evaporation rate of freshwater bodies are of relevance here, indicating that drinking water sources in areas furthest inland were subjected to higher evaporation than the more coastal settings. Additionally, related changes in the composition of the vegetation diet are also indicated by an increase of $\delta^{13}C$ values. The evidence obtained suggests that the eggshell geochemical signature is dependent on the particularities of each palaeoenvironmental setting, potentially masking the fingerprint of wider environmental dynamics.

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TRACE AND BODY FOSSILS FROM THE CONTROVERSIAL 'LOWER IDZIKÓW MEMBER' (SUDETES, SOUTH-WEST POLAND)

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The 'Lower Idzików Member', which is exposed in the Upper Nysa Kłodzka Graben (Sudetes, Poland), one of the Late Cretaceous intracontinental basins, is composed of sandstones and mudstones of Middle Coniacian age. Previous interpretations of its depositional settings ranged from deep-marine turbidites (Jerzykiewicz 1971) to shallow-marine settings (Wojewoda 1997), even to the upper sublittoral zone (Trzęsiok et al. 2014). These different interpretations might have been caused by strong bioturbation of the deposits studied. Other potential reasons for the differences include deposition close to the East Sudetic Island, significant subsidence affecting the Upper Nysa Kłodzka Graben during the Coniacian and a considerable sediment input at that time. The deposits studied were interpreted as Fossil-Lagerstätte by Trzęsiok et al. (2014), who provided geochemical analyses of siderite and calcitic concretions. New finds of crustacean burrows such as *Ophiomorpha nodosa*, *Thalassinoides* cf. *paradoxicus*, *T. suevicus* and *Sinusichnus sinuosus* were recorded by the author of this contribution. The ichnoassemblage also comprises some associated burrows such as *Archaeonassa fossulata*, *Chondrites* isp., ?*Conichnus* isp., ?*Diplocraterion* isp., ?*Gyrochorte* isp., as well as *Planolites*-like traces and borings in xylic substrates (*Teredolites clavatus*). Additionally, some rare or previously unknown body fossils have been collected, e.g., lobsters (*Hoploparia* sp., *Linuparus* sp.), ammonites (?*Scalarites* sp.), inoceramids (*Volviceramus involutus*, *Platyceramus* ex gr. *mantelli*, *Inoceramus* cf. *percostatus*) and echinoids (?*Cardiaster* sp., *Micraste*r sp). Ichnological analysis made by the present author shows the presence of a low – to moderately diverse trace fossil assemblage, indicative of both the distal *Skolithos* ichnofacies and the proximal *Cruziana* ichnofacies, which are characteristic of proximal and lower shoreface settings, respectively. Taphonomic studies, discussed herein, show that the current fossil assemblage is well preserved with up to 20% of bivalve shells still articulated. Some of these specimens were recovered in growth position (*Pinna* sp., *Modiola* sp.) or with the two valves kept close together, e.g., *Nuculana* sp., *Protocardia hillana* and *Trigonia* sp.

Trace fossils have either ferrigenous walls or are infilled with siderite cement (compare Trzęsiok et al. 2014). Background sedimentation of mudstones took place in a shallow epicontinental sea, beneath the fair-weather wave base, under conditions of low to moderate hydrodynamic energy, interrupted by deposition of sandstones during high-energy storm events. The current palaeoecological studies indicate that salinity was normal, judging from the presence of stenohaline taxa. Some episodes of mesohaline waters might have occurred due to fluvial input from an adjacent land mass (East Sudetic Island). The fauna has a boreal character, although migrants from the Tethys also occur.

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ROSSELIA – A TRACE FOSSIL INDICATOR OF BEACH-SHOREFACE SEDIMENTARY SETTINGS IN BOTH TRANSGRESSIVE AND REGRESSIVE SEDIMENTARY SEQUENCES OF THE INTRA-SUDETIC CRETACEOUS BASIN

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Abundant trace fossils that belong to the recently erected ichnofamily Rosselichnidae (compare Knaust 2021), such as the ichnogenera *Rosselia* and *Cylindrichnus*, have been found both in the lowermost part of the Cenomanian sediments and upper part of the Coniacian (Santonian?) strata on the margins of the Intra-Sudetic Cretaceous Basin (Krákorka and Idzików quarries, respectively). *Rosselia* is a dwelling or dwelling-feeding burrow of probably detritus-feeding terebellid polychaetes and is widely distributed in shallow-marine settings (Chrząstek et al. 2020 and references therein). Equilibrichnion is also indicated. Crowded *Rosselia* ichnofabric (called CRI) usually occurs in unstable shoreface settings in substrates around and below fair weather wave base with a high rate of deposition and erosion. This ichnofabric (CRI) is a very useful tool (suggested even as a stratigraphic ichnomaker) in recognizing high-energy shoreface environments, which are usually characterised by storm activity and/or rapid transgression (compare Mello et al. 2021 and references therein). Ethologically, *Cylindrichnus* is regarded as a domichnion. Trace makers are suspension and surface deposit feeding worm-like organisms, probably polychaetes (Chrząstek 2020 and references therein). The trace fossil assemblage here discussed characterises both the *Skolithos* and *Cruziana* ichnofacies and is typical of shoreface settings. Dense occurrences of *Rosselia* and *Cylindrichnus* were encountered in the lowermost transgressional sediments which represent a facies association typical of spit bar subenvironments. A similar set of trace fossils was also determined in tempestites of the upper Idzików Member (Nysa Kłodzka Trough), which represents a beach-to-shoreface environment during final stage of the last Late Cretaceous regression (compare Wojewoda 1997; Chrząstek 2020).

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THE EVOLUTION AND DESCENT OF RUDOLF HEINZ: 1925 – 1945 A PROMISING CAREER DERAILED BY THE THIRD REICH

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An unfulfilled vocation drains the color from a man's entire existence.
Honoré de Balzac

In 1926, at the age of 26, Rudolf Heinz earned his doctorate in geology at the University of Hamburg. Shortly thereafter, he began lecturing there, working towards a faculty position. Heinz published eight solo-authored papers in 1928, constituting early contributions to his landmark *"Beiträge zur Kenntnis der Inoceramen*" series. Unlike his German predecessors, who mainly focused on the paleontology of mainland Europe, Heinz worked on inoceramid bivalve collections from New Zealand, Australia, South Africa, and Madagascar. He appeared to be on-track to becoming the next great invertebrate paleontologist, to whom the torch would pass from greats such as Andert and Heine. However, the onset of the Great Depression in September, 1929 brought to bear economic conditions that would fundamentally change German society. The fall of the old Weimar Republic created space for the brownshirt-wearing Nazi Party. In just three short years the German government changed from conservative Hindenburg to socialist Hitler.

By 1931, many professors had signed a commitment (often reluctantly) to Hitler's NSDAP vision for postsecondary education. Heinz became an enthusiastic Nazi Party member, perhaps not knowing what he was getting himself into. Soon thereafter the departmental chairmanship at Hamburg became available, and Heinz submitted his interest in taking up the mantle of director. The position was instead offered to the accomplished geologist Roland Brinkmann (who at the same time became the manager of the Geological State Institute). This perceived betrayal would lead Heinz to become increasingly embittered and alienated from the other faculty.

His fortunes, as it were, would take a dramatic change of course in March, 1933. Claiming to have witnessed Brinkmann – only 2 years older than

Heinz – engage in a public anti-governmental display, Heinz would mount a campaign to oust the man who took the academic job he considered himself deserving of. With the backing of the Reich, Heinz exposed any member of the Hamburg faculty that dared oppose him. In retribution (and a show of solidarity with Brinkmann) they denied Heinz a full tenure-track profesor position, despite him having lectured there for seven years. His wrath was perhaps motivated by the earlier clash at the University of Hamburg between Karl Gripp and Siegfried Passarge. The later was a staunch racist and anti-Semite, which suited Heinz just fine. Despite Gripp's popularity on campus and among the faculty, he was forced to resign. Heinz would ensure the same happened to Brinkmann, even if he himself had to resign.

In 1936 an embittered Heinz left Hamburg and soon resurfaced at the University of Leipzig. Before long he had a full professorship in geology andpaleontology, and in due course would become the departmental chairman (1937), then Dean of the faculty of Philosophy (1941). The former chair, Franz Kossmat, attempted to oppose Heinz's appointment – but to no avail. Having aligned himself with the ruling socialist government, Heinz was guaranteed lucrative academic positions for the rest of his career. In addition, he was slowly amassing large collections of inoceramid specimens from institutions in France, Belgium, Scandinavia, Poland and other occupied territories. His goal was to have a single "master fossil collection" – and thus be able to control who published what on his beloved extinct clams.

Yet, after 1936, Heinz did not publish a single scientific paper. His appointment as *Gaudozentenbundführer* for Saxony [Regional Lecturers' Association Leader] in 1943 heralded a completely changed man, with little time for research. This high-ranking position within the Reich Ministry of Education allowed Heinz to blur the line between geology and ideology, and use his NSDAP resources to track down anti-Nazi or Jewish faculty at Leipzig and elsewhere.

The defeat of the German and Italian forces in Europe in 1945 was yet anotherunforeseen obstacle to Heinz's ambitions. Just days after the German surrender in early May Heinz was removed from his positions at Leipzig. His departure must have been hastily undertaken, as boxes of borrowed (stolen) specimen collections were unearthed in hidden storage at Leipzig as recently as 2017. These and the entire campus were significantly damaged from British aerial bombings in December, 1943. Those collections that wer enot destroyed during bombing raids have been returned to their institutions of origin.

Lacking a personal memoir or diary, it is difficult to assess what Heinz's motivations were. Authors that have evaluated his tenure at Hamburg and Leipzig (e.g. Ehlers, Renneberg) conclude that Heinz was easily slighted and vengeful. He felt his talents as both a researcher and teacher were overlooked, and so used the Nazi resources at his disposal to "get even" with more liberal colleagues that did not seem to be equally zealous for the German cause.

Nearly 2,000 people were deported from Leipzig to extermination camps – an "Aryanization campaign" so effective there were only 15 Jews remaining in the city at war's end. Whether or not Heinz actively sought to expose Jewish persons in Leipzig after 1942, leading to their transfer to the camps, is unknown. But the stigma of Heinz's legacy has persisted for the many decades since the fall of the Third Reich. his willingness to attack fellow colleagues in the name of political dogma serves as a stark reminder of what can happen when we lose sight of the central mission of the university

HYDRODYNAMICS OF A DEPOSITIONAL ENVIRONMENT DERIVED FROM THE RUTILE-TO-TOURMALINE RATIO (RUTI) – A CASE STUDY FROM THE CAMPANIAN SZOZDY DELTA SYSTEM, SOUTH-EAST POLAND

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The most prominent feature of the Szozdy section (Roztocze Hills, south-east Poland) is the presence of tripartite cyclothems. Where complete, an individual cyclothem consists of three units: from bottom to top, these are calcareous mudstone, calcareous sandstone and calcareous gaize (Remin et al. 2022). A distinct inverse relationship between tourmaline and rutile can be readily recognised in such defined cyclothems. In the section studied, both minerals are of similar shape (highly rounded), durability and size: however, they possess markedly different densities – i.e., 3.03–3.18 and 4.23 g/cm^3 for tourmaline (dravite) and rutile, respectively. Since the weight of the two minerals analysed differs markedly, it might be expected that these two mineral phases will be strongly dependent, both vertically and spatially, on the local sedimentary environment – and by extension, on the hydrodynamic power that existed during deposition of successive cyclothems. A standardised Z-score statistic was calculated to emphasise the relative changes in abundance of these two mineral phases. This statistic quantifies how many standard deviations each sample is from the mean value for the whole group for the entire Szozdy section. The recurring increase in tourmaline abundance, coupled with a simultaneous decrease in rutile abundance in muddy units, most likely resulted from a decrease in hydrodynamic power in the depositional environment. Sedimentologically, this may be interpreted as a transition to a comparatively more distal depositional setting from the main source area, e.g., a river discharge – that is, a prodelta or analogous environment. By analogy, an increase in the proportion of rutile, and simultaneous decrease in tourmaline share, in the sandy units can be linked to an increased flow rate, which might be interpreted as a transition to an environment more proximal to the river discharge, thus representing the main delta lobe and/or slope setting. Simply put, the (lighter) tourmaline will be transported further into the prodelta environment, rendering the prodelta facies overrepresented in this mineral phase, whereas the markedly heavier rutile will be deposited closer to the river discharge. Accordingly, when the RuTi ratio increases, the hydrodynamic power in the sedimentary environment increases as well. It should be noted that the RuTi ratio has some limitations. Both minerals should have a similar degree of roundness, preferably represented by spherical crystals. Fortunately, due to its high resistance and the ability to withstand multiple recycling, they are often preserved in the form of very well-rounded grains. Therefore, the RuTi ratio can be used as an additional tool in recognising the hydrodynamics of depositional environments.

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THE MAGNITUDE AND CAUSE OF SHORT-TERM EUSTATIC CRETACEOUS SEA LEVEL CHANGE

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The timing, magnitude and pace of eustatic events provides insights into driving mechanisms and hence relays important information on the nature of the climate system through time. However, isolating the eustatic signal from the sedimentary record is a challenging task, leading to a lack of consensus on the nature of Cretaceous events. To address this, we have conducted a literature review to establish a statistically confident upper magnitude limit of short-term eustatic events throughout the Cretaceous. We have evaluated the results against different driving mechanisms, supported by insights derived from a global geodynamic model and associated palaeoclimate simulations. Our analysis reveals the presence of four broad episodes of eustatic change. Three of these episodes reflect trends of increasing sea level change magnitudes from the Berriasian to Early Hauterivian, Late Hauterivian to Aptian, and Santonian to Maastrichtian. The fourth episode reflects a decreasing magnitude trend from the Albian to Coniacian. We characterize the maximum magnitude of sea level change as slight (< 10 m), modest (10–40 m) or significant (40–65 m). Significant magnitudes are inferred for the Valanginian, Aptian, Albian and Maastrichtian. The remaining stages contain modest magnitudes with slight magnitudes restricted to the Berriasian. As climatically driven, eustasy is the most likely cause of short-term sea level change, the principal climatic drivers of the observed events relating to either thermo, aquifer-, or glacio-eustasy. While the mechanisms, frequency and magnitude of short-term thermo – and glacio-eustasy cycles are understood, the likely contribution of aquifer-eustasy remains enigmatic. To address this, we analyze palaeoclimate simulations constructed for the differing Cretaceous climates and palaeogeographical configurations (Valanginian, Turonian and Maastrichtian), to assess the spatio-temporal pattern of aridity and humidity under differing CO_2 forcing. Using information on modern water table depths, we estimate that the most likely short-term aquifer-eustasy

response in the Cretaceous is 0.1–0.21 m. Even using the most optimistic values, the largest possible total aquifer-eustasy response remains smaller than 5 m. Our results indicate that glacio-eustasy is the most likely driver of Cretaceous short-term eustatic cycles because thermo – and aquifer-eustasy are unable to account for the estimated Cretaceous magnitudes. This is supported by a clear correlation between palaeoclimate proxy data of the four broad episodes of magnitude change, with periods of warming associated with reducing eustatic magnitude. However, our simulations also demonstrate that the greatest aquifer charge is more likely during lower CO_2/cooler intervals, indicating that aquifer-eustasy may work in-phase with both glacio – and thermo-eustasy in contrast to the previous aquifer-eustasy paradigm. This implies that any ice caps inferred to explain the observed sea level response could be smaller than previously thought.

STRATIGRAPHICAL REVISION AND PALAEOENVIRONMENTS OF THE LOWER CRETACEOUS IN THE SOUTH-EAST OF THE PARIS BASIN (FRANCE)

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The Paris Basin is a Meso-Cenozoic intracontinental basin characterized during the Early Cretaceous by a continental evolution. However, in its south-eastern part, due to transgressions originating from the Tethys, sedimentation of Lower Cretaceous continental strata was occasionally interrupted by deposition of marine sediments. In this area, the sedimentary succession includes the transgressive ‘Sables de Soulaines’ Formation on top of the Upper Jurassic erosional surface crosscutting the lower

Tithonian 'Calcaires du Barrois'. This formation shows facies characteristics of a tidal flat and is reputed to be Valanginian in age, but there is no dating element and deposition might as well have begun in the Late Berriasian. Above, following a major discontinuity, the succession continues with the 'Calcaires à Spatangues' Formation. The facies point to an open-marine setting, also evidenced by the presence of ammonites which indicate an Early Hauterivian age (*radiatus* to *nodosoplicatum* zones). The sedimentary succession continues with the 'Argiles ostréennes', allegedly of Barremian age, but this stratigraphical attribution would imply the absence of the entire Upper Hauterivian, while the transition from the 'Calcaires à Spatangues' to the 'Argiles ostréennes' is gradual without discontinuity. It seems probable that the 'Argiles ostréennes', deposited in very shallow environments with possible occasional emersions, are of Late Hauterivian age at the base where the occurrence of a Faraoni-equivalent level is suspected, and Barremian at the top. During the Late Barremian, emersion occurred, and the study area was subjected to deep continental weathering under hot and humid climates leading to the formation of lateritic weathering profiles. A major transgressive event took place in the Early Aptian, leading to the deposition of lower offshore clays, 'Argiles à Plicatules' Formation, dated by ammonites as basal Aptian (probably *forbesi* Zone) up to *furcata* Zone. In this formation, a chemostratigraphical approach based on ^{13}C has allowed the identification of an OAE1a equivalent in the *deshayesi* Zone (Deconinck et al. 2021). After the deposition of the 'Sables verts de l'Aube' (greensands), of Late Aptian/Early Albian age, the succession is predominantly composed of Albian clays and marls constituting the 'Argiles Tégulines de Courcelles' Formation, well-dated by numerous ammonites (Amédro et al. 2017).

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UPPERMOST TURONIAN–LOWER CONIACIAN INOCERAMID BIVALVES AND BIOSTRATIGRAPHY FROM THE PETRICH AREA, CENTRAL SREDNOGORIE, CENTRAL BULGARIA

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The GSSP for the base of the Coniacian at Salzgitter-Salder (Germany) has been recently ratified, based on the first appearance (FO) of *Cremnoceramus deformis erectus* (Meek) (Walaszczyk *et al*. 2022). The boundary interval captures a marked shift in inoceramid assemblages, from a *Mytiloides*-dominated late Turonian fauna to a the latest Turonian–early Coniacian *Cremnoceramus*-dominated fauna.

The Upper Cretaceous strata in the Central Srednogorie tectonic subzone (Central Bulgaria) are well-exposed near the village of Petrich (Panagyurishte strip), and consist of varied Turonian–Maastrichtian magmatic, volcanic, and sedimentary rocks. The Turonian–Coniacian boundary interval occurs in the volcano-sedimentary successions of two stratigraphic sections: Topolnitsa and Kamenitsa. In the Topolnitsa section, it is notable that the uppermost Turonian inoceramids were collected from red limestones lying directly on peperites; the interaction between the lava flow and sediments is clearly visible (Georgiev *et al*. 2013).

The inoceramid assemblages from the Topolnitsa section denote the uppermost Turonian–lower Coniacian. The uppermost Turonian *Cremnoceramus waltersdorfensis waltersdorfensis* Zone was established based on small *C. waltersdorfensis waltersdorfensis* (Andert, 1911) collected from red sandy limestones. The FO of *C. deformis erectus* (Meek, 1877) is two meters above, marking both the Turonian/Coniacian boundary and the eponymous inoceramid zone. Above, the FO of *C. waltersdorfensis hannovrensis* (Heinz, 1932) defines the lower boundary of the *C. waltersdorfensis hannovrensis* Zone, in the lower/middle lower Coniacian. The index-taxon is accompanied by *C. deformis erectus*, *Inoceramus* aff. *annulatus* Goldfuss, 1836, *C. denselamellatus* (Kotsyubinsky, 1965) and *I. vistulensis* Walaszczyk, 1992.

The inoceramid record from the Kamenitsa section is discontinuous and associated with epiclastic, micaceous, green limestones exposed in the lower part of the section. Well-preserved, medium-sized *Cremnoceramus deformis erectus* indicate the eponymous lowest Coniacian inoceramid zone. Upsection, the occurrence of *C. waltersdorfensis hannovrensis* demonstrates the presence of the eponymous inoceramid zone. In addition to the index taxon, a single *C. websteri* (Mantell, 1822) was collected from the lower *C. waltersdorfensis hannovrensis* zone.

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THE SANTONIAN–CAMPANIAN BOUNDARY INTERVAL IN THE KYUNETSA SECTION, WESTERN SREDNOGORIE ZONE (BULGARIA)

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The Melovete Tectonic Unit is part of the Western Srednogorie Zone in Bulgaria. The best and most continuous Upper Cretaceous sedimentary record within this unit is exposed in the Kyunetsa section which crops out 2.5 km west of the village of Kosharevo, western Bulgaria. The sedimentary succession in this particular section spans the Turonian–Campanian interval; four formations were recognized by Sinnyovsky et al. (2012), as follows: Paramun Formation (Middle Turonian), Izvor Formation (Middle Turonian–Coniacian), Melove Formation (Coniacian–lowermost Campanian) and Kosharevo Formation (Lower Campanian). Recently, in an attempt to define different Upper Cretaceous boundary events, the Kyunetsa section has been logged and sampled in detail. The first integrated biostratigraphical data, based on inoceramid bivalves, calcareous nannofossils and palynomorphs, have yielded an Early Campanian age for the lower part of the Kosharevo Formation, up to bed 11 (Dochev et al. 2020). Fossils recovered include a well-preserved inoceramid assemblage represented by the Early Campanian species *Cordiceramus pseudoregularis* and pollen from the *Normapolles* group, namely *Vacuopollis percentus*, *Oculopollis orbicularis* and *Subtrudopollis* spp. Additional research and detailed sampling have enabled the recognition of the Santonian–Campanian boundary (SCB) interval in the Kyunetsa section within the uppermost portion of the Melove Formation which is composed of thin-bedded carbonate turbidites with rare sandstones and single marl beds. The SCB is defined by calcareous nannofossils, i.e., the first occurrence of large (> 9 µm) *Broinsonia parca parca* (*Aspidolithus parcus parcus* of other authors). Significant variations of field magnetic susceptibility have also been recorded around the uppermost part of the Santonian. Correlation with other biostratigraphical and stable isotope data is in progress.

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WAS OAE 2 TRIGGERED BY THE EMPLACEMENT OF THE HIGH-ARCTIC LARGE IGNEOUS PROVINCE (HALIP)?

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Oceanic Anoxic Event 2 (OAE 2) marked one of the most severe perturbations of the Cretaceous global carbon cycle and was accompanied by peak greenhouse climate conditions (e.g., Jenkyns 2010). Rapid and extensive outgassing of volcanic CO2 is considered as the most likely trigger of OAE 2. The volcanic source regions, however, remain controversial (e.g., Snow et al. 2005; Schröder-Adams et al. 2019). The voluminous igneous rocks in and around the Arctic Ocean, which collectively constitute the High Arctic Large Igneous Province (HALIP), partly formed contemporaneously with OAE 2, suggesting a causal relationship between HALIP emplacement and OAE 2. However, age estimates are limited in number and often inconsistent, complicating a robust correlation of events. Here, we present geochemical and grain-size data from a Cenomanian–Turonian sedimentary section at Glacier Fiord (Axel Heiberg Island, Nunavut, Canada) that was deposited on the Arctic continental shelf within a distance of <300 km from the eruptive centers of Strand Fiord flood basalts, a remnant of HALIP volcanism. Carbon and osmium isotope stratigraphy clearly demarcates OAE 2 and its characteristic sub-events (carbon isotope segments A–C) at Glacier Fiord, providing a robust stratigraphic framework. Volcanoclastic material is abundant at Glacier Fiord and occurs both as discrete bentonite beds and dispersed in the black shales that constitute the background sedimentation. The volcanoclastic material possesses a characteristic geochemical and grain-size fingerprint that allows to estimate mixing ratios with background sedimentation. Two stratigraphic intervals just below and in the upper part of OAE 2 contain particularly large quantities of volcanoclastic material (80–100% of the sediment), which are interpreted to represent two major pulses of HALIP volcanism interrupted by a period of volcanic quiescence. Chemostratigraphic correlation of the Glacier Fiord section with astronomically constrained reference sections from the Western Interior Seaway indicates that the first volcanic pulse commenced ~50 kyr prior to OAE 2 and coincided with the onset of global warming and changes in global ocean chemistry at that time. The period of volcanic quiescence appears to be coeval with the Plenus Cold Event, while the second volcanic pulse was contemporaneous with renewed warming during the later stages of OAE 2. These temporal relationships indicate that the waxing and waning of carbon emissions from HALIP volcanism may have been instrumental in driving global climate dynamics during OAE 2.

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CRETACEOUS PEAK WARMING CAUSED BY THE EARLY OPENING OF THE EQUATORIAL ATLANTIC GATEWAY

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The Cretaceous opening of the Equatorial Atlantic Gateway (EAG) is thought to have had a major impact on global oceanography, carbon cycling and climate. However, there is considerable uncertainty as to when the EAG opened. As a consequence, controversial hypotheses have been put forward regarding the global climatic implications, with both global warming (Poulsen et al. 2003) and cooling (Forster et al. 2007; Friedrich et al. 2012) proposed as possible effects. We here present new sea water Nd-isotope, bulk geochemical and micropalaeontological data from two South Atlantic drill cores (Deep Sea Drilling Project Sites 363 and 364) that constrain the onset of shallow (<500 m) and intermediate (<~1,000 m) water mass exchange across the EAG to 113 and 107 Ma, respectively. Deep water mass exchange (>2,000 m) was possible by at least ~100 Ma. This revised chronology suggests that the EAG opened at least 10 myr earlier than previously thought. The EAG opening induced more vigorous deep water circulation and ventilation in the South Atlantic, North Atlantic and Tethys basins, causing basin-scale reductions in organic carbon burial. We propose that the irreversible loss of these large-scale regional carbon sinks was a key mechanism promoting long-term climate upheaval that culminated in peak greenhouse conditions during the mid-Cretaceous. We further propose that widespread remobilization and remineralization of organic carbon from surface sediments in the South Atlantic basin may have fuelled CO_2 emissions, causing particularly rapid warming during the early Albian. Our results challenge the commonly held hypothesis that enhanced magmatism was the primary trigger of peak warmth during the mid-Cretaceous.

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EVIDENCE FOR CHANGES IN SEA–SURFACE CIRCULATION PATTERNS AND ~20° EQUATORWARD EXPANSION OF THE BOREAL BIOPROVINCE DURING A COLD SNAP OF OCEANIC ANOXIC EVENT 2 (LATE CRETACEOUS)

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The Plenus Cold Event (PCE) temporarily interrupted the super-greenhouse conditions of the Cenomanian–Turonian Oceanic Anoxic Event 2 (OAE 2); it is coeval with the occurrence of Boreal benthic macroinvertebrates and of the nektonic belemnite *Praeactinocamax plenus* (after which the event is named) in Europe, and to the re-oxygenation of bottom waters in the Northern Hemisphere. However, its effects on the sea-surface circulation are unknown and evidence for changes in the biogeography of planktic organisms are limited to the equatorward migration of dinoflagellate cysts grouped in the *Cyclonephelium compactum–membraniphorum* morphological plexus. The present study provides new planktic foraminiferal quantitative data from two complete OAE 2 records in the Anglo-Paris (Eastbourne, south-east England) and Vocontian (Clot Chevalier, south-east France) basins that show a transition from an oligo-mesotrophic Tethyan assemblage (rotaliporids and whiteinellids) at the onset of OAE 2 (prior to the PCE) to a cold and meso – to eutrophic assemblage (praeglobotruncanids, dicarinellids and muricohedbergellids) during the PCE. The cold-water assemblage shows strong affinities with the coeval fauna of the Norwegian Sea and yields the Boreal endemic species *Muricohedbergella kyphoma* and *Praeglobotruncana plenusiensis*. Planktic foraminifera are passively transported by currents, thus changes in the assemblages have been interpreted to reflect the transition from a dominant influence of warm, saline and thermally stratified waters carried by the proto-Gulf Stream prior to the PCE to cold and low-saline Boreal waters originating in the Norwegian Sea during the PCE. We suggest that such changes were forced by the equatorward shift of the proto-Arctic Front (i.e., the boundary between warm saline Tethyan-Atlantic and cold low-saline Boreal waters) from offshore Norway to southern England. In this southerly position, the proto-Arctic Front likely represented an oceanographic barrier that limited the influence of the proto-Gulf Stream in the Anglo-Paris Basin, and favoured the inflow of Boreal waters from the north to the European epicontinental basins leading to ~20° equatorward expansion of the Boreal marine bioprovince. The sea-surface cooling and equatorward expansion of Boreal planktic assemblages during the PCE are of the same order of magnitude of those reconstructed between some glacial and interglacial intervals of the Plio–Pleistocene. Despite obvious differences between Cretaceous and Plio–Pleistocene palaeogeography and climate dynamics, the present study reviews the extent of environmental changes occurring in this interval and provides evidence of a profound re-organisation of sea-surface circulation patterns during a cold snap of the Cretaceous supergreenhouse (Falzoni and Petrizzo 2022).

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FORAMINIFERA IN THE BIOSTRATIGRAPHICAL AND PALAEOENVIRONMENTAL CONTEXT OF THE BELGOROD CHALK

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The Belgorod chalk quarry exposes a 13 m thick Campanian succession of white, homogeneous and rather poorly lithified chalk. The co-occurrence of benthic foraminiferal species such as *Gavelinella annae*, *Gavelinella monterelensis*, *Globorotalites michelinianus* and *Globorotalites emdyensis* has recently been recorded within the succession and indicates the Middle Campanian *Globorotalites emdyensis* Zone (Walaszczyk et al. 2016). This time interval is exceptionally important in terms of correlation between the tripartite US and two-fold traditional European subdivisions of the Campanian Stage. The present study discusses an analysis of planktic and benthic foraminiferal assemblages from the Belgorod succession, combined with newly conducted $\delta^{13}C$ and $\delta^{18}O$ measured separately in planktic (*Globigerinelloides prairiehilensis*) and benthic (*Gyroidinoides globosus*) foraminifera. Planktic foraminifera are represented by comparatively highly diverse assemblages consisting of morphologically and ecologically various forms: (1) shallow-water r-strategists (*Heterohelix*, *Globigerinelloides*), (2) deep-dwelling K-strategists (*Globotruncana*), and (3) intermediates (*Rugoglobigerina*). Such a deep-dwelling foraminiferal community is not observed on the Russian Platform within the Campanian and Maastrichtian succession apart from the Belgorod Formation here studied (Beniamovskii et al. 2014). This demonstrates that the Belgorod Formation represents a sea level highstand that likely corresponded to the transgressive peak No. 3 of Hancock (1993), recognized low in the *Belemnitella langei* Zone in north-western Europe and North America. Benthic foraminiferal assemblages are dominated by large calcitic epifaunal morphotypes, the most frequent taxa being *Cibicidoides*, *Gavelinella*, *Globorotalites* and *Stensioeina*. Based on the classic TROX model of Jorissen et al. (1995), deposition must have occurred under mesotrophic or even slightly oligotrophic conditions. Both planktic and benthic foraminiferal communities are comparable within the entire succession with no significant changes. Similarly, $\delta^{18}O$ and $\delta^{13}C$ values do not show any discernible events. Integration of these results generally suggests stable oceanographic conditions during the time interval studied.

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UPPER CRETACEOUS PHOSPHORITES OF THE IONIAN ZONE (ALBANIA) AS PART OF THE MEDITERRANEAN (TETHYAN) PHOSPHOGENIC PROVINCE

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The Mediterranean (Tethyan) Phosphogenic Province represents one of the most extensive distributions of phosphorites, constituting an exceptional period of phosphate deposition principally during the Late Cretaceous. In Albania, Upper Cretaceous (Coniacian) phosphorites are represented by a regular horizon, almost throughout the Ionian Zone (Serjani and Ylli 1984), extending from Albania towards Greece (Machairas et al. 1979). This particular horizon comprises carbonates, phosphates and siliceous levels, and the wide distribution and characteristic nature of its faunal association make it a good marker level. In Albania, it crops out on a distance of about 300 km, from Shpiragu Mountain in the north, up to Astakios Bay in the south (Greece) and from the Ionian Sea in the west to the Melesini Mountain in the east. Its thickness from the coastline to Melesini is about 70 km. The greatest concentrations of phosphate and primary ore deposits are situated in the central subzone of the Ionian zone, in the so-called Kurveleshi anticline belt (Serjani 1991). The horizon has a sharp contact at the base, distinguished by the presence of thin green clay layers. These layers reveal rich microfaunal associations with a predominance of planktic foraminifera such as *Globototalia renzi, G. schneegansi, G. coronata, G. sigali, G. concavata,* as well as radiolarians, *Pithonella sp*. and other globigerinids. The Coniacian horizon consists of carbonates, while the phosphate beds are intercalated with thin siliceous layers. The typical thickness of the horizon varies from several meters to 40–50 m, but mostly is between 8 and 14 m. Based on the relationships between lithological components, the average content of P_2O_5 fluctuates. Commonly, it is very low, at about 10%. Only in the Gusmari deposit a phosphate horizon of high P_2O_5 content (33%) is found. Biopelmicritic, biomicropeloidal, marly limestone and planktic fauna are seen in limestone beds in the upper parts of the studied sections. The limestone beds of the phosphatic horizon consist of a micritic, often marly, laminated texture, planktic fauna and phosphate grains.

The phosphate beds themselves comprise massive micritic, biomicritic (with a laminated texture) phosphorites rich in globotruncanids. Many phosphatic pellets and abundant small coprolites also occur in these phosphate beds. The Coniacian phosphate horizon formed in the pelagic zone of the Ionian Trough. The absence of terrigenous material, pyrite crystals, iron-manganese hydroxides, organic matter and traces of Pb, Zn and Ag in these phosphate layers testifies to the formation in a pelagic, reducing environment with minimum oxygen levels (Serjani and Pirdeni 1998).

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LEARNING FROM BEAUTIFUL MONSTERS: THE CASE OF 'SEX REVERSALS' IN THE AMMONOIDEA AND THEIR SIGNIFICANCE

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Expression of sexual dimorphism is recognised in various fossil groups of molluscs such as the Ammonoidea, an extinct group of shelled cephalopods (Klug et al. 2015). During the Jurassic, the best-documented sexual dimorphic examples are seen in the superfamilies Stephanoceratoidea, Haploceratoidea, Hildoceratoidea and Perisphinctoidea (Davis et al. 1996). It is usually expressed by distinct adult size and apertural modifications between the antidimorphs. Putative males (otherwise referred to as microconchs) are small in size and develop lappets at the end of the shell, while the females (macroconchs) are larger and have a simple peristome. The discovery of two specimens of the Callovian aspidoceratid *Peltoceras athleta*, having both female and male features, questions the significance and causes of 'sex reversals' in the Ammonoidea (Frau and Boursicot 2021). The two specimens have started with the macroconch ontogeny of *Peltoceras athleta* and show an apparent change towards maleness in the adult, as illustrated by their rounded whorl section, ribs retroversion, fading of tubercles and presence of lappets typical of microconchs. Few other cases of female-to-male, as well as male-to-female 'sex reversal', are known in the fossil record, all belonging to the Jurassic Perisphinctoidea (families Perisphinctidae or Aspidoceratidae). Since all Jurassic Perisphinctoidea are considered to be strictly gonochoristic, these 'sex reversals' are pathological in nature and are herein referred to as a new forma-type pathology: namely 'forma hermaphrodita'. In the absence of any clear evidence of injury or parasitism, we hypothesise that such 'forma hermaphrodita' individuals illustrate pathological cases of intersexuality. Little is known about the ammonoid soft parts, and it is not possible to determine which internal sexual organs occur in intersex specimens having both male and female external shell features. Abnormal feminisation and/or masculinisation also occur in modern cephalopods, the latter also grouping only gonochoric species. This phenomenon is similarly illustrated by a change in the adult body size and a mixing of both female and male structures. In that case, intersexuality is either advantageous in the population or caused sterility. The causes of intersexuality are not clearly established but environmental pollutants are evoked in modern cephalopods because they act as endocrine disrupters. 'Sex reversals' and/or non-functional reproductive abnormalities have also been caused by endocrine disrupters in various gonochoric gastropod species, but infestation, genetic abnormalities, temperature fluctuations or viruses are multiple causes, which can stimulate or inhibit neural-endocrinal activity by direct gonadal influence, and ultimately lead to feminisation or masculinisation in fishes, isopods, other crustaceans and gastropods as well. Regardless of whether 'forma hermaphrodita' is due to an exogenic or endogenic cause, the record of intersex Perisphinctoidea in the Jurassic can be explained by the ready recognition of dimorphic pairs, and the easy collection of large and sufficiently preserved fossil palaeopopulations in which intersex specimens have statistically more chance to be found than their Cretaceous counterparts.

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INTERROGATING POTENTIAL SHORT LIVED EPISODES OF OCEAN ACIDIFICATION DURING OCEANIC ANOXIC EVENT 2

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OAEs are episodes of major palaeoceanographic and palaeoclimatic changes associated to carbon cycle perturbations registered both in land and marine strata. Among the OAEs, the so-called Oceanic Anoxic Event 2 (OAE 2), spanning the Cenomanian-Turonian boundary (c. 94 Ma) was one of the most severe. Several lines of evidence suggest that this event was triggered by an increase of atmospheric pCO2 caused by massive gas emissions from volcanic sources. Global warming initiated a cascading chain of palaeoenvironmental perturbations, which eventually resulted in faunal extinctions and alteration of many biogeochemical cycles. The sedimentary record of the OAE 2 in marine carbonate successions worldwide, is characterised by a positive carbon isotope excursion (CIE) of up to 5‰, which records the perturbation of the global carbon cycle. In the most complete records, the OAE 2 CIE shows a complex pattern consisting of a first build-up, a trough, a second build-up and a plateau with spikes, which is followed by decay toward background values. The 'through' coincides with a short interval of cooling known as the Plenus Cold Event, defined by the southward spread of boreal fauna into the Tethys and by a positive 18O excursion. It is tentatively interpreted as the expression of CO2 drawdown due to enhanced burial of organic matter. One major effect of the pulses of volcanic degassing during OAE 2 would have been increase of dissolved CO2 in the oceans, which, if rapid enough, could have resulted in ocean acidification. Limited studies based on morphometric analyses of nannoplankton species and abundance of planktonic foraminifera suggest that short phases of ocean acidification may have occurred during OAE 2. However, up to date, there is no definitive proof supporting this hypothesis, unlike other OAEs for which geochemical and palaeontological data have provided more solid evidence of ocean acidification. Moreover, at present there are no studies testing the hypothesis of ocean acidification during OAE 2 in subtropical carbonate platforms, whose massive biocalcifiers would have been particularly sensitive to a decrease in carbonate saturation. In this study we present new data from a 60 m thick succession of shallow-water carbonates belonging to the Apennine Carbonate Platform (Southern Italy). We compared the available carbon-isotope data with high-resolution facies analyses coupled with laser $\delta^{11}B$ measured on both bulk carbonate and well-preserved bivalve shells. Furthermore, we measured the shell mechanical properties (shell hardness). Preliminary data show a negative inflection in both $\delta^{11}B$ and shell hardness associated to the negative CIE of the Plenus Cold Event. We discuss possible scenarios for these patterns, including a short-lived episode of ocean acidification.

THE 200 YEAR HISTORY OF THE CRETACEOUS, 1822-2022

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The Cretaceous was created by the aristocratic Belgian geologist, anthropologist and politican Jean Baptiste d'Omalius d'Halloy (1783-1874), who had studied under Lamarck and Cuvier in Paris. In 1822, d'Halloy produced the first geological map of France, on which he designated the "Terrains Crétacé"as represented by the Chalk with associated tuffeau and clays. The English geologist Henry Thomas de la Beche had the map redrawn and published it together with an English translation of d'Halloy's major findings in 1836.

The French geologist and palaeontologist Alcide Dessalines d'Orbigny recognised major faunal turnovers within the Mesozoic succession which he used to define what he called "Stages", named after regions of France, and each characterised by distinctive suites of fossils. He named the Aptien and Neocomien in 1840, the Albien, Cenomanien and Senonien in 1842 and the Turonien in 1847. Further subdivision and refinement of the stages was provided by Coquand (Barremien 1861; Berriasien 1871, Renevier (Hauterivien,1874), Coquand (1857; Coniacien, Santonien, Campanien) and Desor (Valanginien, 1854). The Upper Cretaceous Stages were reviewed and refined by de Grossouvre (1901). The usage of Cretaceous stages was very irregular until the 1960s, when Hollis D. Hedberg introduced the concept of the unit stratotype, with stages defined at their bases by golden spikes (GSSPs). The currently used Cretaceous subdivision was standardised in the 1970s. Most stages, excepting the Berriasian, Valanginian, Barremian and Aptian now have ratified or proposed GSSPs. The advent of magnetostratigraphy and chemostratigraphy (particularly stable carbon isotopes) has provided novel and effective means of correlation with which to supplement biostratigraphy. Through palaeoclimatology and palaeoceanography we are now beginning to understand the causes of the major faunal changes which d'Orbigny originally recognised. At the same time, high-resolution radiometric dates and Milankovitch cyclicity permit more precise refinement of Cretaceous geochronology.

A PROPOSED GSSP FOR THE CAMPANIAN STAGE

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A proposal for a Campanian GSSP by the Campanian Working Group is now with the Subcommission for hopeful ratification. This proposes the Bottacione Gorge section at Gubbio, Italy, with the primary marker as the magnetic reversal to chron C33r, terminating the Cretaceous Long Normal Polarity Zone (C34n). The palaeomagnetic marker (Maron and Muttoni 2021) is bracketed by numerous bioevents (planktic foraminifera, calcareous nannofossils) and a high-resolution $\delta^{13}C$ record (Miniati et al. 2020). A series of auxiliary sections in different regions are also described, including Seaford Head (UK; Boreal, chalk facies), Bocheniec (Poland; marls), Postalm (Austria), Kansas (USA) and Tepeyac (Mexico; pelagic carbonates). These successions are correlated to the GSSP using high-resolution carbon isotope stratigraphy, palaeomagnetics and calcareous nannofossils. The correlations permit regionally developed ammonite zonations to be placed in context to the new GSSP.

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CRETACEOUS MICROCRINOIDS – PHYLOGENY, BIOSTRATIGRAPHY AND PALAEOCEANOGRAPHY

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Tiny pelagic crinoids belonging to the Order Roveacrinida underwent an evolutionary radiation in the Albian Stage, and 20 genera of Roveacrinidae, plus 8 Saccocomidae occur in the Albian to Maastrichtian interval; the group became extinct at the K/Pg boundary. Isolated plates and entire cups are common in residues of clays and chalks. The abundance and diversity varies temporally and regionally (Gale 2019; Gale et al. 2020; Gale and Matrion 2021); in the Albian, roveacrinids are abundant throughout the middle and upper substages of the Gulf coast of the USA, and in Europe and North Africa, roveacrinids occur with local rock-forming abundance in the Turonian. The resurgence of saccocomids in the Santonian and Campanian occurred on a global scale. Rapid evolution and widespread distribution permits the use of microcrinoids for high-resolution biostratigraphy. This is illustrated using the Albian–Cenomanian boundary succession in Texas and North Africa, the Turonian of North Africa, Europe and the Gulf coast, and the Lower Campanian of the United Kingdom and Texas (Gale et al. 2020). The significance of morphological innovation to specific pelagic lifestyles remains speculative. It is, however, clear from the morphology that many migrated vertically with the zooplankton (streamlining, stabilising structures, possible gas/oil retaining structures) and that they occur most abundantly in shelf sediments which were oligotrophic to moderately eutrophic.

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MICROPALAEONTOLOGICAL CHARACTERISTICS OF UPPER CRETACEOUS DEPOSITS IN SECTIONS OF EASTERN GEORGIA

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A detailed study of calcareous nannoplankton (NP) and planktic foraminifera (PF) in the sections along the southern slope of the Greater Caucasus and the folded system of the Lesser Caucasus have added some ambiguities (why ambiguities? Have your studies not made things clearer? References needed). In the lower Cenomanian, in sediments of the Ukugmarti succession of the Mestia-Tianeti Zone, the upper part of the NP *Eiffelitus turriseiffelii* (CC9) Zone and the PF *Rotalipora appenninica* Zone have been established. The upper boundary of this zone which one? lies within the *Microrhabdulus decoratus (*CC10) NP zone, dated as late Cenomanian. The upper half of the PF *Whiteinella archaeocretacea* Zone and *Helvetoglobotruncana helvetic*a Zone are dated as early Turonian and cover the extent of the NP *Quadrum gartnerii* Zone (CC11). The Margalitisklde succession is fairly rich in microfaunal complexes. The upper Turonian NP *Lucianorhabdulus maleformis* (CC12) and lower Coniacian *Marthasterites furcatus* (CC13) match three PF zones: *Marginotruncana pseudolinneiana, M. renzi and M. sigali*. The upper boundary of the last-named coincides with the NP *Marthasterites furcatus* (CC13) Zone. At the end of this zone, the presence of nannofossils sharply decreases both in terms of species and quantity. The Eshmakiskhevi succession begins with the NP *Micula decussata* Zone (CC14) and ends with the *Calculites ovalis* Zone (CC19). The following PF zones were established: *Dicarinella concavata, Contusotruncana fornicata* and *Globotruncana arca.* These zones are dated as late Santonian and early

Campanian. The Jorchi succession covers the NP *Ceratolithoides aculeus*(CC20), *Uniplanarius sissinghii* (CC21), *Uniplanarius trifidus* (CC22), *Tranolithus phacelosus* (CC23) and *Reinhardtites levis* (CC24) zones and the lower subzone of the *Arkhangelskiella cymbiformis* (CC25a) Zone. The PF *Globotruncana ventricosa/Rugoglobigerina rugosa* is located only at the level of the nannoplankton zones CC20, CC21 and CC22. The age of the zones is middle and late Campanian. In the lower part of the Tsitelkalaki succession (Lesser Caucasus), the NP *Ceratolithoides aculeus* (CC20) and *Uniplanarius sissinghii* (CC21) zones, belonging to the middle Campanian were identified, as well as the PF *Globotruncana ventricosa* Zone. The upper half of the formation corresponds to the lower part of the *Uniplanarius trifidus* zone (Doeven 1983). The PF *Rugoglobigerina rugosa* Zone was established in this interval. The Saskhori succession covers the upper part of the *Uniplanarius trifidus* and the *Arkhangelskiella cymbiformis* | *Lithraphidites quadratus* and *Micula murus* zones. Within the last two zones a complex zone Globotruncana contusa was documented.

The study of calcareous NP and PF in sections made it possible to develop a zonal scheme for the Upper Cretaceous of Georgia based on the zonal PF scale (Robaszynski and Caron 1995 [not mentioned in the references]; Coccioni and Premoli Silva 2015; Kopaevich 2019) and the standard NP scale (Sissingh 1977; Doeven 1983; Perch-Nielsen 1985). Thus, the creation of a unified stratigraphical scale for the division of the Upper Cretaceous of Georgia was ensured.

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GEOCHEMICAL CHARACTERIZATION OF BELEMNITE ROSTRA FROM NORTH-WEST BOHEMIA (UPPER CENOMANIAN) – A CONTRIBUTION TO THE PALAEOENVIRONMENTAL INTERPRETATION OF A PERI–TETHYAN SHELF

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The Bohemian Cretaceous Basin (BCB) extends across Saxony, Bohemia, Moravia and Silesia. Sedimentary rocks preserved within the BCB possibly range in age from the ?latest Early to Late Cretaceous (Cenomanian to Santonian) (Čech et al. 1980). Here we focus on belemnite-bearing Upper Cenomanian strata that correspond to the Oceanic Anoxic Event II (OAE II). High-resolution climate records have revealed considerable changes in temperature, carbon cycling and ocean chemistry during this climatic perturbation. A prominent cooling phase within the greenhouse Cretaceous period, the Plenus Cold Event (PCE), has for the first time been recognized in the English Chalk, based on an invasive Boreal fauna and subsequently by bulk oxygen-isotope excursions in the early stages of OAE II. The PCE is generally accompanied by a faunal shift and temperature drop worldwide (O'Connor et al. 2020). We have investigated the occurrence and geochemical characteristics of the belemnite species, Praeactinocamax plenus within the north-western parts of the BCB. The characterization of rostra has been performed using $\delta^{18}O$, $\delta^{13}C$,$^{87}Sr/^{86}Sr$ and elemental analysis. Stratigraphically, these records correspond to the *Metoicoceras geslinianum* ammonite Zone (Košťák et al. 2018). Rostra of P. *plenus* studied are morphologically consistent, with all typical morphotypes recognised of this species that is distributed from Kazakhstan to Great Britain (Košťák 2004). We have recognized a few thin horizons bearing belemnite rostra which can be correlated with Jefferies's beds in the Anglo-Paris Basin (Jefferies 1963) and those in Lower Saxony, Germany (Wiese et al. 2009).

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THE EAGLE FORD FORMATION IN NORTH-EAST MEXICO: FACIES AND GAMMA-RAY CORRELATION

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The Cenomanian–Turonian Eagle Ford Formation in southern Texas and northern Mexico is an organic-rich succession of black mudstone with interbedded limestone and bentonite (Donovan et al. 2012; Denne et al. 2014).

Several studies on the Comanche Platform and its intrashelf basins have documented in detail the depositional history and lateral continuity of this unit (Lowery and Leckie 2017; Minisini et al. 2018). However, a critical knowledge gap on these issues remains in Mexico. Palaeoenvironmental conditions during the deposition of the Eagle Ford Formation are here reconstructed on the basis of sedimentological and gamma-ray spectrometric analyses of two cores (IR-1 and IR-2) drilled in the Sabinas Basin. A total of seven facies were identified: (1) hummocky cross-laminated dark limestone (facies G); (2) poorly-laminated grey limestone (facies H); (3) planar-laminated dark mudstone (facies C); (4) planar-laminated, rippled mudstone (facies E); (5) imbricated bioclastic mudstone/limestone (facies GL); (6) burrowed fish-bearing limestone (facies J) and (7) green bentonite (facies TUV). In general, the lower Eagle Ford Formation is characterized by an alternation of facies C and G, with rare occurrences of facies H, E and GL, whereas the upper Eagle Ford consists mostly of facies J and shows an occasional presence of facies C. Furthermore, the spectrometric uranium content, which is commonly used as a tracer of organic matter richness, increases abruptly along the Buda–Eagle Ford contact and remains high through the lower Eagle Ford. A progressive decrease of this parameter occurs towards the upper Eagle Ford. Altogether, these data indicate a depositional environment for the lower Eagle Ford that was characterized by oxygen-poor and low-energy conditions and was related to occasional bottom currents; and another one for the upper Eagle Ford dominated by oxygen-rich bottom waters and/or a non-stratified water column. The common presence of the TUV facies throughout the entire unit indicates a high volcanic activity during the Cenomanian–Turonian interval. The standard gamma-ray response along the Eagle Ford Formation is dominated by U content and shows trends that can be correlated with the ones observed in cores and outcrops in Texas. This points towards an extensive lateral continuity of lithological characteristics and gamma-ray properties of this unit from the southern USA into northern Mexico.

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A DIGITAL CEPHALOPOD WORLD: MICRO-CT IMAGING IN THE STUDY OF CRECCTACEOUS CEPHALOPODA

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High-resolution X-ray computed tomography (micro-CT) offers significant new opportunities for the study of fossil Cephalopoda. In the near-absence of soft-tissue preservation, nearly all that survives of the cephalopod animal are remains of their complex, 3D-shaped calcified buoyancy device, or shell. The non-destructive character of micro-CT currently makes it by far the most powerful tool for studying cephalopod fossils in three dimensions and in unprecedented detail, as well as to reveal internal (hidden) structures and characters, even when still embedded in sediment. While a decade ago, micro-CT imaging was still very expensive and could be executed only on a very limited number of specimens, today, with ongoing large-scale collection digitization efforts by an ever-growing number of taxonomic facilities (e.g., RBINS, part of the European DiSSCo consortium), micro-CT imaging data are becoming accessible for a much increased number of specimens and taxonomic groups and increasingly accessible to a wider group of researchers than ever before. Some examples of ongoing studies in which micro-CT imaging proves to be a major tool will be discussed. Micro-CT imaging currently aids in resolving the taxonomy of Cretaceous Nautilida from the Mons, Campine and Liège-Maastricht basins (Belgium, the Netherlands). Here, most of the faunas are dominated by the so-called 'waste basket' genus for globular, involute and smooth-shelled nautilids with nearly straight sutures, namely *Eutrephoceras*.

Recognition of species and evolutionary lineages is difficult due to the limited set of taxonomic characters that can be measured on the final (exposed) whorl. Micro-CT offers major help here, allowing for correct measurements of conch parameters throughout ontogeny, as well as inspection of possible changes in siphuncle size and position and estimates of embryo size and number of chambers and so on. As a nice bonus, the virtual casts serve easier morphological comparisons between specimens, even allowing for retro-deformation, as well as for improved exchange of data with colleagues from all over the world. Micro-CT imaging is currently also applied in the digitization of a collection of small, originally pyritic ammonites from the uppermost Maastrichtian of Tunisia. Although micro-CT imaging of pyritic specimens generally is challenging, good results have been obtained for most of them. A digital copy now safeguards their data for the future, regardless of further decay. In addition, highly accurate WER curves can now be created, from the protoconch onwards and septal surfaces can be better quantified, thus allowing for a more reliable quantification of morphological disparity of the taxonomically most diverse latest Maastrichtian ammonite fauna in the world. Micro-CT imaging of a baculitid ammonite (and surrounding sediment) from the Lower Paleogene Cerithium Limestone near Stevns Klint (Denmark) also reveals details on sedimentology and bioturbation that are possibly important to interpret presumed Chicxulub meteorite survivors.

CRETACEOUS TRIGONIID BIVALVES FROM SINAI, EGYPT: A REVIEW

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Cretaceous trigoniids from Egypt have not been systematically updated since the monographs of Douvillé (1916) and Abbass (1962). New material was collected from fossiliferous horizons of Aptian–Albian strata exposed around Gebel Maghara, North Sinai and from Upper Cenomanian to Coniacian deposits of west-central Sinai. Based on Cooper's papers (2015a, b), the material studied is here adapted and updated systematically. Of ten

trigoniid species that have been described from Cretaceous sequences of Sinai, ranging in the age from the Aptian to the Coniacian, seven belong to the family Rutitrigoniidae and three to the Pterotrigoniidae, i.e., *Zulutrigonia analoga, Z. picteti, Lycettitrigonia depauperata, L. cf. longa, L. undulatocostata, Lycettitrigonia sp., Levantotrigonia magharensis, Praescabrotrigonia orientalis, Arabotrigonia pseudocrenulata and Scabrotrigonia scabra.* Nine species have been collected from the Aptian–Albian oolitic shoal carbonate ramp facies of sections at Gabal Maghara. *Scabrotrigonia scabra* has been recorded only from Cenomanian marls and extends into and is abundant in Coniacian oolitic and calcareous sandstone facies. These species have been taxonomically discussed at the generic and specific levels and compared with those previously described by several authors (Mahmoud 1955; Abbass 1962; Aboul Ela et al. 1991; Aly 1993; Abdel Gawad 1999; El-Hedeny 2006). The palaeobiogeographical distribution of the trigoniids studied shows that they belong to the southern Tethyan Realm, and the majority are endemic to the Middle East Province.

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RECENT PROGRESS IN DEFINING THE TITHONIAN/BERRIASIAN AND JURASSIC/CRETACEOUS BOUNDARIES

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The new Berriasian Working Group (BWG) started its activity in February 2021. The decisions of the former BWG were again discussed and reconsidered. It was confirmed that the Tethys domain provides the best-quality, continuous stratigraphical data set, based on integrated calpionellid, calcareous nannofossil and magnetic stratigraphy, ranging from the base of the Upper Tithonian to the Berriasian/Valanginian boundary. The Tethyan ammonite stratigraphy in the J/K boundary interval has recently been largely modified, and we support the opinion of the former BWG that ammonites should be regarded rather as useful, but not as first-order markers in defining the J/K boundary, at least in the Tethyan domain. As integrated Tethyan stratigraphy offers multiple possibilities to place the system boundary, we have attempted to select horizons with the highest potential enabling correlation with shallow-marine and terrestrial environments, as well as other palaeogeographic domains. We have tested broad intervals from the middle part of Upper Tithonian (base M20n1r magnetosubzone), up to the Lower Berriasian (base M17r magnetozone). The present-day J/K boundary at the base of the *Calpionella alpina* Subzone (base NC0 nannozone, within M19n2n magnetosubzone) works very well within the Alpine Tethys; however, some researchers have raised issues that its exact correlation with 'Purbeckian' and 'Volgian' is far from being precise, at the present state of knowledge. The *alpina* event falls in the middle of the Upper Volgian and may correspond to the base of the *Arctoteuthis tehamaensis* belemnite zone of Siberia. In the Neuquén Basin succession (South America), rich in recently obtained radioisotopic ages lacking in the Tethyan area, the position of the base of the *alpina* Subzone according to ammonite stratigraphy is debated. Shifting the J/K boundary a bit up or down might apparently solve some problems. The position of the boundary in the Lower Berriasian around the base of magnetozone M17r and the base of the *Calpionella elliptica* Subzone would approximately correspond to the base of NC1 nannozone, being close to (probably slightly older than) the base of *Occitanica* ammonite Zone, the major Middle Berriasian transgression in the Jura Mountains and the Volgian/Ryazanian boundary. The boundary is probably possible to identify in platform limestones based on benthic foraminiferal and calcareous algal stratigraphy. Problems still remain with correlation with the Neuquén Basin. The third solution placing the J/K boundary in the Upper Tithonian, between M20n1r and the base of M19r, falls in the interval of important palaeoecological changes within the Tethys domain (such as the demise of *Saccocoma* and the first nannofossil calcification event). It is apparently close to the base of the *Crassicollaria intermedia* calpionellid subzone, the base of the NJT17 nannozone, the base of the *Protacanthodiscus andreaei* Zone of the Mediterranean subrealm, the Middle/Upper Volgian boundary of the Boreal region, and might coincide with the VOICE excursion on the $\delta 13C_{org}$ curve, unfortunately not yet confirmed in Tethyan $\delta 13C_{carb}$ data. In north-west Europe, it is probably not far from the 'Portlandian/Purbeckian' transition, while in South America it is close to the base of the *Corongoceras alternans* ammonite zone. The three options outlined above might be roughly related to palaeohumidity variations documented in north-west European and Russian sections: aridification in the Upper Tithonian, fully arid conditions around the Tithonian/Berriasian boundary and a return to more humid conditions between the Lower and Upper Berriasian. Integration of biotic and palaeoenvironmental trends might help to overcome the well-known faunal provincialism which has hitherto prevented a consensus on the global definition of the J/K boundary.

MORPHOMETRICAL ANALYSIS OF *ARKHANGELSKIELLA CYMBIFORMIS* – A CASE STUDY FROM THE SANTONIAN–CAMPANIAN BOUNDARY INTERVAL IN THE EASTERN ALPS (LOIBICHL, NORTH-WEST AUSTRIA)

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Arkhangelskiella cymbiformis is a commonly occurring constituent of calcareous nannofossil assemblages in Upper Cretaceous marine sedimentary rocks. Its morphometrics has been previously studied for stratigraphic and palaeoenvironmental purposes (e.g., Girgis 1987). The size variation in this genus has revealed a generally increasing trend in average coccolith size across the Campanian–Maastrichtian boundary, ending with a brief decrease ('dwarfing effect') in average size prior to the Cretaceous–Paleogene boundary confirming correlation to palaeoenvironmental proxies (e.g., Thibault et al. 2004; Linnert and Mutterlose 2009). However, morphometric analyses of *A. cymbiformis* in the Santonian–Campanian boundary interval are scarce. A first morphometric consideration of the genus *Arkhangelskiella* for this period was that by Lauer (1975), who distinguished two groups: Group 1 including four perforations along the short axis of the central area and Group 2 with six or more perforations. However, more data are needed in order to estimate the general response of coccolith morphometric features for this interval. The present study focuses on the light-microscope morphometric analysis of *A. cymbiformis* with incorporation of the number of holes arranged in the central area during the Santonian–Campanian boundary (CC17–CC18b) from the Loibichl section (Austrian Eastern Alps). A total of 130 specimens, suitable for the counting of hole numbers, have been selected, representing a moderate to good state of preservation. For each specimen, the short (S1) and long (L1) axis of the central area, the short (S2) and long (L2) axis including the outer rim, the surface of the rim and the central area, as well as the number of holes arranged in the central area have been measured. Our results show variation in size of *A. cymbiformis* with a slight decreasing trend along the section. Different numbers of holes were also observed (2–6 along the short axis of the central area), thus distinguishing the two groups that Lauer (1975) recorded. However, the statistical results do not yield a significant correlation (similarity) between morphometric parameters and the number of holes. This unexpected relation needs more detailed evaluation and further investigation such as geochemical analysis so as to reveal reasons of coccolith arrangement.

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CALPIONELLID BIOSTRATIGRAPHY JUDGED BY THE YARDSTICK OF SEDIMENTOLOGY

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Calpionellids *sensu lato* are well-known unicellular microfossils with a simple unilocular body plan. However, this relatively limited morphological variability has not prevented micropalaeontologists from identifying genuine morphogroups and therefore defining genera and species. Jürgen Remane (1934–2004), once President of the International Commission of Stratigraphy, efficiently advocated their use as primary proxies to define both the Tithonian/Berriasian and Berriasian/Valanginian boundaries in the Vocontian Trough in south-east France (Remane 1963, 1964, 1970). There he worked jointly with a specialist of ammonites, Gérard Le Hégarat (1939–1997), in order to calibrate his calpionellid scale with the zones based on ammonites (Le Hégarat and Remane 1968). Our team is now reassessing the biozonal boundaries in their key sections (Ferry 2017), starting with Le Chouet and Tre Maroua (Granier et al. 2020), with special emphasis on events compromising the continuity of the sedimentary record. In some places, depending on the scale of observation, reworking of calpionellid loricas is easily demonstrated. The opposite is not true, because pristine preservation does not necessarily stand for calm water sedimentation. The case study of so-called Hauterivian calpionellids from Busot, south-east Spain (Granier et al. 1995), provides a striking example of reworking processes that have left us with no evidence of their occurrence (work in progress).

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THE KALKOWSKY PROJECT: A DECADE OF ADVANCES IN OUR KNOWLEDGE OF CALCITE OOIDS, ILLUSTRATED BY CRETACEOUS EXAMPLES

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The post-2000 literature on oolites (see Diaz and Eberli 2019, and references therein) deals mostly with modern aragonite ooids, whereas the ancient calcite ooids are commonly not discussed. Modern aragonite ooids with tangentially arranged needles (concentric fabric) are marine, as documented by iconic examples from the Bahamas and the Persian Gulf. In contrast, aragonite ooids with radially oriented needles (radial fabric) are lacustrine. Recently, Diaz and Eberli (2019) reviewed theories regarding the formation of modern marine aragonite ooids. However, they did not discuss the processes behind the occurrence of high-Mg calcite (HMC) ooids, which still remain unknown or poorly understood. Fossil HMC ooids with radially oriented fibres (radial and radial-concentric fabrics), e.g., the Cretaceous ooids documented here, are reported either from marine or lacustrine environments. To complicate matters, it was long assumed that fossil leached or recrystallised ooids could only have been former aragonite ooids on the basis of the instability of this $CaCO_3$ polymorph. Multiple reports with calcitic oolitic cortical layers partly leached or recrystallised (Granier et al. 2014, 2016; Granier 2019; Granier and Lapointe 2022) remind us that HMC also is unstable and that leaching is not restricted to aragonite. The author and his former co-authors have repeatedly demonstrated that the cortices of some so-called bimineral or two-phase ooids originally consisted only of HMC. To mention one more example, broken ooids have been considered to be a high-energy index. However, breakage occurs in all sorts of environments from quiet water to strongly agitated water. It is intimately associated with the radial fabrics. In conclusion, to put it simply, there is still much to learn about calcite ooids.

This is a contribution to the Kalkowsky Project.

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PLANKTIC FORAMINIFERAL BIOSTRATIGRAPHY AND PALAEOENVIRONMENTAL INFERENCES FOR THE UPPER CRETACEOUS OF THE SABINAS BASIN, COAHUILA (MEXICO)

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The Late Cretaceous records several horizons of organic-rich sediments related to episodes of accelerated global change called Oceanic Anoxic Events (OAEs). The OAE 2 at the Cenomanian–Turonian boundary represents one of the most widespread perturbations in the carbon cycle (Schlanger and Jenkyns 1976; Scholle and Arthur 1980; Jenkyns 2010; Eldrett et al. 2014). However, OAE 3 in the Coniacian–Santonian interval is considered to be only of regional extent, having been identified in the Atlantic region and the Western Interior Basin (Jenkyns 2010; Wagreich 2012). During these episodes, changes in physical and chemical parameters in the water column had significant effects on the diversity and assemblage composition of planktic foraminifera (Leckie et al. 2002; Keller et al. 2008; Lowery et al. 2014; Falzoni et al. 2018). The IRME2 core recovered from the Sabinas Basin in northern Coahuila (Mexico) records the transition between the Buda Limestone and the Eagle Ford and Austin formations, inclusive of the Cenomanian–Turonian and Coniacian–Santonian boundaries (Eguiluz de Antuñano 2001; Lowery et al. 2014). Here we present a detailed biostratigraphic analysis of thin-section samples from the IRME2 core, based on planktic foraminiferal bioevents and quantitative microfossil data to infer biozones and palaeoenvironmental conditions in the Sabinas Basin, which represents a linking area between the Western Interior Seaway and the equatorial Atlantic water mass.

The interval studied comprises pelagic limestones intercalated with shale and bentonite. Microfossils are represented mainly by planktic foraminifera, radiolarians, calcispherulids and roveacrinid crinoids. Based on planktic foraminiferal assemblages, the stratigraphic record of the IRME2 core encompasses the Upper Cenomanian *Rotalipora cushmani* Zone to the Santonian *Dicarinella asymetrica* Zone. The Cenomanian–Turonian boundary was inferred between the last occurrence (LO) of *Rotalipora cushmani* and the first occurrence (FO) of *Marginotruncana renzi*; the Turonian–Coniacian boundary was established between the FOs of *Dicarinella concavata* and *Globotruncana*. Furthermore, the Coniacian–Santonian boundary was placed by reference to the LO of *Whiteinella archaeocretacea*. Intermediate and mixed layer dwellers (with r/K selected and r-opportunistic strategies) are the major components in the transition interval from the *Rotalipora cushmani* to *Whiteinella archaeocretacea* zones. This also includes increments of filaments before the emplacement of the $\delta^{13}C$ positive excursion and records the '*Heterohelix* shift' between peaks B and C of the carbon isotope signature related to OAE 2. Similarly, the *Dicarinella asymetrica* Zone records a positive excursion of $\delta^{13}C$ related to OAE 3. In this interval, intermediate dwellers amongst planktic foraminifera (with r/K strategies) represent the most abundant component, denoting mesotrophic to eutrophic conditions.

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THE HIDDEN DIVERSITY OF CRETACEOUS ANGIOSPERMS: SMALL TRICOLPATE POLLEN FROM THE CONIACIAN–SANTONIAN OF LOWER SILESIA, POLAND

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In terms of megaflora and mesoflora, plant assemblages of the North Sudetic Basin (Lower Silesia, western Poland; Coniacian–Santonian) are dominated by angiosperms, but by ferns when the microflora is considered (Halamski et al. 2020). However, a large fraction of angiosperm pollen is represented by small tricolpate grains that are customarily disregarded in standard (LM) analysis, being described in open nomenclature as, for instance, *Tricolpites sp. or Tricolporites sp.* (Halamski et al. 2020). Detailed SEM investigation of such pollen grains from the Upper Coniacian? – Lower Santonian? at Rakowice Małe (Czerna Formation, Nowogrodziec Member; Assemblage 5/Palynoassemblage A, *sensu* Halamski et al. 2020) has revealed their diversity in terms of surface sculpture. A preliminary cursory survey indicates that part of these small pollen grains might represent the beech family, Fagaceae. If confirmed, this will constitute another piece of evidence for the importance of the Fagales in Late Cretaceous floras (e.g., Grímsson et al. 2016). In any case, it should be stressed that the genuine diversity of angiosperm palynoflora studied this way is shown to be higher than when investigated by standard (stratigraphy-oriented) methods only.

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200 YEARS OF THE CRETACEOUS SYSTEM: A PERSONAL VIEWPOINT

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Two weeks after becoming an undergraduate student at Imperial College (London), we were taken to the Dorset Coast (now a UNESCO World Heritage Site) and shown the Jurassic and Cretaceous succession, including the famous chalk cliffs around Lulworth Cove and Durdle Door. Prof. D.V. Ager explained the origins of the Cretaceous System and how the Latin *creta* was used as one of the typical lithologies in NW Europe in order to provide the name. In April 1964 I was shown the chalk cliffs of the Beer area; an area for which I still have a great attraction. With an interest in the Cretaceous, I was assigned a 10-week mapping project in the French Alps as the area was supposed to include much of the Cretaceous succession. This was true, and after looking at some thin-sections of the limestones I was able to identify the Ce/Tu boundary (using planktic foraminifera), the K/Pg boundary, larger foraminifera (including *Orbitolina*, *Nummulites*, *Discocyclina* and *Asterocyclina*) and even calpiopnellids. Having convinced David Carter that I really knew something about the Ce/Tu boundary (using rotalipords and *H. helvetica*), I was sent to speak to Dr. R.P.S. Jefferies – the then expert on the Plenus Marls. He had moved on to study blastoids and other ancient echinoderms by that time, though he did explain his thoughts on the Ce/Tu boundary and the 'Plenus Cold Event'. At weekends, during my final year as an undergraduate, I worked in the Channel Tunnel laboratory in Dover Castle, using the occurrence of rotaliporids to confirm the cross-Channel correlations and the possible tunnel alignment.

With that undergraduate record, it was no surprise that PhD research on the chalk foraminifera followed – and a lifetime of involvement with the Cretaceous. I had, almost without taking a decision, been launched into a career of micropalaeontology, biostratigraphy, OAE 2, Cretaceous climates, Milanković cycles, issues around the K/Pg boundary and the use of calpionellids in lowermost Cretaceous biostratigraphy. Our knowledge of all these components of the Cretaceous System has moved on in the last 50 years, though they all remain topics for discussion at this meeting

MID-CRETACEOUS CLIMATIC PERTURBATION IN THE SOUTHERN HIGH LATITUDE OCEAN: DRASTIC WARMING AND COOLING ACROSS THE OAES AND THE MID CENOMANIAN EVENT.

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The mid-Cretaceous, especially the late Cenomanian through early Turonian interval, is well-known to be a period of climatic optimum of greenhouse Earth. On the other hand, less information is available for the progressive warming interval before the optimum. How was the climatic optimum established? Was it gradual or stepwise developed with or without fluctuations? It is especially important to understand paleoenvironmental fluctuations in higher latitude regions during the greenhouse world as they generally respond sensitively to climatic warming and cooling.

Alkenones are primary proxies for Quaternary paleothermometry, whereas they are rarely applied for earlier geological intervals. This is partly because of less information about their producer and lack of reliable calculation formula for paleotemperature. Though acquiring paleotemperature values is difficult, it is still available to discuss relative levels of paleo-SST, provided the mechanism that produces unsaturation in the alkenone molecule is the same as that of the present haptophytes. From southern rim of the paleo-Indian Ocean near southwestern Australia (IODP Sites U1513, U1516), alkenones composed of forty carbons with two or three unsaturation sites were solvent-extracted and analyzed with gas-chromatography to obtain the C_{40} alkenone unsaturation index ($U^{K'}_{40}$). The trend of $U^{K'}_{40}$ from the late Albian through latest Cenomanian is interpreted to reflect that of SST through this interval. $U^{K'}_{40}$ gradually decreased through the late Albian and early Cenomanian, then showed a clear and considerable but short-lived drop near the MCE horizon, then recorded a maximum within the lower part of OAE 2. Then it dropped clearly within the black mudstone representing OAE 2 but not as significantly as in the MCE. This fluctuation is concordant with paleoceanographic data from other regions of the world. Dramatic paleotemperature response is also suggested by bulk carbonate oxygen isotope data across the OAE1b horizon. The southern rim of the proto-Indian Ocean is interpreted to be a very sensitive region to climatic change. The paleothermometry scale for $U^{K'}_{40}$ should be developed for further research on the alkenone index.

EARLY CRETACEOUS LIGNITES FROM INNER-CONTINENTAL ASIA AS A PALAEOCLIMATE ARCHIVE

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Records documenting terrestrial environments of continental interiors during the late Early Cretaceous are critical for a better understanding of fossil ecosystem functioning and for constraining state-of-the-art Cretaceous climate models for predicting global temperature and humidity distribution under greenhouse conditions. The continental Choir-Nyalga Basin in central Mongolia contains thick, lignite-rich successions hosting an exceptionally well-preserved fossil flora, which is composed of multiple types of pine and redwoods as well as representatives of extinct seed plant lineages. Based on existing U/Pb ages, the base of the coal-bearing Khukhteeg Formation can be dated at 118.5 ± 0.9 Ma and 119.7 ± 1.6 Ma. It thus corresponds to the Aptian, a time interval characterized by extreme climatic fluctuations, global oceanic anoxia (OAE 1a) and ecological turnover (e.g., Castro et al. 2021). Terrestrial climatic and environmental conditions of inner-continental palaeo-Asia are reconstructed by combining brGDGT-based palaeothermometry, coal petrology and geochemistry with palynology of lignite-bearing successions from open-cast mines in central Mongolia. The low-maturity lignites from the Shivee Ovoo site in the Choir-Nyalga Basin are relatively mineral-rich (ash yields of 6.5 to 17.4 wt. %) and show brGDGT-based MAT estimates of 12.3 to 14.5°C. These brGDGT-based MATs are in line with calculated MATs of 13.8°C obtained from a coupled atmosphere-ocean-sea ice general circulation model for an Early Aptian high CO2 (1.200 ppm) scenario, but contrast with stable isotope estimates derived from vertebrate teeth and bones (Amiot et al. 2011). Model-derived precipitation estimates (1.5 mm/day) are rather low given the required wetland conditions for lignite accumulation in the Choir-Nyalga Basin. Our new results highlight the suitability of continental lignite-rich strata as valuable archive of palaeoclimatic conditions prevailing in Cretaceous palaeo-Asia.

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GEOCHEMICAL AND BIOMARKER ANALYSES OF THE LOWER APTIAN SUCCESSION IN THE BASQUE-CANTABRIAN BASIN, SPAIN: IMPLICATIONS FOR ORGANIC MATTER SOURCES DURING OAE 1A

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Cretaceous sedimentary deposits are characterized by intermittent organic-rich levels associated with oceanic anoxic events (OAEs).The Lower Aptian succession of the Northern Basque-Cantabrian Basin (NBCB) in the Cuchía section of northern Spain includes OAE 1a. Previous litho – and biostratigraphical studies have shown that the Early Aptian evolution of the NBCB included environmental conditions such as open-marine, shallow mixed carbonate-siliciclastic and an interval of restricted conditions with limestones, marlstones, calcareous shales and shales. Here we present the results of a 67-m, high-resolution (n = 83) study along the Cuchía section to determine the specific geochemical characteristics associated with local conditions of the basin during the global event, using total organic carbon (TOC), major elements (Al, Si, Ti), redox sensitive trace elements (RSTEs; V, Cr, Cu, Co, Ni, Mo, U) and biomarkers. Elevated major element concentrations throughout the section studied display episodes of expanded terrigenous input that increased rapid burial and preservation of OM within OAE 1a. Vanadium, Cr, Cu and U correlate most strongly with Al ($r = 0.96$, V; 0.84, Cr; 0.74, Cu; 0.76, U), suggesting a common source for these trace metals. The RSTEs also share moderate correlations with TOC ($r = 0.50$, V; 0.51, Cr; 0.35, Cu; 0.51, U), indicating that the basin likely experienced periods of reducing conditions that further enhanced the preservation of OM. The biomarker analysis has revealed that the aliphatic fraction is dominated by *n*-alkanes (from nC_{11} to nC_{33}) and the acyclic isoprenoids pristane (Pr) and phytane (Ph). The terrestrial aquatic ratio (TAR) values range from 0.06 to 1.41, with the highest values generally occurring within the shale layers, confirming higher terrigenous input at those times. Long chain *n*-alkanes ($\geq nC_{24}$) have an average carbon preference index (CPI) of 0.82 (from 0.6 to 1.4) and an average odd over even preference (OEP) of 0.75 (from 0.5 to 1.5) indicating that the succession is not thermally overmature since values approaching 1 indicate increased thermal maturity. Values

for Pr/nC_{17} and Ph/nC_{18} are relatively low, averaging 0.31 and 0.23, respectively, thus indicating that the OM are composed of marine type II kerogen, mixed type II/III kerogen, and one sample that plots in terrigenous type III kerogen. The geochemical results of the present study highlight the role of terrigenous fluxes in supplying terrestrially derived OM and enhancing marine productivity. The main driving mechanism controlling the preservation of OM in these sediments was mostly due to rapid burial and intermittent reducing conditions.

ALBIAN-CENOMANIAN PRELUDE TO THE HOT CRETACEOUS GREENHOUSE CLIMATE AT SOUTHERN HIGH LATITUDES

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Cretaceous marine sediments from southern high latitudes (SHL) provide valuable archives of paleotemperature change with considerable spatial and temporal coverage. Obtaining these paleotemperature estimates is especially important because of the greater sensitivity of high latitudes to changes in global climate. Previous foraminiferal oxygen isotopes and TEX_{86} compilations from studies of DSDP and ODP sites in the southern South Atlantic and Naturaliste Plateau yield a consistent record with warm greenhouse conditions persisting through the Cretaceous and highest global temperatures occurring from the Turonian through Santonian. Gaps in the paleotemperature compilations spanning portions of the Albian–Cenomanian and the late Santonian–Campanian have prevented determination of the timing and rate of temperature changes into and out of the mid-Cretaceous hot greenhouse climate.

One of the key objectives for IODP Expedition 369 drilling in the Mentelle Basin (SE Indian Ocean) was to fill the remaining gaps in the SHL Cretaceous temperature curve. We present new stable isotope and microfossil assemblage observations from the Albian-late Cenomanian spanning ~108–94 Ma for IODP sites U1513, U1514, and U1516, located <70 km apart at ~60˚S paleolatitude and at middle bathyal paleodepths. Black claystone and nannofossil-rich claystone dominate the cored sediment, which yields foraminifera showing good to excellent preservation. Planktonic foraminiferal diversity is very low throughout the interval, with assemblages dominated by a single species of Microhedbergella; biostratigraphic index species were absent from nearly all samples. The age models developed for the three sites are entirely based on calcareous nannofossil datums.

Oxygen isotope values from the upper Cenomanian and middle–upper Albian show remarkable uniformity among the sites and across time. Benthic d18O values range between – 0.5 and – 1.0‰ and planktonic values range between – 1.4 and – 1.6‰. Assuming a seawater d18O value of – 1‰$_{V\text{-}SMOW}$, these values suggest seafloor temperatures between 13°–15°C and sea surface temperatures between 17°–18°C with a vertical temperature gradient of about 4°C. There is no apparent warming prior to the latest Cenomanian onset of Oceanic Anoxic Event 2.

The lower Cenomanian (96.5-100 Ma) is carbonate-poor in all three drill sites due to dissolution and/or nondeposition. The stratigraphic extent of the low carbonate interval is greater at Site U1516, which may have occupied a deeper paleodepth or was influenced by different deep-water currents. Magnetic susceptibility, natural gamma ray emission, and the abundance of siliceous microfossils are all high in the calcite-poor intervals, features that may have been caused by higher nutrient input during igneous province eruptions or increased continental runoff due to an increased hydrologic cycle.

A LITHIUM ISOTOPE CURVE BASED ON UPPER CAMPANIAN–MAASTRICHTIAN BOREAL CHALK: EVIDENCE OF A STRONG CONNECTION BETWEEN WEATHERING INTENSITY, DEEP-SEA TEMPERATURE AND SEA LEVEL FALL ACROSS THE CAMPANIAN–MAASTRICHTIAN BOUNDARY EVENT

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The Late Cretaceous was a period known for its long-term climatic cooling and several carbon cycle perturbation events (Friedrich et al. 2012; Jarvis et al. 2002; Voigt et al. 2010, 2012). In particular, the Campanian–Maastrichtian Boundary Event (CMBE) is characterized by a long-lasting negative carbon isotope (CIE) excursion for which the causes are not well understood to date. Mainly, it correlates with a falling sea level and climatic cooling for which changes in ocean circulation and/or glaciation were proposed as a mechanism. The lithium isotopic composition (δ^7Li) of marine carbonates can serve as a proxy for chemical weathering, which is considered as a sink for atmospheric CO_2 in the global carbon cycle. High δ^7Li values reflect more incongruent weathering typically occurring during colder climates and in high-relief terrains, whereas low δ^7Li values reflect more congruent weathering typically occurring during warmer climates and in peneplained terrains (Pogge von Strandmann et al. 2021). Here we present a detailed chalk-derived Late Cretaceous δ^7Li record (75–66 Ma) of the boreal white chalk of northern Germany (Lägerdorf–Kronsmoor–Hemmoor) as an archive for the lithium isotopic composition of seawater. Late Campanian–Maastrichtian δ^7Li values show a net increase of 3.7 ‰ in its long-term trend. Superimposed on this trend, the curve displays constant values in the Late Campanian, a distinct increase by 2 ‰ during the CMBE, followed by a decrease in the *sumensis* Zone and finally a subsequent rise during the mid – to Late Maastrichtian. The long-term Late Campanian–Maastrichtian δ^7Li rise correlates well with the increase in seawater strontium isotopes and long-term climatic cooling,

suggesting a link between an enhanced total weathering flux and lowered atmospheric CO_2 concentrations. This relation seems to have been amplified during the CMBE when the distinct δ^7Li rise occurred contemporaneously with deep-sea cooling and a major sea level fall, documented in European chalk sections and the New Jersey margin. Here, we suppose that exposed large shelf areas and flood plains were subject to more erosion and incongruent weathering and delivered a higher amount of particulate material to the ocean. Further, increased reworking of organic matter could have driven the negative CIE.

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THE MUDEUNGSAN UNESCO GLOBAL GEOPARK IN THE REPUBLIC OF KOREA: ACADEMIC VALUES

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The Mudeungsan UNESCO Global Geopark is situated in the south-western part of the Korean Peninsula near the large city of Gwangju, its administration being shared between Gwangju Metropolitan City and two counties (Damyang-gun and Hwasun-gun) in the province of Jeollanam-do. The core area of 75 km^2 is within Mudeungsan National Park. Twenty geosites, illustrating seven geological periods, spread out over 1,051 km^2 of the Mudengsan UGGp area. Geosites range from five large colonnades of polygonally jointed tuff columns recording at least three phases of Cretaceous volcanic activity (Lim et al. 2015), unique dinosaur footprints and trackways (Huh et al. 2006; Kim and Huh 2010; Lockley et al. 2012), and a variety of other geological and geomorphological objects. Among them, outstanding universal value sites are the colonnades of Mudeung Mountain, Unjusa stratified tuff, Hwasun Dolmen site, and Seoyuri dinosaur fossil site. Moreover, one of the greatest features of the Mudeungsan UGGp is its unique culture stemming from geological features. The Unjusa temple (Unjusa stratified tuff) has well-developed tuff stratification by the volcanic activities in the Cretaceous. Also, the citizen movements for conserving Mudengsan UGGp are outstanding and interesting.

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PALYNOLOGICAL STUDIES OF THE TUKHUM COAL DEPOSIT, EASTERN MONGOLIA

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Non-marine Cretaceous deposits are widely distributed in eastern and southern Mongolia (Hasegawa et al. 2018). During the Aptian and Albian Stages terrigenous and coal-bearing sediments accumulated, now assigned to the Khukhteeg Formation. This represents the major coal-bearing level in the Choyr, Nyalga and Tamtsag basins of eastern Mongolia. The age of the Khukhteeg Formation has been indicated as Aptian-Albian on the basis of vertebrate fossils, palynological assemblages, and magnetostratigraphy (Nichols et al. 1997; Hicks et al. 1999; Ichinnorov 2005; Hasegawa et al. 2018). The dominant lithologies within the Khukhteeg Formation include dark grey to black, laminated mudstone, whitish grey sandstone, pebbly sandstone, and dark grey mudstone intercalated with coal seams. The formation attains an overall thickness between 250-470 m. The palynological assemblage described from the open-pit Tukhum coal deposit documents an Aptian-Albian age for the Khukhteeg Formation. The quantitative composition of palynofloras is characterised by the a predominance or abundance of pollen produced by bisaccate conifers (*Piceapollenites*, *Pinuspollenites*, *Podocarpidites*, *Podosporites* and *Cedripites)* and non-saccite gymnosperm pollen such as *Cycadopites*, *Ginkgocycadopites* and *Inaperturapollenites.* Spores are not numerous, but some species of *Retitriletes*, *Cyathidites*, *Osmundacidites*, *Baculatisporites*, *Biretisporites* and *Contignisporites* occur. In contrast, this assemblage differs significantly from the other assemblages with an appearance of some angiosperm such as *Triporopollenites* and *Fraxinoipollenites.* This palynocomplex is different from an older, Early Cretaceous palynocomplex (Ichinnorov 2005, 2009; Ichinnorov et al. 2016, 2017). In those assemblages numerous species of spores, i.e., *Pilosisporites*, *Cicatricosisporites*, *Cooksonites*, *Trilobosporites* and *Aequitriradites* occur, lacking in the present assemblage. Associated are some angiosperms, i.e., *Triporopollenites* and *Fraxinoipollenites.* Based on spores and pollen, the age of the palynoassemblage is Aptian-Albian (i.e., correlatable to the Khukhteeg Formation). Palynological evidence points to a humid and warm palaeoclimate.

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AMMONOID AND INOCERAMID BIOSTRATIGRAPHY AND CHEMOSTRATIGRAPHY OF THE TEPEYAC SECTION (COAHUILA, MEXICO), A CANDIDATE FOR ASSOCIATED STRATOTYPE SECTION AND POINT FOR THE BASE OF THE CAMPANIAN

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The Tepeyac section near Jiménez, northern Coahuila (north-eastern Mexico), has meanwhile become known for its giant ammonites (Ifrim et al. 2021); it may thus correspond to one of the historical sites in the area from which Böse and Cavins documented such giants around 90 years ago. Fossil-rich shelf carbonates of Late Santonian–Early Campanian age are superbly exposed at Tepeyac and more ammonoids were found. Altogether, 330 specimens, assigned to 24 species and 12 genera, have been documented from this section (Ifrim and Stinnesbeck 2021). Specimens were mostly recorded *in situ* and thus allow for a detailed biozonation of the section, permitting the first formal biozonation across the Santonian–Campanian boundary in the Gulf Coast region to be established. The *Plesiotexanites shiloensis*, *Menabites* (*Delawarella*) *tequesquitense*, *M.* (*D.*) *delawarensis* and *Baculites taylorensis* biozones of the northern Gulf Coast are correlated with a stable carbonate isotope curve. The faunal assemblage provides evidence for repeated and increasing ammonoid exchange with Europe and southern latitudes, but also includes intervals of faunal cut-off and endemic evolution. Most of the 213 specimens of inoceramids available, assigned to 12 species, were recovered *in situ*. The definition of an inoceramid biozonation is challenging due to differing vertical ranges of the species found in other regions. Two giant growth events are found among the Tepeyac inoceramids, but they are unrelated to giant growth in ammonoids from the same section. The inoceramid record in the Tepeyac section provides the most abundant and detailed survey of this group of bivalves known to date across the Santonian–Campanian boundary. Still, they are not suited for the definition of the base of the Campanian, unlike for other Upper Cretaceous stage boundaries (Walaszczyk et al. 2021). Altogether, the abundance of fossils, the excellent outcrop conditions and biozonal completeness favour the use of the Tepeyac section as a potential reference section for the base of the Campanian in the Americas.

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THE WORLD'S LARGEST AMMONITE, *PARAPUZOSIA (P.) SEPPENRADENSIS:* ITS ONTOGENY, EVOLUTION AND PALAEOGEOGRAPHICAL DISTRIBUTION

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The world's largest ammonite, *Parapuzosia* (*P.*) *seppenradensis,* has fascinated the world ever since the discovery in 1895 of a specimen measuring 1.74 m in diameter near Seppenrade in Westfalia, Germany. Subsequent findings of this taxon are exceedingly rare and its systematic position remains enigmatic. We have revised the historical specimens and documented abundant new material from England and Mexico (Ifrim et al. 2021). Our study (Ifrim et al. 2021) comprises 154 specimens of large (< 1 m diameter) to giant (> 1 m diameter) *Parapuzosia* from the Santonian and Lower Campanian, mostly with stratigraphical information. High-resolution integrated stratigraphy allows for precise trans-Atlantic correlation of these occurrences. Our analysis of specimens considered morphometry, growth stages and stratigraphical occurrence wherever possible, and provides insight into the ontogeny of *Parapuzosia* (*P.*) *seppenradensis* and into the evolution of this species from its potential ancestor, *P.* (*P.*) *leptophylla*. The latter grew to shell diameters of about 1 m and was restricted to Europe during the Early Santonian, but it had reached the Gulf of Mexico by the Late Santonian. *Parapuzosia* (*P.*) *seppenradensis* first appears in the uppermost Santonian-lowermost Campanian on both sides of the Atlantic. Initially, it also reached diameters of about 1 m, but gradual evolutionary increase in size is seen in the mid Early Campanian to diameters of 1.5 to 1.8 m. The species is characterised by five growth stages and by size dimorphism. We therefore here include the many historical species names used in the past to describe the morphological and size variability of the taxon. The

concentration of adult shells in small geographical areas and paucity of *Parapuzosia* in nearby coeval outcrop regions may point to a monocyclic, possibly even semelparous reproduction strategy in this giant cephalopod. Its gigantism exceeds the general trend of size increase in Late Cretaceous cephalopods. Whether the coeval increase in size of mosasaurs, the top predators in Cretaceous seas, led to ecological pressure on *Parapuzosia* towards larger diameters remains unclear.

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AN ENIGMATIC NEW TAXON FROM THE PHILIPPINES SUGGESTS THAT THE RUDIST FAMILY HIPPURITIDAE ORIGINATED IN THE PACIFIC REALM

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Rudists are bizarrely shaped bivalves comprising the order Hippuritida. The Hippuritidae is one of the major rudist families in the Upper Cretaceous (Turonian–Maastrichtian), but its origin and early evolutionary history remain uncertain (Skelton and Smith 2000). Recently, a new hippuritid rudist has been recovered from Caramoan Peninsula, the Philippines. The age of this new taxon is most likely to be around the Cenomanian–Turonian boundary interval. The Caramoan hippuritid has a multiple-fold system in the right valve, which is usually considered to be a derived character restricted to advanced hippuritid genera of Campanian–Maastrichtian age (Mitchell 2020). However, the shapes and positions of the basic three infoldings and the myo-cardinal arrangement in its right valve are closely similar to those of *Vaccinites rousseli*, one of the primitive species (Upper Turonian in the Mediterranean area) of the Hippuritidae (Toucas 1903–1904). On the other hand, the rim of its left valve seems not to have covered that of the right valve, and possibly has a very thin outer shell layer. These characteristics of the left valve are similar to those of the enigmatic hippuritid genus *Torreites* (Santonian–Maastrichtian, mainly in the Caribbean area), in which they are considered to have been derived. The Caramoan hippuritid combines morphological characters both of *Torreites* and of early species of *Vaccinites*, as well as a multiple fold system considered derived in other hippuritid genera. The discovery of the Caramoan hippuritid challenges the present hypothesis that the first hippuritid suddenly appeared in the Early Turonian of both the Mediterranean and Caribbean areas. Considering the bloom of advanced forms of the Polyconitidae, the candidate ancestors for the Hippuritidae, in the Pacific Realm during the Albian, the Pacific should be considered as the best site in the search of the origin of the Hippuritidae. The early evolutionary history of the Hippuritidae is more complex than previously thought, and can now be discussed by reference to Cenomanian rudists, from places in and around the Pacific.

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NEW LATE MAASTRICHTIAN TRIGONIID BIVALVES FROM THE SOUTH-EAST NETHERLANDS

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Briart (1888) formally named the commonest Late Maastrichtian trigoniid from southern Limburg, *Trigonia maestrichtiana*. Subsequently, Vogel (1895), seemingly unaware of Briart's 1888 paper, erected another new species: *T. geulemensis*. This is now considered a junior subjective synonym of *T. maestrichtiana* and can be assigned to the genus *Oistotrigonia*. *Oistotrigonia maestrichtiana* is both the youngest member of that genus known to date, as well as the commonest form in the upper Maastrichtian, being represented in the great majority of institutional and private collections. It is abundant, in external/internal mould preservation (occasionally in butterfly position) in coquinas/lumachelles of subunit IVf-6 of the Meerssen Member, primarily in the Geulhem area. A single specimen is on record from above the Cretaceous–Paleogene (K/Pg) boundary, from subunit IVf-7 of the Meerssen Member. Already in the mid-1990s additional species had been recognized in museum collections and in newly collected material (Dhondt et al. 1996); one form was then attributed to *Rutitrigonia*, typical of South Africa and Argentina (Cooper 2015). Today we have four trigoniid taxa from the Maastricht Formation, the commonest one being *O. maestrichtiana*, followed by a new rutitrigoniid genus (= new genus 1) from the Emael and Nekum members, in external/internal mould preservation as well as in the form of silicified shells. Another species of the same genus is known from the Meerssen Member; this unit has also yielded another new rutitrigoniid genus (new genus 2), of which only a single external/internal mould is known. These new trigoniid bivalves represent the youngest members of the family on record from the uppermost Maastrichtian, within the final 400,000 years of the Cretaceous (Vellekoop et al. 2022).

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'Changing of the Guard' amongst echinoids in the upper Maastrichtian of the south-east Netherlands: *Echinocorys* out, *Hemipneustes* in

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The holasteroid *Echinocorys* is a widely distributed echinoid genus in Boreal and Tethyan settings alike; it appears to have been mostly unaffected by environmental perturbations across the Cretaceous-Paleogene (K/Pg) boundary (Smith and Jeffery 2000). Various species have been recorded from Campanian and Maastrichtian siliciclastic and carbonate rocks in the extended Maastrichtian type area (north-east Belgium, south-east Netherlands; Jagt 2000 and references therein). A distinct acme is seen in the Lixhe 1 Member (Gulpen Formation), which also involves the largest test sizes on record; Jagt (2000) referred to this as *Echinocorys* gr. *conoidea*. Until recently, no representatives of *Echinocorys* were known from the Lixhe 3 Member (Gulpen Formation) and higher upsection, in spite of intensive searches by several collectors over recent decades. Now a well-preserved test of *Echinocorys* (without any episkeletozoans, but a conspicuous tuberculation) has been recovered from between flint levels 10 and 11/12 of the Lanaye Member (Gulpen Formation) at the former ENCI quarry (Maastricht; Felder and Bosch 1998). One flint level higher, a specimen of another holasteroid, *Hemipneustes striatoradiatus*, with a full cover of episkeletozoans has been collected. *Hemipneustes* is a typical Tethyan genus, the northernmost occurrence on record being the Maastrichtian type area (Smith and Jeffery 2000). In that area, *H. striatoradiatus* ranges across the K/Pg boundary (Jagt et al. 2013), while *H. oculatus* is apparently restricted to the Lanaye Member and overlying Valkenburg Member (Maastricht Formation). The 'Changing of the Guard' amongst large-sized epifaunal holasteroid genera can be dated either as 68.0 Ma (relying on biostratigraphy and isotope stratigraphy), or 67.6 Ma (isotope stratigraphy only) (Vellekoop et al. 2022). In the Lanaye Member, more echinoid genera of Tethyan type make their first appearance in the succession, including *Oolopygus*, *Catopygus* and *Nucleopgus*.

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CARBON ISOTOPE EVENTS AS THE ULTIMATE TOOL FOR GLOBAL CORRELATION AND DATING: EXAMPLE OF THE TURONIAN AND CAMPANIAN STAGES

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The global carbon cycle constitutes one of the most fundamental biogeochemical systems affecting all surface reservoirs on our planet, with complex interactions that modulate and drive climate change on both short and long timescales. Secular variation in stable carbon isotope ratios determined from fossil carbonate ($\delta^{13}C_{carb}$) and organic matter ($\delta^{13}C_{org}$) provides evidence that the sizes of, and fluxes between, global carbon reservoirs have changed significantly throughout the geological record. A residence time of c. 100 kyr for carbon in the ocean-atmosphere system ensures that the rock record has the potential to capture a global high-resolution signal of palaeoenvironmental change affecting the carbon cycle. The geological history of carbon cycle perturbations is revealed in profiles of carbon isotope variation from individual stratigraphical sections, with episodes of major change evidenced by positive or negative carbon-isotope excursions or shifts in the direction or rate of isotopic change (Cramer and Jarvis 2020). Coincident changes in multiple sections from different sedimentary basins enable the definition of carbon isotope events (CIEs) which, when suitably calibrated using biostratigraphy, magnetostratigraphy and/or geochronology, provide a basis for correlation and dating. Carbon isotope stratigraphy (CIS) offers higher precision than possible using conventional biostratigraphy, potentially down to 10 kyr, and as a result it is being increasingly adopted for the refinement of Cretaceous stratigraphy and as one of the criteria for the definition of GSSPs (e.g., Walaszczyk et al. 2021). A unique feature of CIS is the ability to compare records derived from oxidised carbon ($\delta 13C_{carb}$) and reduced carbon ($\delta^{13}C_{org}$, including individual organic compounds), with potential for the reconstruction of changes in atmospheric pCO_2, and for correlation between marine and non-marine (terrestrial and lacustrine) environments (e.g., Jarvis et al. 2015). The most prominent feature of Upper Cretaceous carbon isotope profiles is a large $\delta^{13}C$ positive excursion that spans the Cenomanian–Turonian boundary, linked to the widespread accumulation of organic-rich sediments during an oceanic anoxic event (OAE2). This CIE provides one of the criteria used to define the GSSP for the Turonian Stage. However, many other lower-amplitude excursions characterise the Upper Cretaceous curve (Jarvis et al. 2006). The present paper will focus on the application of new high-resolution carbon isotope profiles and biostratigraphical data from southern England, France, Denmark, Germany and Italy to refine the CIS of the Turonian and Campanian stages, including the application of CIEs to defining the Coniacian and Campanian GSSPs. Unresolved issues concerning the correlation of Campanian stratigraphy between Europe and North America will be considered. We will demonstrate how CIS can be employed not only for global correlation and dating but can also provide unique information for reconstructing the history of environmental change in the Cretaceous hothouse, including climate and sea level.

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OVERVIEW OF CRETACEOUS DINOSAUR EGGS FROM SOUTH KOREA

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Ever since the find of the first dinosaur egg at Hadong, South Korea, in 1972 (Yun and Yang 1997), dinosaur eggs and nests have been discovered and studied in various non-marine Cretaceous deposits. In South Korea, dinosaur eggs have been recovered at 15 localities (Kim and Huh 2018 and references therein). Recently, nests of herbivore dinosaurs were found on Jaeun Island (Shinan); excavations and research are underway. Six oofamilies are now known from South Korea, namely *Faveoloolithidae, *Spheroolithidae, Dendroolithidae, Ovaloolithidae, Elongatoolithidae, and Prismatoolithidae, the ones with an asterisk being dominant, suggesting that ornithopods and sauropods prevailed in the Cretaceous of the Korean Peninsula. The age of dinosaur egg-bearing deposits ranges from the Aptian (Hasandong Formation) to the Campanian–Maastrichtian (Dadaepo Formation) (Kang and Paik, 2013). Most eggs appear in the form of nests, but some are found in isolation, in reddish fine sandstones and mudstones, or in pebbly sandstone-mudstone layers. The egg interior is often filled with the same sediment as the surrounding matrix; only very rarely are eggs found empty. To date, there are no records of eggs with preserved embryos in Korea. Most dinosaur eggs are interpreted as fossilized *in situ*, and levels containing them are accompanied by calcretes or calcareous nodules, suggesting that the development of an alkaline palaeosol played an important taphonomic role in dinosaur egg preservation. Various types of eggs and contemporary environments provide important data on dinosaur reproduction and Cretaceous dinosaur diversity in the Korean Peninsula.

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MICROFACIES AND DEPOSITIONAL ENVIRONMENT OF THE LOWER CRETACEOUS TLAYÚA FORMATION IN SOUTHERN MEXICO

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The Tlayúa Formation in southern Mexico comprises three distinctive members and is a richly fossiliferous Lower Cretaceous succession that is considered to be a Konservat Lagerstätte (Applegate et al. 2006; Alvarado-Ortega et al. 2007). Most previous studies that have focused on understanding the depositional environment of this unit have been undertaken in the Middle Member, in which fossil preservation is exceptional (Applegate 1987; Martill 1989; Pantoja-Alor 1992; Applegate et al. 2006). The present study outlines a detailed microfacies analysis of a ~48 m thick section exposed to the east of Tepexi de Rodríguez, Puebla; this encompasses the Lower Member and the base of the Middle Member of the Tlayúa Formation. The succession consists of the following microfacies, from bottom to top: 1) bioclastic packstone with abundant benthic foraminifera, ostracods and molluscan fragments, 2) bioclastic floatstone with rudist and non-rudist molluscan fragments, 3) pelletal wackestone with abundant intraclasts and scarce benthic foraminifera, 4) miliolid packstone with ostracods and pellets, and 5) microbial-peloidal wackestone with abundant filaments. In general, the microfacies in the lower part of the section suggest a shallow-marine carbonate platform influenced by the input of debris derived from the reworking of nearby reefal facies or skeletal shoals. This idea is supported by the presence of *Thalassinoides* isp. burrows in some beds, which indicate that both surface sediments and bottom water conditions were well oxygenated. Upsection, shallow platform deposits grade upwards into a semi-restricted lagoon setting with local peritidal facies inferred from the presence of birdseye fabrics and half-moon ooids. In summary, our petrographic data and lithofacies analysis indicate a shallow-marine setting for the succession of the Tlayúa Formation analysed here.

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THE PTEROSAUR TRACK ASSEMBLAGE IN THE HWASUN SEOYURI TRACKSITE OF KOREA: DIVERSITY OF PTEROSAURIAN ICHNOFOSSILS OF THE KOREAN PENINSULA

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Ever since the first record of pterosaur tracks from the Upper Cretaceous Uhangari Formation in 2002 (Hwang et al. 2002), various pterosaur tracksites have been discovered in Cretaceous deposits of South Korea, most of them being limited to the Lower Cretaceous, except for a site that yields giant tracks in the Uhangri Formation. Here we report on a small-sized pterosaur track assemblage from the Hwasun Seoyuri tracksite of the Mudeungsan UNESCO Global Geopark in Korea. This tracksite is in the Upper Cretaceous Jangdong Formation (uppermost Cenomanian); it is famous for well-preserved dinosaur footprints, especially theropod trackways (Huh et al. 2006; Kim and Huh 2010). The pterosaur footprint assemblage, consisting of at least 300 prints, is characterized by manus-dominated, randomly oriented tracks of various sizes. About 90% of these footprints are made up of manus, which is believed to have been caused by interaction between the center of mass and substrate condition or by a semi-aquatic behavior of the trackmaker, such as wading. The wingspan of the trackmaker is estimated to have been between 0.5 and 1.5 m; thus, it would have been one of the smallest Late Cretaceous pterosaurs. The standardized and broad size range (manus length: 21.50–61.15 mm) suggests that these tracks may be attributed to a single population of multi-aged individuals. Given the morphology of manus and pes, their relative size, and the ratio of pes digit/metatarsus, the trackmaker of the Hwasun Seoyuri tracksite might be identified as a dsungaripteroid as yet known. To sum up, diverse pterosaurs, ranging in size from small to giant, inhabited the Korean Peninsula during the Late Cretaceous. Their tracks provide essential information on pterosaur ecology and diversity in East Asia during the Late Cretaceous.

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UPPER CRETACEOUS OPOKA AS A RECORD OF THE SIILCA CYCLE IN THE EPICONTINENTAL EUROPEAN BASIN

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The name opoka originates from Poland, but due to the lack of a proper mineralogical definition the term has been rejected from the geological literature or incorrectly synonymized with names of other similar rocks such as siliceous chalk, chert or siliceous limestone. Recently conducted studies have enabled the formulation of a definition of opoka as a carbonate-siliceous rock composed of calcite (38–90%) and an insoluble residue (10–62%), the main component of which is authigenic opal-CT (4–46%), forming networks consisting of adjoining lepispheres (Jurkowska 2022). Opoka occurs in different parts of the Upper Cretaceous European Basin in the form of thick (up to 500 m) successions usually with abundant fossils of siliceous sponges (Świerczewska-Gładysz 2012). The presence of authigenic silica polymorphs in the form of opal-CT (paracrystalline form of silica with trydymite-crystobalite stacking units; see Jones and Segnit 1971) is indicative of massive outflow of Si during opoka formation via burial in sediments. Detailed mineralogical and microtextural studies of silica polymorphs and other mineralogical components of opoka has enabled the recognition of mechanisms and processes which led to such significant Si outflow from the marine biogeochemical Si cycle through early diagenetic silica precipitation. Silica polymorph precipitation was a complex, multi-staged process, which occurred through biotic-abiotic control of external factors, responsible for the overall Si concentration in seawater, and internal factors which sustained certain geochemical conditions within the muddy sea floor. Studies of siliceous sponge remains (bodily reserved specimens, spicules and voids left after spicule dissolution) from opoka has permitted the recognition of Si circulation in the water column: Si was incorporated into the sponge skeletons. Taphonomic studies of fossil siliceous sponges have revealed biogenic silica dissolution after burial. The Late Cretaceous Si cycle differed significantly from the modern one in shelf seas, by being characterized by a predominance of siliceous sponges among silicifiers, significant Si burial and high Si sea water concentrations.

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CARBON-ISOTOPE STRATIGRAPHY AND PRELIMINARY REGIONAL CORRELATION OF THE JURASSIC–CRETACEOUS TETORI GROUP IN CENTRAL JAPAN

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The Tetori Group is a well-known Upper Jurassic to Lower Cretaceous shallow-marine and non-marine siliciclastic succession in Japan. Belemnites and bivalves of the Tetori Group are characterized by boreal taxa, whereas most ammonoid assemblages are dominated by Tethyan and Pacific genera, suggesting they are potential tools for the clarification of the relationship and link between the Boreal and Tethys realms (Sano 2018). On the other hand, the limited occurrence of age-diagnostic ammonoids and a shortage of radiometric age determinations make it difficult to understand the evolution of the entire Tetori sedimentary basin. Accordingly, we have attempted to employ stable carbon isotope stratigraphy to the Tamodani section for intra-regional correlation, as this showed good stratigraphic continuity and some chronostratigraphic data had already been obtained from the adjacent Shokawa section. The stable carbon isotope value ($\delta^{13}C$) of bulk organic matter from the Tamodani section was determined for 18 stratigraphic horizons. Three separated samples were analyzed for each horizon to check the variation of the value in the same horizon. For the Shokawa section, 77 samples were analyzed for $\delta^{13}C$. The variation of $\delta^{13}C$ ranges at ~3.8‰ and stratigraphically fluctuates mostly within the range of – 24 to – 24.5‰ through each of the two sections. The positive $\delta^{13}C$ excursion in the middle part of the Tamodani section correlates it with the middle part of the Shokawa section and is possibly comparable to the Weissert event, while the positive excursion in the upper part may indicate OAE 1a. Hasegawa and Hibino (2006) reported a positive $\delta^{13}C$ excursion in the Tateyama section that may indicate OAE 1a as well. A positive $\delta^{13}C$ excursion, associated with OAE 1a, is likely to be a useful stratigraphic marker for regional correlation of the Tetori Group. As the Tetori Group is a potential sedimentary sequence to link the Boreal and Tethys realms in East Asia, it is significant to construct ^{13}C stratigraphy through a considerable time span covering the Tithonian to Aptian.

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FAUNAL AND ENVIRONMENTAL CHANGES ACROSS THE CRETACEOUS–PALEOGENE BOUNDARY (K/PG) IN CENTRAL ANATOLIA, TURKEY

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The fundamental interaction between Large Igneous Provinces (LIPs) and major mass extinctions has been known for long (Courtillot and Renne 2003). The importance of the K/Pg boundary (KPB) extinction is the coincidence of two cataclysmic events, i.e., Deccan volcanism and the Chicxulub impact, in a very short time (Schoene et al. 2019). The effects of Deccan activity on the ecosystem need to be elaborated so as to understand the causality between volcanic eruptions and associated environmental stress. In order to unravel this story, we here document this relationship in terms of high-resolution quantitative species counts coupled with isotope and geochemical analysis on two complete sections in the Mudurnu-Göynük and Haymana basins of central Anatolia (Turkey). Throughout the Late Maastrichtian, our $\delta^{13}C$ measurements in the Haymana Basin show cyclical patterns highlighting the effect of precession cycles on the $\delta^{13}C$ record. Remarkably, each cycle terminates by a cold peak (i.e., a positive shift in $\delta^{18}O$ values). On the other hand, quantitative analysis of planktic foraminifera reveals that there was an ongoing reduction in species richness throughout the Late Maastrichtian (Karabeyoglu et al. 2019). In fact, it even accelerates before the boundary. In the Göynük and Okçular sections, this reduction corresponds to well-defined, low magnetic susceptibility intervals suggesting a possible ocean acidification event during the Late Maastrichtian. The K/Pg boundary itself is characterized by a 2-3-mm-thick reddish oxidized layer. It demonstrates a series of events: sudden annihilation of large, ornamented ecological specialists (e.g., globotruncanids, racemiguembelinids, planoglobulinids), a Hg anomaly and enrichments in Ir, Te, Ba, Ni, Cr and Co. Among these, Hg/Te shows good correlation implying that Te may be used as another proxy for volcanic activity. For the faunal record, we detected acmes of *Thoracosphaera* and *Guembelitria cretacea*, indicating ecosystem collapse after the KPB. Overall, our detailed paleontological, isotopic and geochemical records show that the deteriorating effects of Deccan volcanism had already started before the Chicxulub impact which predisposed faunas to eventual extinction at the K/Pg boundary.

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MERCURY OCCURRENCE IN BASAL AND TOP CRETACEOUS BOUNDARY INTERVALS OF CARPATHIAN SEDIMENTARY SEQUENCES

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At least since the past decade, mercury (Hg) chemostratigraphy has been increasingly used as a potential proxy for volcanism in the geological record (e.g., Grasby et al. 2019). While poor or no evidence of extensive volcanic activity was provided for the Jurassic–Cretaceous (J/K) boundary, the timing of the Deccan traps with its Hg signal was set around the Cretaceous–Paleogene (K/Pg) boundary. Data on Hg concentrations collected from several J/K and K/Pg boundary sections in the Carpathians were correlated with other stratigraphical methods (e.g., magnetostratigraphy, biostratigraphy). At the J/K boundary, comprehensively studied sections such as Kurovice (Czech Republic), Sněžnica (Slovakia), Velykyi Kamianets (Ukraine) and newly investigated sections such as Ropice (Czech Republic) and Goleszów (Poland) cover a wide range of lithologies, as well as different depositional environments with wide palaeobathymetric settings. Compared to J/K boundary sections, K/Pg boundary sections at Uzgruň (Czech Republic), Bukovec (Czech Republic) and drill core ZA1 (Slovakia) are at most only weakly calcareous. Usually, organic matter, sulphides or clay minerals are listed as the main sedimentary host phase of Hg in such rocks (Shen et al. 2020). Thus, correlations between total organic carbon, total sulphur and aluminium contents were determined in order to identify anomalous Hg values. Hg contents vary from 0.2 ng/g to 92.8 ng/g in J/K sections and from 4.4 ng/g to 221.1 ng/g in K/Pg sections. Current research aims to identify differences in Hg deposition during the period of fairly low volcanic emission (J/K) to extensive volcanic emission (K/Pg), as well as to characterise the sedimentary host phase of Hg in various depositional environments.

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THE MID-MAASTRICHTIAN EVENT RECORDED IN THE FLYSCH BASIN (OUTER CARPATHIANS, SKOLE NAPPE, POLAND)

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The Mid-Maastrichtian event (MME) is a lesser-known biotic episode typifying the latest Cretaceous; however, it is also one of the most important events preceding the great extinction at the K/Pg boundary. The MME is linked to rapid cooling that likely led to the extinction of rudist bivalves and many benthic foraminiferal taxa. Inoceramid bivalves also became extinct during this time, although this appears to have occurred somewhat earlier than the main cooling phase (see Wignall 2001). The Maastrichtian cooling, persisting until the Paleocene, was triggered by changes in deep-water oceanic circulation that occurred about 70 myr ago when the bottom waters became cooler and less saline (e.g., MacLeod and Huber 1996). Interestingly, the inoceramid extinction during the MME was preceded by a short-lived Inoceramid Acme Event (IAE) dated as 71 Ma, i.e., within UC18 nannofossil Zone in many sections around the world, including pelagic deposits (e.g., Dameron et al. 2017). This globally abundant Early Maastrichtian appearance and then rapid disappearance of inoceramid clams from the fossil record still is the subject of conjecture. Nevertheless, it is suggested that inoceramids fell victim to enhanced seasonality, and hence surface productivity, that characterised the latest Cretaceous, announcing the upcoming Cenozoic (e.g., Gómez-Alday and Elorza 2003). Herein, we present IAE and MME records from flysch deposits of the Skole Basin which was a fragment of the north-eastern part of the Tethys Ocean, directly adjacent to the shelf of the European platform, which is the source area of a large part of the Polish Outer Carpathian flysch sediments. The sections investigated embrace the deep-water deposits of the Kropivnik Fucoid Marls, part of the Ropianka Formation, formerly known as Inoceramian Beds (Kotlarczyk 1978). The IAE occurred here as a sudden in situ appearance of shells of *Inoceramus (Platyceramus) salisburgensis.* Initially, they occur in the uppermost part of the turbiditic sequence or pelagic sediments in almost every turbidite. Then, 5-6 m upsection, inoceramids disappear completely. The massive abundance of inoceramid shells makes a very good case for the historical name of Inoceramian Beds.

Complementary micropalaeontological and geochemical studies show that the IAE interval may represent the MME environmental perturbation. This is especially well documented via principal component analysis (PCA) of calcareous nannofossil assemblages supported by similar analyses conducted on major and trace elements. It seems that deep-water cooling followed by better bottom oxygenation and changes in primary seasonal productivity were the main factors operating during the Mid-Maastrichtian extinction event.

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CRETACEOUS DINOSAURS FROM INDIA AND THEIR PALAEOBIOGEOGRAPHICAL IMPLICATIONS

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Globally, the Indian Mesozoic dinosaur record is famous for documenting significant aspects of their evolution during the Triassic, Jurassic and Cretaceous (Jain et al. 1975; Loyal et al.1996; Wilson et al. 2003; Kutty et al. 2007; Bandyopadhyay et al. 2010; Novas et al. 2010, 2011; Khosla 2017; Khosla and Bajpai 2021). Cretaceous (Cenomanian–Turonian) strata assigned to the Nimar Sandstone in the Lower Narmada valley, have yielded fragmentary skeletal remains of Sauropoda indet. (Khosla et al. 2003), whereas at least two valid taxa of sauropods (*Antarctosaurus septentrionalis* and *Titanosaurus colberti*) and at least three valid theropod taxa (*Laevisuchus indicus*, *Rajasaurus narmadensis* and *Rahiolisaurus gujaratensis*) and three questionable ones (?*Indosaurus matleyi*, ?*Indosuchus raptorius* and ?*Lametasaurus indicus*) are known from the Maastrichtian Lameta Formation (Huene and Matley 1933; Chatterjee 1978; Wilson et al. 2003; Novas et al. 2010; Kapur and Khosla 2016; Khosla 2021). Apart from skeletal remains, infra – and intertrappean beds of peninsular India have yielded more than 10,000 dinosaur eggs belonging to five oofamilies (Fusioolithidae, Megaloolithidae, Spheroolithidae, Elongatoolithidae and Subtiliolithidae) and 15 oospecies. Most of the Indian ootaxa show distinct affinities with the Late Cretaceous ootaxa of four other continental areas, i.e., Spain, France, Argentina and Morocco (Fernández and Khosla 2015; Khosla and Lucas 2020). Palaeobiogeographically, the presence of the two predominant oofamilies Fusioolithidae and Megaloolithidae in the infra – and intertrappean localities of peninsular India and their shared presence on three different mainlands (South America, Europe and Africa) further shows an ancient Gondwanan affinity and basic terrestrial association among these three landmasses. Based on the phylogenetic analysis of skeletal material, the most plausible pathway of dinosaur dispersal between Indo-Madagascar took place during the Late Cretaceous. The other conceivable dispersal pathway for the small animals was between India and Asia by means of the Kohistan Dras volcanic bend framework or a north-east pathway through Somalia, while the very large vertebrates, like theropod dinosaurs, may have emerged as a component of a 'Pan Gondwanan' model.

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A POSSIBLY NEW AND ENDEMIC AMMONITE SPECIES FROM THE LOWER TURONIAN OF THE BOHEMIAN CRETACEOUS BASIN (CZECH REPUBLIC)

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A new Early Turonian ammonite species from the southern part of the Bohemian Cretaceous Basin (BCB) is presently under discussion, based on 17 completely preserved specimens. All were collected in the first half of the 20th century from the vicinity of the small town of Ždánice, some 30 km south-east of Prague. All specimens are preserved as laterally compressed internal molds, but overall preservation is good and ornamentation well visible. The collection contains small – to medium-sized specimens (c. 55–250 mm). The species shows a clear affinity to the Acanthoceratidae, with strictly evolute shells. The earliest whorls, which show constrictions, are smooth, with the exception of umbilical tubercles. Late growth stages are ornamented with seven rows of tubercules (10 per whorl) and mostly long, straight ribs that extend from the umbilical to the siphonal tubercles. On the ventral side, strong siphonal clavi are present; these correlate with other rows of tubercles. Ornamentation (mainly the nature and expression of ribbing) varies not only during the growth of individual specimens, but also intraspecifically, similar to many genera in the family Acanthoceratidae (Kennedy and Wright 1954). Problems surrounding ammonite classification and systematics will be briefly discussed, along with a demonstration of extraordinarily ornamented

specimens as well as differences from other acanthoceratid genera (e.g., Kamerunoceras). The new species ranges from the Watinoceras coloradoense to the Fagesia catinus zones; its occurrence in the Mammites nodosoides Zone is still unclear. This ammonite represents an endemic taxon, which probably evolved directly at the boundary between the Peri-Tethyan shelf and the Boreal Realm in the BCB (Košťák et al. 2020).

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INTEGRATIVE CHARACTERISTICS OF THE TURONIAN–CONIACIAN BOUNDARY IN THE NORTH-WESTERN CAUCASUS

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Strata assigned to the Natukhai Formation (K2*nt*) (Upper Turonian–Coniacian) in the section exposed at the Shapsug quarry have been studied litho-, bio – and chemostratigraphically. The section is a rhythmic, carbonate-dominated one, with the Turonian–Coniacian boundary situated within this unit. Four main types of microfacies (MCF) have been identified, differing from each other in composition, colour, structure, texture and palaeontological characteristics. Microfacies are cyclically repeated in the section. MCF 1 is a foraminiferal limestone (mudstone), uniformly light grey to beige and unstratified, while MCF 2 is a spiculite-foraminiferal limestone (wacke-/mudstone), uniformly light grey to beige and thin-bedded. MCF 3 is a limestone (wacke-/packstone), with pithonellids and foraminifera, the colour varying from light to dark grey and unstratified, while MCF 4 is a fine-grained sandstone, biolithoclastic, unclearly stratified, of medium grade and with clay-carbonate cement and a light grey to beige colour. The microfacies of the section studied can be correlated with certain facies zones. MCF 1 and

MCF 2 are assigned to deep-sea basin facies. Microfacies MCF 3 and MCF 4 are attributed to open-shelf facies. On the basis of these facies, it can be concluded that the Turonian–Coniacian deposits studied formed under conditions of a distal shelf or an open-sea basin, with slow or moderate hydrodynamics and a rather slow sedimentation. Eustatic fluctuation caused by periodic sea level changes controlled this process. Macrofaunal remains were not found in the section. In order to refine the age of the deposits, foraminifera were identified to species; planktic (PF) forms predominate. To determine the age of the rocks, the zonal scheme for the Crimean-Caucasian region was used. In its composition, the foraminiferal assemblage is close to associations of the central parts of the Tethyan region, but it is less diverse. Analysis of the taxonomic composition of these foraminiferal assemblages from Shapsug quarry and their palaeoecological characteristics has shown that these deposits formed in an open-sea basin with a relatively high taxonomic diversity of PF, with a periodic predominance of 'deep-sea taxa'. The best PF marker for the base of the Coniacian is the FAD of *Dicarinella concavata.* However, this species is very rare in the sections of the Greater Caucasus, as it is in the Salzgitter-Salder section. On the basis of changes in $\delta^{13}C$ and $\delta^{18}O$ values on isotopic curves, isotopic zones and event levels have been identified. The excursion values of $\delta^{13}C$ can be compared with isotopic events found in coeval sections in western and eastern Europe. The record of climatic fluctuations and changes in bioproductivity makes it possible to correlate these levels with other sections of the Peritethys. The presence in the section of clayey bentonite interbeds, formed during periods of volcanic activity, has also been noted. The integrative characteristics of the Shapsug section have a similarity to the Salzgitter-Salder stratotype in Germany for the Global Stratotype Section and Point for the base of the Coniacian (Walaszczyk et al. 2021).

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A SLIGHT CARBON PERTURBATION AT THE J/K BOUNDARY (BASE OF THE ALPINA SUBZONE) AT SELECTED TETHYAN LOCALITIES

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Stable isotope ($\delta^{18}O$, $\delta^{13}C$) data from bulk rock at the Jurassic–Cretaceous transition are characterised by stability of values in many Tethyan carbonate sections (Price et al. 2016), predominantly those laid down under deeper-water conditions. The generally straight trend in the $\delta^{13}C$ curve just at the J/K boundary interval does not show any significant value expressions that are useful for interregional correlation (Ogg and Hinnov 2012). However, in several bio – and magnetostratigraphically well-calibrated sections studied, especially in the Carpathian-Alpine system (and some additional sections in the Tethyan Realm), a very slight carbon isotopic negative excursion just at the J/K boundary (sensu base of the Alpina Subzone within the Calpionella Zone) shows an almost identical trend. Slight $\delta^{13}C$ isochronous perturbations at the base of the Alpina Subzone probably reflect smaller trophic changes in the oligotrophic system and they may be related to the predominance of smaller globular forms of Calpionella alpina among calpionellid associations (Kowal-Kasprzyk and Reháková 2019), being accompanied by a bloom of nannofossils, mainly nannoconids (Bornemann et al. 2003). This assumption may support the isochroneity of the base of the Alpina Subzone based on $\delta^{13}C$ expressions. However, the causality in relation to a general rise of the bioproductivity in this interval cannot be excluded.

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A SPECIMEN OF PRIONOCYCLUS GERMARI (REUSS, 1845) FROM THE UPPER TURONIAN OF THE BOHEMIAN CRETACEOUS BASIN (CZECH REPUBLIC) WITH JAWS PRESERVED

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Cephalopod mandibles are amongst the rarer fossils in the Bohemian Cretaceous Basin (BCB) of central Europe, occurring only as isolated apparatuses, the sole exception being a specimen of *Scaphites geinitzii* found with jaw/aptychus *in situ* (Fritsch and Schlönbach 1872, pl. 13, fig. 8). Here, we present a second record of great taphonomic importance: a specimen, identified by us as *Prionocyclus germari* from the Upper Turonian at the active Úpohlavy quarry (Bed 15 *sensu* Wiese et al. 2004). The ammonite preservation shows similarities to ammonoids described from Solnhofen-type Lagerstätten including phosphatised siphuncle, while the flattened ammonite shell is rather poorly preserved. The associated fauna consisting of complete crustaceans (e.g., *Mesostylus*, crabs), articulated fish and chondrichthyan remains and more or less carbonised jaws of other cephalopods, represents an unusual and unique preservational/taphonomic window within the BCB. The lower jaw of *P. germari* is a typical calcitic morphotype 'Aptychus' (*sensu* Tanabe et al. 2015). Lacking harmonic facets, the mandible is referred to the genus *Praestriaptychus* Trauth, 1927. The preservation of original organic matter at the tip of the aptychus has been revealed by Raman spectroscopy analysis, showing an original organic pigment, corresponding to the low degree of degradation of organic matter in the sediment. However, the original chitinous composition of the jaw studied has not been confirmed. Possible stomach contents of this ammonite are also discussed. Linking the jaw apparatus with an index ammonite taxon of the uppermost Turonian fills a gap in our knowledge on Upper Cretaceous acanthoceratid ammonite anatomy.

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THE PROVENANCE OF ALBIAN ARENITES IN SOUTHERN POLAND: CHIME GEOCHRONOLOGY OF DETRITAL MONAZITES AND MUSCOVITE $^{40}Ar/^{39}Ar$ DATING

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The sands and sandstones of the middle and upper Albian (uppermost Lower Cretaceous, c. 110.8–100.5 Ma) in southern Poland constitute a thick series of rocks representing the great Upper Cretaceous transgression. The advancing sea transgressed into the Polish Basin from the north-west and probably also from the south-east (Świdrowska et al. 2008). During the first stage of the transgression, clastic sediments were laid down onto the older, mainly Upper Jurassic, carbonate rocks. Until recently, the provenance of this detrital material was the subject of dispute, in the absence of solid constraints (Marcinowski and Radwański 1983; Leszczyński 2010). In order to resolve this issue we applied CHIME geochronology of detrital monazites and muscovite $^{40}Ar/^{39}Ar$ dating of Albian arenites in the southern part of Extra-Carpathian Poland. Monazite is common in the detrital heavy mineral assemblages. Absolute ages of monazite, calculated with the use of CHIME (Chemical Th–U-total Pb Isochron MEthod) approach, have allowed for a division of the study material into two domains: western and eastern, which are related to the Miechów and Lublin zones, respectively. Samples from the western domain are characterised by a monomodal distribution of CHIME ages of approximately 330–370 Ma, which indicate a predominance of Variscan detrital monazite. This corresponds well with the 40Ar/39Ar age of detrital muscovite from the same domain, equal to 357 ± 4.2 Ma. The samples from the eastern domain are characterized by a polymodal distribution of CHIME ages with peaks at 450-500 Ma, 0.8-1.1 Ga, c. 1.5 Ga and c. 1.8 Ga. This indicates that the eastern domain was supplied with detritus mainly from the Scandinavian Caledonides, the Sveconorwegian zone and the Svecofennian zone located in the Baltic Shield. Moreover, detrital monazite ages allow us to distinguish in this domain two sub-domains, a north-eastern and a south-eastern one. The latter is characterized by the additional presence of Variscan monazite ages (330–370 Ma). Furthermore, in the eastern domain $^{40}Ar/^{39}Ar$ ages of detrital muscovite, equal to 473 ± 4.7 Ma in the north-eastern sub-domain, 475 ± 2.7 Ma and 492 ± 1.2 Ma in the south-eastern sub-domain reveal their Caledonian provenance. Therefore, a comparison of absolute ages of detrital monazite and muscovite suggests at least two independent main source areas: the Bohemian Massif for the Miechów area (i.e., western domain) and the Baltic Shield for the Lublin area (eastern domain). A mixed zone of the above-mentioned provenance areas was identified in the southern part of the eastern sub-domain.

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CEPHALOPOD JAWS FROM THE BOHEMIAN CRETACEOUS BASIN – PRESERVATION, TAXONOMY AND STRATIGRAPHICAL IMPLICATIONS

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The Bohemian Cretaceous Basin (BCB) represents the Central European sedimentary space that links the Peri-Tethyan shelf with the Boreal Realm (Wiese et al. 2004). Cephalopod jaws have only occasionally been studied or mentioned in the past (especially in several monographs by Frič, such as Fritsch 1910; Fritsch and Schlönbach 1872), yet have been noted more recently by Košťák et al. (2010). The revision of older collections and addition of newly discovered cephalopod jaws have enabled a new insight into their taphonomy, taxonomy and stratigraphy. The most common records are referred to nautilid rhyncholites (conchorhynchs being exceptionally rare), followed by 10–12 well-distinguished ammonite aptychi taxa. The most abundant are aptychi of heteromorph ammonites, such as *Sciponoceras/Baculites* and *Scaphites*. Coleoid jaws are possibly also represented. The manner of preservation differs at various stratigraphic levels, the dominant type being the calcified state; less common are jaws preserved with carbonised organic matter. The mineralogy/geochemistry has been studied by Raman spectroscopy, documenting an original organic composition. The stratigraphic distribution ranges from the Upper Cenomanian (*M. geslinianum/N. juddii* zones), lower Turonian (*F. catinus/M. nodosoides* zones), upper Turonian (*S. neptuni/P. germari* zones) to the Lower to Middle Coniacian (*F. petrocoriensis–P. tridorsatum* zones). They are virtually missing from the Middle Turonian, which could be a result of sampling bias. The fossil record is not continuous; cephalopod jaws occur at distinct horizons showing variable diversity.

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HIGH-RESOLUTION PALAEOTEMPERATURE RECONSTRUCTIONS FOR CENOMANIAN–CONIACIAN SHALLOW–WATER CARBONATES OF THE FRIULI CARBONATE PLATFORM

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The Cenomanian–Coniacian interval (Late Cretaceous) was characterised by abrupt climate perturbations, within one of the warmest periods in Earth history. Following the trend of temperature rise across the Cenomanian–Turonian boundary (CTB), the highest ocean temperatures of the entire Cretaceous were reached in the Early Turonian and were associated with the highest sea levels of the Phanerozoic (Jarvis et al. 2015 and references therein). This phase of warming was followed by a general cooling trend, punctuated by short-term hot-snaps and relative lowering of sea level (Wiese and Voigt 2002). These climate changes have been well studied in deep-water environments, where they are reflected by variations in several geochemical proxies, as well as by spatial and distribution patterns of macro – and microfauna. However, such climatic and environmental fluctuations must have had severe impact on carbonate platforms, sedimentary environments that are particularly sensitive to climate changes. Published data report a major crisis amongst the main Late Cretaceous shallow-water carbonate producers, such as rudist bivalves, which show the most significant taxonomic turnover at the CTB. The Early Turonian was characterised by a collapse in rudist diversity, followed by a further re-radiation in the Late Turonian and continuing into the Coniacian (Skelton 2003). Here, we discuss geochemical, sedimentological, and palaeontological data from key outcrops in the Friuli Carbonate Platform (north-east Italy), at which thick Upper Cretaceous shallow-water carbonate successions are exposed. A precise chronostratigraphical framework has been developed using foraminiferal biostratigraphy and isotope stratigraphy ($\delta^{13}C$ and $^{87}Sr/^{86}Sr$), allowing correlation with the pelagic record. $\delta^{18}O$ analyses on both well-preserved rudist shells and bulk rock samples were used, for the first time, to build

a high-resolution palaeotemperature curve in shallow-water settings covering the Cenomanian–Coniacian interval. The resulting palaeotemperature trends are comparable with those from the deep-water record and allow to investigate the relationship between palaeoclimate/palaeoenvironmental changes and the distribution patterns of the main carbonate platform producers.

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TECTONIC CONTROL ON LATE CRETACEOUS SEDIMENTATION WITHIN THE SOUTHERN BALTIC SEA, AS REVEALED BY REGIONAL ANALYSIS OF SEISMIC REFLECTION DATA

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In 2016, 850 km of multi-channel seismic reflection data of the BALTEC survey were acquired offshore Poland within the transition zone between the East European Craton and the Palaeozoic Platform. BALTEC data, processed up to Kirchhoff pre-stack time migration, were integrated with other seismics available for this area and calibrated by deep and shallow wells.

All these data provided new information regarding Late Cretaceous inversion, i.e., the last major tectonic event that shaped the geology of this area. It led to uplift of basement blocks, localized erosion and formation of syn-inversion growth strata. Until now, this phase of geological evolution could hardly be resolved by industrial seismic data due to limited shallow seismic imaging and very strong overprint of multiples. Within the south-west Baltic Sea, the main structure formed during Late Cretaceous inversion is the north-westerly segment of the Mid-Polish Anticlinorium (MPA) that extends for over 1,000 km from the vicinity of Bornholm towards south-east Poland and western Ukraine. Subtle thickness variations, progressive unconformities and contourites identified within the Upper Cretaceous succession document the complex interplay of Late Cretaceous basin inversion, erosion and redeposition. Seismic data from within the Bornholm-Darłowo fault zone located to the north-east of the MPA imaged a system of deep-rooted steep reverse faults and associated zones of prograding wedges that testify to a complex depositional pattern controlled by transgression. Farther to the east, within the Ustka and Słupsk blocks, the Precambrian basement is overlain by a Cambro-Silurian sedimentary cover. It is dissected by a system of steep, mostly reverse faults rooted in the deep basement. Until now, this fault system was regarded to have formed mostly in Palaeozoic times, due to the Caledonian orogeny. As a consequence, the Upper Cretaceous succession, locally present in the area, has been vaguely defined as a post-tectonic cover, which locally onlapped uplifted Palaeozoic blocks. Our results have confirmed that, contrary to previous models, at least some of these deep-rooted faults were active as reverse faults during the Late Cretaceous, in particular those that continue into the inverted Christiansø Block further to the north. It can therefore be unequivocally proved that large offshore blocks of Silurian and older rocks, located presently directly beneath the Cenozoic veneer, must have been at least partly covered by Upper Cretaceous successions; then, they were uplifted during the widespread Late Cretaceous inversion. All these results prove that Late Cretaceous inversion in this part of Europe strongly affected large areas located much further towards the east than previously assumed.

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UPPER CRETACEOUS INVERSION-RELATED CONTOURITES WITHIN THE POLISH BASIN – THEIR SEISMIC EXPRESSION AND GEODYNAMIC SIGNIFICANCE

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The Polish Basin, together with its axial, most subsiding part, the Mid-Polish Trough, formed the eastern part of the Permian–Mesozoic system of epicontinental basins in western and central Europe (Dadlez et al. 1995; Doornenbal and Stevenson 2010; Ziegler 1990). Following its Permian rifting, the Polish Basin experienced long-term Mesozoic thermal subsidence. Its Late Cretaceous–Paleogene inversion was associated with uplift of the axial part of the Polish Basin that led to the formation of a regional anticlinal structure referred to as the Mid-Polish Anticlinorium that extends for over 1,000 km from the vicinity of Bornholm towards south-east Poland and western Ukraine where it plunges beneath the Carpathians (Dadlez et al. 1995, 2000). Basin inversion led also to more localized tectonic activity such as compressional reactivation and growth of salt diapirs that took place in its central and northern part. Inversion-related localized uplift of the basin floor led to the formation of regional or local morphological barriers and slopes that focused the flow of bottom currents to localized routes (Krzywiec et al. 2009; Remin et al. 2016). This has recently been recognised using seismic reflection data from two segments of the Polish Basin. In its south-easterly segment, the Upper Cretaceous succession from the north-eastern flank of the Mid-Polish Anticlinorium is characterised by the presence of a low-angle progradational complex directed towards the north-east, away from the regional inversion axis (Krzywiec et al. 2009; Remin et al. 2022). Within the Campanian part of this inversion-related syn-kinematic sedimentary succession contourite drifts have been recognised; these represent deposits of contour currents that were flowing along the slope formed by the Mid-Polish Anticlinorium, progressively uplifted during the Late Cretaceous. Another area where contourites have been recognised is located in the north-westerly segment of the Polish Basin, where a complex system of salt structures was formed, including the Szamotuły salt diapir located near Poznań. Local thickness reductions of the Upper Cretaceous syn-kinematic succession and local progressive unconformities, clearly visible on seismic data in the vicinity of this diapir, indicate continuous growth of the salt structure during basin inversion. The uplifted and arched roof of this diapir created a local intra-basinal morphological barrier, encircled by contour currents that formed contourites, perfectly visible on seismic data within the Santonian section. The formation of the contourites hints at the fact that strong sea floor currents must have sculpted the bottom over hundreds of thousands of years. The duration of deposition in the contourite pattern constrains the period of protrusion of inversion-related bathymetric barriers at the sea bed. Our results provide independent evidence for bottom-current palaeocirculation, supporting published regional basin reconstructions (Remin et al. 2016).

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CHANGES IN BIVALVE ASSEMBLAGES AT THE ONSET OF THE OAE 2 EVENT IN THE BOHEMIAN CRETACEOUS BASIN (CZECH REPUBLIC): PALAEOECOLOGICAL IMPLICATIONS

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The Ocean Anoxic Event (OAE 2) at the Cenomanian–Turonian boundary presents a unique record of gradual global warming and its effects on benthic organisms. The present research considers a statistical evaluation of bivalve assemblages from the Pecínov Member in the Bohemian Cretaceous Basin (BCB). The well-exposed succession of Cenomanian through Lower Turonian strata contains one of the most complex records of the OAE 2 in central Europe (Uličný et al. 1997). The rich molluscan fauna has been thoroughly studied; however, the bivalve associations and their potential for palaeoenvironmental reconstructions have received very little attention until now. The present study provides an updated taxonomic investigation according to current bivalve systematics. The assemblage from this locality has been divided into guilds based on their ecospace utilisation using statistical and population analysis and resulting in new palaeoecological interpretations. Close attention was also paid to preservation, fragmentation, shell orientation and spacing and mutual positions. In total, over 350 specimens have been studied and assigned to 20 genera within 15 families and 9 orders. The Pecínov section is divided into four units (P1 to P4; see Košťák et al. 2018) with the peak of the event at the base of unit P3. No benthic fauna occurs above subunit P2f. The bivalve association of unit P1 unit is strongly dominated by infaunal suspension feeders, followed by semi-infaunal suspension feeders. The near-absence of free-living epifaunal bivalves (6%) was probably caused by the very fine, muddy substrate and water turbidity, which is a significant limiting factor for many epifaunal species, especially under shallow, near-shore conditions. Infaunal deposit feeders are also present but comparatively rare (<2%), indicating a nutrient-rich environment with energy levels sufficiently high to keep organic matter in suspension. The *Cucullaea glabra–Pseudoptera anomala* assemblage of unit P1 is considered to have formed during normal, shallow

(15–20 m, supported by abundant material of *Pinna*) marine conditions. Subunit P2a is characterized by the Panopea gurgitis-Rhynchostreon suborbiculatum assemblage; it was probably deposited in a similar environment as unit P1, but at considerably shallower depths and with higher energy levels. Clusters of *Pycnodonte* and *Modiolus* characterize the upper parts of unit P2, the final bivalve assemblages prior (interpreted as onset herein) to the major peak of OAE2.

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LATE CAMPANIAN SEA LEVEL FALL AND ORBITAL CYCLES RECORDED FROM THE PIOTRAWIN SITE (MIDDLE VISTULA RIVER SECTION, POLAND)

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The uppermost Campanian siliceous marl succession exposed at Piotrawin quarry (Middle Vistula River section, eastern Poland) is widely known for its biostratigraphical and palaeontological importance, albeit is monotonous from the sedimentological point of view (Remin 2012). The present contribution is aimed at the extraction of trends and cyclicity from the sedimentary record based on a quantitative approach. For the first time, we provide a high-resolution record of magnetic susceptibility (MS) and changes in calcium-carbonate contents for the Piotrawin site. A set of complementary statistical, multivariate and time series analytical methods was used to investigate the interrelationship of variables measured and detect patterns in these.

MS and calcium-carbonate content display an inverse relationship. MS and calcium-carbonate content record curves reflect the late Campanian sea level fall episode, inferred also by earlier micropalaeontological studies (Niechwedowicz et al. 2021). The upward increase of MS values can be attributed to the intensification of terrigenous material supply along with a sea level drop. Orbital cyclicities (short eccentricity, obliquity and precession) are identified independently by means of Multi-taper Method-based spectral analysis (Li et al. 2019) and multivariate Singular Spectrum Analysis (SSA) (Weedon 2003). The short eccentricity cycles recorded in the succession, including the non-exposed interval covered by scree, were reconstructed using the gap-filling SSA technique (Yi and Sneeuw 2021). An average sedimentation rate statistically determined at 1.5-2 cm/kyr is similar to earlier estimates (Machalski 2012). The entire 25.4-m-thick Piotrawin section contains approximately 12 or 13 short eccentricity, 100-kyr cycles. The time span of its deposition is estimated at 1.3-1.7 myr, based on both sedimentation rate estimates and counts of short eccentricity cycles identified.

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AMMONITES AT CRETACEOUS-PALEOGENE SECTIONS IN NORTH AMERICA

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Almost a dozen Cretaceous-Paleogene (K-Pg) sections containing ammonites have now been reported from North America. Many of these sections occur on the Atlantic and Gulf Coastal Plain (GCP) and reveal the geologic record of ammonites in the uppermost Maastrichtian. In New Jersey, ammonites are abundant at the top of the Tinton Formation and even extend above the boundary (Landman et al. 2012). They are represented by four genera: *Discosaphites*, *Eubaculites*, *Sphenodiscus*, and *Pachydiscus*. K-Pg sections with ammonites are also present in Missouri, Alabama, Mississippi, Arkansas, and Texas. Ammonites are abundant at the type section of the Owl Creek Formation in northern Mississippi and extend to the boundary (Larina et al. 2016). At a nearby site (4th St.), the base of the Danian Clayton Formation consists of a layer containing ammonites (*Discoscaphites*, *Eubaculites*) and other macrofossils intermixed with Chicxulub impact spherules and evidence for high-energy deposition (Witts et al. 2018). Recent field work has uncovered another site near Starkville, Mississippi, in which the Prairie Bluff Formation is overlain by multiple event deposits. Ammonites, including a jaw of *Discoscaphites*, are present in the Clayton Formation above the event deposits and may represent survivors. On the western end of the GCP at Brazos, Texas, ammonites are abundant in the Corsicana Formation just below a clastic event deposit, which also contains ammonites (*Discoscaphites*, *Eubaculites*, *Sphenodiscus*), other macrofossils, and impact debris (Witts et al. 2021). The Tanis site in northwestern North Dakota is a fluvial rather than an open marine site. However, published reports indicate the presence of a few ammonites belonging to *Sphenodiscus* and *Hoploscaphites*, suggesting the persistence of the nearby Western Interior Seaway (DePalma et al. 2019). The fragmentary nature of the specimens could indicate that they were exhumed from underlying sediments at the time of the impact. All of these sections demonstrate the 'robust health' of the ammonites at the end of the Maastrichtan and, in some areas, their possible survival into the early Danian.

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IDENTIFICATION OF ANCIENT STRATIGRAPHICAL INTERVALS BASED ON STUDIES OF FORAMINIFERAL TESTS FROM CLAYS OF THE MUD VOLCANO SHUGO (TAMAN PENINSULA, RUSSIA)

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One of the most interesting and unique objects of the Taman Peninsula (north-western Caucasus) is the active mud volcano Shugo, the largest in the Kerch-Taman volcanic area. During the last century, it was believed that the clay pulp of the Shugo mud volcano did not contain deposits older than the Neogene. However, later geochemical studies have shown that fragments of older rocks of both sedimentary and magmatic origin are brought to the surface with eruptions of mud volcanoes. In the present note we use a micropalaeontological approach to obtain scientific data on foraminiferal assemblages from the Shugo mud volcanic breccia in order to determine the age of the levels below the surface and intersected by volcanic vents. Moreover, this research could assist in studying Cretaceous and lower Paleogene strata, lying hidden under younger Neogene and Paleogene rocks. Assemblages of planktic foraminifera from the Paleogene interval are dominated by *Acarinina* and *Subbotina*; tests of *Morozovella*, *Hantkenina*, *Morozovelloides*, *Turborotalia* and *Parasubbotina* are rare. Based on the results of foraminiferal identification, it can be stated that they belong to the Middle Eocene *Acarinina bullbrooki*, *A. rotundimarginata* and *H. alabamensis* zones. The base of the *Acarinina bullbrooki* Zone in the ISS (International Stratigraphic Scale) is accepted as the lower boundary of the Lutetian Stage (mid-Eocene). Above is the *A. rotundimarginata* Zone. *Hantkenina alabamensis* is characteristic of the Upper Lutetian and Lower Bartonian. The presence of *Globotruncana linneiana*, *Dicarinella* cf. *concavata*, *D. asymetrica*, *Contusotruncana plummerae*, *Globotruncana ventricosa*, *Contusotruncana morozovae* and *Radotruncana* cf. *subspinosa* in the Shugo mud pulp volcano indicates the possible presence in the section of strata of Early, Middle and Late Campanian age. *Globotruncanita stuarti* and *Conrusotruncana contusa* indicate the presence of the Maastrichtian Stage (Vishnevskaya and Kopaevich 2020). The presence of well-preserved specimens of *Elphidium macellum* may indicate the presence of Miocene deposits (Konkian and Sarmatian stages) in the area of the Shugo mud volcano. Our finds of Late Cretaceous, Middle Eocene and Miocene foraminifera in the mud volcanic breccia indicates the presence of strata of these ages in the section. The poorer preservation of the Cretaceous tests may be linked to the composition of the accommodating rocks, probably represented by terrigenous and carbonate-terrigenous turbidites.

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A NEW VIEW OF THE MUNK MARL BED – PALAEOECOLOGICAL STUDY OF A CONDENSED SECTION (UPPER HAUTERIVIAN TO LOWER BARREMIAN) IN THE DANISH CENTRAL GRABEN

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The lower Barremian Munk Marl Bed (MMB) is a key marker horizon in the Danish Central Graben (North Sea), typically defined by organic-rich, laminated, fine-grained sediments bounded by bioturbated organic-poor mudstones, marlstones or marly chalks (Jensen et al. 1986; Crittenden et al. 1991; Copestake et al. 2003). The Deep Adda-1 well in the Danish Central Graben was cored in the Upper Hauterivian–Lower Barremian Tuxen Formation, inclusive of the lower boundary of the laminated organic-rich MMB. This core provides a record of mid-Cretaceous sedimentation on the eastern flank of the intrabasinal Adda–Tyra inversion high. Multidisciplinary sedimentological/biostratigraphic/palaeoecological data document an abrupt environmental shift at the boundary accompanying the switch from chalk to marl sedimentation (Ineson et al. sub.). The Upper Hauterivian–lowermost Barremian chalk and marly chalk (nannofossil zones BC 10–lowermost BC 14) represents a well-ventilated, current-swept setting supporting a diverse nektic and benthic fauna (bivalves, brachiopods, bryozoans, crinoids, sponges, belemnites and asterozoans), 'typical' chalk trace fossils (e.g., *Thalassinoides* isp., *Planolites* isp. and *Chondrites* isp.) and is characterized by a condensed succession with hardgrounds, including one which correlates with a biostratigraphic hiatus, and stacked, thin shallowing-upward parasequences. The succeeding Lower Barremian MMB (nannofossil zone BC14) attests to poorly oxygenated bottom waters and a total lack of epi – and infauna; the calm, inhospitable sea floor was intermittently disturbed by muddy turbidity currents and debris flows. The dominant trends in the nannofossil data set reflect a temporal shift in upper water mass conditions between the Hauterivian and Barremian that was initiated prior to the onset of de-oxygenation of the sea floor. The base-MMB surface is a complex fractured hardground indicative of a relative sea level fall and protracted winnowing of the cemented sea floor. The Deep Adda-1 core thus records a sea level excursion that accompanied the onset of late Early Barremian oxygen depletion in concert with additional potential forcing factors such as coeval surface-water warming, as indicated by nannofossil assemblages, and volcanism. There is no nannofossil evidence to suggest that the stratification and oxygen depletion experienced at the sea floor were encountered in the photic zone.

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A RICH AND PREVIOUSLY UNKNOWN INOCERAMID BIVALVE FAUNA FROM THE EARLY AND LATE CRETACEOUS OF KILEN, NORTH GREENLAND

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Kilen is a remote semi-nunatak on Kronprins Christians Land in NE Greenland. The sedimentary rocks form part of the Mesozoic Wandel Sea Basin succession which represents one of the only Cretaceous exposures north of 74°N in Greenland (Hovikoski et al., 2018; Svennevig et al., 2018). A previous expedition to the area revealed an unusually rich and diverse inoceramid bivalve fauna but hitherto no systematic data has been published (Håkansson et al., 1993). The successions on Kilen dates from Jurassic–Cretaceous and is dominated by faulted and folded sedimentary rocks. Some beds contain a rich inoceramid fauna sometimes in high diversity communities with other benthic faunas such as other bivalves, brachiopods, gastropods, asteroids, monoplacophores and bryozoans as well as with pelagic species such as ammonites and belemnites.

This talk will present the preliminary results from Kilen comprising inoceramids of middle to late Albian age and inoceramids from early Turonian to possibly earliest Campanian age. At Kilen, the inoceramids were successfully used to date a tectonically complex and disturbed sedimentary sequence and were the means of correlation between localities and profiles. The ages were in some cases supported by ammonite, dinoflagellate cyst or foraminifera data. The study shows that the inoceramids were an important faunal group of the Mesozoic shelf in the Arctic and that the Greenlandic inoceramids show affinities to the North American, European, and Siberian faunas in the Cretaceous.

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RESPONSE OF SEA LEVEL CHANGE TO ORBITAL ECCENTRICITY IN A GREENHOUSE CLIMATE

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Climate-controlled changes in eustatic sea level (ESL) are linked to transfers of water between ocean and land, thus offering a rare quantitative insight into the past hydrological cycle. In the present study, we examine the structure and phase of Milankovitch-scale ESL cycles in the peak Cretaceous greenhouse, the early Turonian (~93-94 million years ago).

A high-resolution astronomical framework established for the Bohemian Cretaceous Basin (central Europe; Laurin et al. 2021) suggests a 405-kyr pace and a distinct asymmetry of interpreted ESL cycles. The rising limbs of ESL change constitute only 20–30% of the cycle, and are encased entirely within the falling phase of the 405-kyr eccentricity; the intervening ESL falls (<10 m in magnitude) are more protracted, starting within 80 kyr prior to the eccentricity minimum and culminating 30–60 kyr after the 405-kyr eccentricity maximum. The asymmetry resembles the sawtooth shape of ~100-kyr glacioeustatic oscillations of the Oligo-Miocene (Liebrand et al. 2017) and Late Pleistocene (Hagelberg et al. 1991). The causal mechanism, however, requires a hydrological reservoir that charges (accumulates) slowly with rising eccentricity and discharges (decays) steeply with declining eccentricity on the 405-kyr scale. Such a phasing is not compatible with a glacioeustatic response. Simple, one-dimensional reservoir models suggest that aquifers responding to seasonality variations at low to middle latitudes (charging during seasonality extremes and discharging during episodes of moderate seasonality) can explain the observed phasing.

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LATE VALANGINIAN DROWNING OF THE GETIC CARBONATE PLATFORM (SOUTHERN CARPATHIANS) ASSOCIATED WITH THE WEISSERT OCEANIC ANOXIC EVENT

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The Upper Jurassic–Lower Cretaceous carbonate successions that crop out in the eastern end of the Southern Carpathians reflect the evolution of different palaeosettings of the Getic Carbonate Platform (Patrulius and Avram 1976). The Upper Valanginian–Hauterivian strata reveal a crisis in neritic and pelagic carbonate production, along with changes in fossil assemblages and a $\delta^{13}C$ positive excursion most probably linked to the Weissert Oceanic Anoxic Event. The shallowest settings of the platform are represented by reef limestones, intraclastic/bioclastic-dominated shoals and peritidal deposits, followed by rudstones and grainstones enclosing a foraminiferal assemblage indicative of the Berriasian–Lower Valanginian. At the end of the Berriasian, the structural highs of the platform were emerged, generating a hiatus that is well constrained to the Early Valanginian. The drowning event is documented by the intra-Valanginian discontinuity surface associated with an interval of stratigraphical and taphonomic condensation and specific fossil assemblages containing ammonites, belemnites, brachiopods, gastropods and microfossils (foraminifera, calcareous dinoflagellates, calpionellids). Based on the ammonites and microfossils identified above the discontinuity surface, we have found that the onset of the drowning event was diachronous; it started towards the east during the middle Early Valanginian (*Neocomiensiformis* ammonite zone) and towards the west during the earliest Late Valanginian (*Verrucosum* ammonite zone) (Grădinaru et al. 2016). The deepest setting of the carbonate platform in the Bucegi Mountains is represented by resedimented lithoclasts and shallow-water fossils, mixed with pelagic sediments, indicating progradation of the platform. The autochthonous background pelagic sediment is represented by bioclastic-lithoclastic packstone-wackestone containing a calpionellid assemblage that indicates a Late Tithonian–Berriasian age. During the Late Berriasian, the slope of the carbonate platform was affected by extensional tectonics, generating normal faulting and tilting of blocks. Relative sea level lowstands and, locally, emersion were followed during the Late Valanginian (upwards of the *Verrucossum* Zone) by a sea level rise that led to the final drowning of the platform. Calcareous nannofossils identified just above the discontinuity surface indicate a Late Valanginian age. The Upper Valanginian–Hauterivian post-drowning pelagic deposits highlight the presence of a dysaerobic episode and record the occurrence of the Late Valanginian nutrification event in the Southern Carpathians. The associated fossil assemblage contains small benthic foraminifera, radiolarians, ostracods, crinoid ossicles, aptychi, ammonite fragments, nautiloids, belemnites and siliceous sponges.

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LATE BERRIASIAN–EARLY VALANGINIAN PALAEOENVIRONMENT IN THE VERGOL SECTION (VOCONTIAN BASIN, SOUTH-EAST FRANCE): EVIDENCE FROM MAGNETIC SUSCEPTIBILITY, PORTABLE XRF AND GAMMA-RAY SPECTROSCOPY

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During the Early Cretaceous, the Vergol section (Drôme, south-east France) was located at a palaeolatitude of 25–30° N, in the central part of the epicontinental Vocontian Basin, in a marginal position of the western Ligurian Tethys Ocean (Gréselle and Pittet 2010). The present research is focused on a c. 53 m thick interval of hemipelagic marls and limestones of Late Berriasian–Early Valanginian age (mainly *Alpillensis–Pertransiens* ammonite zones). High-resolution field magnetic susceptibility, gamma-ray spectrometry and X-ray fluorescence measurements allowed for a palaeoenvironmental reconstruction: lithogenic input, relative palaeohumidity and redox variations. The Upper Berriasian–lowermost Valanginian part of the section accounts for increasing lithogenic input (e.g., K, Th and Ti), whereas the Lower Valanginian beds reveal elevated, but stable concentrations of these elements. Magnetic susceptibility values correlate only moderately with content of lithogenic elements. This might point to a complex (i.e., not solely detrital) origin of the magnetic carriers, which is also supported by exclusively normal polarity of characteristic remanent magnetization indicating its secondary age. The Ti/K and Th/K ratios are interpreted as palaeoclimate proxies connected with K-leaching, the process that gains on efficiency under warm and humid climatic conditions.

Consequently, their increasing trends throughout the Upper Berriasian *Alpillensis* Zone, point to progressing humidification, whereas stable values above, within the Lower Valanginian, document a persistently humid climate in the *Pertransiens* Zone. As this picture correlates well with patterns in clastic input, it is suggested that lithogenic influx was primarily dependent on climate-related inland weathering. Additionally, palaeohumidity trends are in good accordance with published reconstructions based on clay mineralogy for other Vocontian sections (e.g., Montclus and Orpierre) (Charbonnier et al. 2013; Morales et al. 2013). Bottom-water palaeoredox proxies (authigenic U, U/Th) are characterized by a sudden decrease within the Upper Berriasian NK-2A nannofossil zone, and the lack of any significant variations above. Noteworthy, the corresponding applies to enrichment in Zn, which is known for its nutrient-like distribution in sediments. This phenomenon is interpreted as being connected with an interval of a relatively arid climate, hence weakened seasonal monsoons. This, in turn, should have lowered the efficiency of monsoonal upwelling processes, leading to stratification of the water column, oxygen deficient at the sea floor as well as intensified burial of trace metals due to weakened nutrient shuttle system in the upper ocean. Ultimately, palaeoenvironmental perturbations at the Berriasian–Valanginian transition are evidenced also by changes in abundance and diversity of calcareous nannofossils.

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PALAEOENVIRONMENTAL CHANGES DURING OCEANIC ANOXIC EVENT 2 AT THE WESTERN NORTH ATLANTIC IODP SITE U1407: EVIDENCE FROM GEOCHEMICAL PROXIES AND MICROFOSSIL ABUNDANCES

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A succession of organic-lean and organic-rich sediments representing Oceanic Anoxic Event 2 (OAE 2) was recovered at Integrated Ocean Drilling Program (IODP) Site U1407 on the south-east Newfoundland Ridge (Norris et al. 2014). Data from elemental concentrations, biomarkers and microfossil abundances (radiolarians, benthic and biserial planktic foraminifera) were combined to reconstruct the progression of palaeoenvironmental changes before, during and after OAE 2 and to assess the controlling mechanisms of organic matter (OM) accumulation. Here we analysed the calcareous nannofossil biostratigraphical data against the global $\delta^{13}C_{org}$ signal to constrain the timing of these changes. Our results from the interval concomitant with the OAE 2 show a sharp negative carbon isotope excursion (CIE ~-3‰) underlies a similar +3‰ rise in isotopic values that commonly defines the start of OAE 2. At Site U1407 the initial $\delta 13C_{org}$ positive increase falls within carbonate-rich sediments (total inorganic carbon or TIC between 66-84 $CaCO_3$%) with abundant benthic foraminifera (average 540/g). This initial positive CIE continues up-core and is followed by ~+2‰ increase that falls within a punctuated drastic decrease in carbonate content ranging from 0.02-0.2 $CaCO_3$% and associated with OM-rich (up to 16%) sediments with few or no foraminifera and abundant radiolarians (as high as 14,700/g). Silicified moulds and poorly preserved tests of both planktic and benthic foraminifera in the low carbonate layer suggest dissolution may have been a factor after deposition. This interval is also associated with an increase in terrigenous input, higher micro-nutrient content, occurrence of fish debris and radiolarians, suggesting higher palaeoproductivity from upwelling. It also includes gammacerane, a biomarker indicative of stratified environments (Sinninghe Damsté et al. 1995), occurring in conjunction with higher terrigenous inputs which implies a heightened hydrological cycle that weakened vertical mixing and induced stronger reducing conditions. The low sedimentation rate at Site U1407 (0.43-0.54 cm/kyr) may have time-averaged the two separate palaeoceanographic states of upwelling and water column stratification. Thus, we postulate that the accumulation of OM during OAE 2 at Site U1407 was facilitated by fluctuating intervals of upwelling and higher productivity with periods of stratification and reducing bottom conditions that preserved the OM. These fluctuations are believed to be associated with climatic variability where humid/wet periods produced water-stratification and drier periods and intermittent upwelling increased vertical mixing of nutrients and reoxygenation, promoting surface productivity. Following the OM-rich interval, the bottom is reoxygenated as evidenced by a rapid increase in benthic foraminifera (to 2,500/g) and an overall increase up-core in carbonate content between 74 and 88%.

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OCEANIC DISPERSAL OF CRETACEOUS DINOSAURS AND PALEOGENE MAMMALS

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Darwin and Wallace tried to explain the distribution of living species by invoking dispersal processes, including land bridges and oceanic dispersal via rafting, swimming and drifting. Wegener's hypothesis of continental drift and the subsequent discovery of plate tectonics seemed to eliminate the need for improbable oceanic dispersal scenarios to explain species distributions. Instead, lineages could passively drift on continental plates. However, an improved understanding of palaeogeography, biogeography, fossil diversity and molecular clocks all show that continental fragmentation occurred too long ago to explain the distribution of many clades, both modern and fossil. Pangaea fragmented in the Jurassic, followed by fragmentation of Gondwana in the Cretaceous, with continental breakup largely complete by 100 Ma. High sea levels driven by seafloor spreading created additional marine barriers in the form of seaways. Dinosaur clades becoming widespread after the formation of these geographic barriers, such as hadrosaurs and lithostrotian titanosaurs, appear to have done so via oceanic dispersal, crossing marine barriers. Following the end-Cretaceous mass extinction, the Gondwanan landmasses of Africa, South America, India and Australia were populated by placentals and marsupials of Laurasian origin, implying mammals rafted and swam between the continents. Oceanic dispersal is not just a phenomenon of obscure island clades such as Galápagos tortoises and iguanas, but populated continents. It drove major radiations like Afrotheria, Australoselphia, Hystrycognathi and Simiiformes. Many novel designs can trace their origin to lineages undergoing oceanic dispersal, including kangaroos, horses, elephants, whales and humans. Oceanic dispersal shows the extraordinary impact of low probability, high impact events in driving evolution. Everyday processes are not necessarily sufficient to explain macroevolutionary patterns, because over long periods of time, rare, once-in-a-million year events become not just possibly but highly probable.

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A GIANT CARNIVOROUS MOSASAURID (SQUAMATA) FROM THE UPPER MAASTRICHTIAN PHOSPHATES OF MOROCCO

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The Cretaceous–Paleogene (K/Pg) transition saw mass extinctions in terrestrial and marine ecosystems. Terrestrial vertebrate diversity patterns across the K/Pg boundary have seen extensive study, but less is known about marine vertebrates. We describe a new giant mosasaurid from the uppermost Maastrichtian phosphatic beds of Morocco, showing how mosasaurids evolved to become apex predators in the latest Cretaceous. A 10-m-long mosasaur from the Oulad Abdoun Basin of the province of Khouribga, closely related to Prognathodon, is characterised by large size, a broad skull, massive jaws and reduced cranial kinesis, suggesting adaptation for carnivory. Teeth resemble those of killer whales and show heavy wear and damage. Among the associated fauna, three genera of mosasaurids, an elasmosaurid plesiosaur, a chelonioid turtle and enchodontid fish show acid damage, and appear to be prey ingested by large mosasaurids. The new species shows how mosasaurids filled the marine apex predator niche, a niche occupied by orcas and white sharks today, as part of a major adaptive radiation in the Late Cretaceous. Diversification of mosasaurids suggests that Late Cretaceous ecosystems became increasingly diverse and complex prior to the end-Cretaceous mass extinction, mirroring patterns seen in carnivorous dinosaurs, and emphasising the catastrophic nature of the K/Pg extinction. Broadly similar evolutionary dynamics seem to characterise marine and terrestrial ecosystems, suggesting a common driver of mosasaur and dinosaur diversification.

MORTONICERATINAE (CRETACEOUS AMMONITINA) FROM THE BASQUE-CANTABRIAN BASIN (BCB, WESTERN PYRENEES): A KEY TO UNDERSTANDING UPPER ALBIAN BIOSTRATIGRAPHY

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The standard Upper Albian ammonite biozonation for the Mediterranean region is based mainly on the phyletic succession of the cosmopolitan genus *Mortoniceras* (Mortoniceratinae) for most of the Late Albian (Reboulet et al. 2011). Many mortoniceratine markers have been defined on the basis of specimens occurring in condensed intervals (e.g., at Cambridge, UK), although recently, expanded successions with representatives of this subfamily have been studied in detail (>300 m, Vocontian Basin; Gale et al. 2011). The Upper Albian succession in the BCB amounts to a thickness of 5,000 m in the central part as a result of high depositional rates in subsiding rifted blocks (e.g., López-Horgue et al. 2009). Ammonites occur throughout the entire succession in marly offshore sediments surrounded by deltaics and shallow carbonates. Mortoniceratines and other brancoceratids (e.g., *Hysteroceras*) co-occur with common Tethyan forms such as *Desmoceras* and *Puzosia, Kossmatella and Anisoceras*. However, boreal hoplitids (*Discohoplites, Hyphoplites*) occur in the uppermost Albian. The first BCB mortoceratines are bituberculated forms (*Deiradoceras*) in association with the brancoceratines *Hysteroceras orbignyi* and *H. carinatum*, featuring a lower *Mortoniceras pricei* Zone. Upsection, *Goodhallites, Deiradoceras* and early Mortoniceras occur with *Hysteroceras binum*, characterizing an upper M. *pricei* Zone. Succeeding this, the presence of *Goodhallites, Deiradoceras* with a subtle lateral tubercle, a new quadrituberculate *Mortoniceras* and the brancoceratines *Hysteroceras bucklandi and H. choffati* suggests the uppermost *M. pricei* Zone to lower *M. inflatum* Zone. The overlying M. inflatum Zone is characterized by *Goodhallites* and *Mortoniceras* with a lateral tubercle, and by *H. bucklandi*. The first *Cantabrigites* occurs above this association, becoming abundant and diverse upwards, indicative of a transitional zone (*Mortoniceras fallax* Zone) between the *M. inflatum* and *M. rostratum* zones. Upwards, *M. fallax* co-occurs with *M. rostratum* and other related forms, suggesting the *M. rostratum* Zone. Sediments of the *M. perinflatum* Zone are characterized by ***Durnovarites perinflatum***, smaller *Durnovarites* and the hoplitids *Discohoplites* and *Hyphoplites*. The record of Mortoniceras may be rare in uncondensed sections and zonally mixed in condensed ones; besides, some species are not well known yet (e.g., fragmentary records). Accordingly, we suggest the following: firstly, to use also other markers such as *Hysteroceras* and *Cantabrigites*; secondly, to avoid the use of species first defined from condensed sections and, thirdly, to take into account the ontogenetic stages (e.g. tuberculation).

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HYDROTHERMAL SYSTEMS IN HYPEREXTENDED RIFT BASINS: INSIGHTS GAINED FROM THE MID-CRETACEOUS BASQUE-CANTABRIAN BASIN (WESTERN PYRENEES, SPAIN)

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The study of sedimentary records, geodynamical evolution, igneous processes and hydrothermal products are basic issues rarely approached in a more holistic research of sedimentary basins. In the present work, mid-Cretaceous hydrothermal mineralizations, the sedimentary record and igneous rocks of the western part of the pericratonic Basque Cantabrian Basin (BCB) are studied. After integration of synchronous hydrothermal magmatic and tecto-sedimentary events, we suggest that common genetic controls existed. The hyperextension model proposed for the BCB (Manatschal et al. 2021) provides a valid template to contextualise the extremely thick sedimentary succession, the distribution and timing of the studied products and their controlling factors in a phase of extreme crustal thinning and likely mantle exhumation. The timing, source of fluids/elements and the origin of the heat for the distinct hydrothermal and igneous products can be correlated with crustal-thinning evolution. The Late Aptian reactivation of major faults led to a fluid flow that penetrated downwards and hydrothermally altered the extending crust. These deep fluids migrated and created different mineralisations within the sedimentary succession. Some of the main extensional faults evolved during the Early Albian to early Middle Albian into detachments that reached the mantle, allowing high subsidence and sedimentation rates and, finally, likely mantle exhumation that might be linked to the origin of a basin-wide Middle Albian

unconformity. During the Late Albian–Early Cenomanian, upcoming mantle-derived fluids along these faults would create sediment-hosted mineralisations as compaction-driven fluids and sea water were also provided (e.g., dolomitization; see López-Horgue et al. 2010) in a phase of high local geothermal gradients. The integration of sedimentation, tectonics and hydrothermal activity into the BCB evolution supports its formation as a hyperextended rift basin during the mid-Cretaceous, and contributes to the ongoing debate about the mode of the opening of the Bay of Biscay-Pyrenean rift system.

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GROWTH PATTERN AND MODE OF LIFE OF THE MAASTRICHTIAN SCAPHITID HOPLOSCAPHITES CONSTRICTUS: POTENTIAL LESSONS FOR AMMONOID PALAEOBIOLOGY

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Scaphitids (family Scaphitidae) are a group of Cretaceous ammonoids with partially uncoiled shells, assigned to 'heteromorphs' (Hoffmann et al. 2021, but see Landman et al. 2021). Two recent studies have focused on moulds and aptychi (calcitic coverings of the lower jaw) of the common European scaphitid *Hoploscaphites constrictus* from Upper Maastrichtian successions in Poland (Machalski 2021; Machalski et al. 2021). On the basis of growth marks on moulds and aptychi, their ontogenetic stages have been reconstructed and correlated, in order to estimate the individual growth rate and age at maturity and to assess the role of the aptychus as a protective operculum (Machalski 2021). The growth rate accelerated rapidly at the onset of formation of the mature body chamber and decelerated shortly before the cessation of growth. The resultant growth curve departs from the growth curve previously proposed for ammonoids. A proposed age of five years at maturity conforms to previous estimates for ammonoids of comparable size. The role of the aptychus as an operculum has been firmly rejected, based on a misfit in size and shape between the aperture and aptychus recorded during ontogeny of the scaphitid studied (Machalski 2021). Another study was based on moulds and aptychi of two temporal subspecies of *H. constrictus* from a chalk succession. In order to reconstruct the habitat depth preferences of these ammonoids, Machalski et al. (2021) used a combination of oxygen and carbon stable isotope data from aptychi and co-occurring benthic and planktic foraminifera with an analysis of predation marks preserved on scaphitid specimens. They concluded that the populations of the older subspecies led a nektic, and those of the younger subspecies, a nektobenthic lifestyle. This change has been interpreted as an opportunistic response of populations to the shallowing of the sea. It remains to be tested by future reseach how many of the above results may be extended to other species of the genus *Hoploscaphites*, to other scaphitids and, on an even broader scale, to all ammonoids. At least the opercular role of the aptychus seems to be untenable for all ammonoids (compare Morton 1981).

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BURROW-GENERATED PSEUDOBRECCIA– AN IMPORTANT PHENOMENON FOR INTERPRETATION OF SOME CRETACEOUS-PALEOGENE (K-PG) SUCCESSIONS

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In 1975, the renowned geologist and ichnologist Richard Granville Bromley (1939–2018) published a seminal, now classic work on trace fossils at omission surfaces (Bromley 1975). In his figure 18.3 he illustrated a heavily burrowed interval at the base of the Santonian Upper Brown Chalk at Taplow (Buckinghamshire, England). Here, the intense development of successive generations of *Thalassinoides* omission and post-omission burrows resulted in near-total replacement of the underlying white chalk by phosphatic chalk that had piped down from above (Bromley 1975). In consequence, although burrow outlines were clearly recognizable in the lower portion of the burrowed zone, its upper portion acquired the appearance of what Bromley called a 'pseudobreccia', with irregular white chalk shreds floating within a mass of phosphatic chalk. The position of highest 'pseudo-clasts' is indicative of the level of the original omission surface, of which little survived (Bromley 1975). Similar pseudobreccias occur at or near the Cretaceous-Paleogene (K-Pg, Maastrichtian-Danian) boundary, e.g., in the Middle Vistula River section, central Poland (Machalski and Jagt 2018, fig. 2) and in New Jersey, USA (Wiest et al. 2016, fig. 3). A Holocene example of massive replacement of an underlying deposit by younger sediments as a result of repetitive excavation by callianassid ghost shrimps and storm infilling of burrow networks was recorded by Tedesco and Wanless (1991). As far as the Middle Vistula River and New Jersey examples are concerned, the highest shreds of the Upper Maastrichtian deposits left by burrowers are so soft, irregular and filigree in shape that they certainly could not have survived any reworking. Consequently, the location of these shreds marks the position of the original omission surface at the top of the Maastrichtian, or, alternatively, a level reached by post-Maastrichtian erosion. A proper recognition and interpretation of burrow-generated pseudobreccias allows us to solve at least some of the persistent stratigraphical controversies surrounding heavily burrowed K-Pg boundary intervals.

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THE ALBIAN–CENOMANIAN (MID-CRETACEOUS) PHOSPHORITE INTERVAL IN CENTRAL POLAND: A STRATIGRAPHICAL AND GEOCHEMICAL REAPPRAISAL

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Several closely spaced phosphorite beds characterize the Albian–Cenomanian boundary interval in the mid-Cretaceous transgressive succession along the northeastern margin of the Holy Cross Mountains in central Poland, forming a distinctive, condensed interval of considerable stratigraphic, palaeontological and economic importance. Based on new integrated data gained from a recently investigated section at Chałupki and partial reassessment of the classic section at Annopol, we propose a new stratigraphic interpretation of the phosphorite interval, drawing on lithological correlations, Rare Earth Elements and Yttrium (REE+Y) signatures of phosphorites, age-diagnostic macrofossils and sequence-stratigraphic patterns

(Machalski et al. sub.).The phosphorite interval has long been considered as exclusively of Albian age (e.g., Cieśliński 1959). However, new macrofossil data allow us to assign the higher phosphorite levels at Annopol and Chałupki, which were the primary target of phosphate mining, to the lowermost Cenomanian, confirming the stratigraphical assignments of some earlier authors (e.g., Samsonowicz 1925). In terms of sequence stratigraphy, the phosphorite interval encompasses the depositional sequence DS Al 8 and the Lowstand System Tract of the successive DS Al/Ce 1 sequence. The correlation proposed here suggests that lowstand reworking during the Albian–Cenomanian boundary interval played an important role in concentrating the phosphatic clasts and nodules to exploitable stratiform accumulations. Our conclusions are pertinent to regional studies, assessments of natural resources (in view of the recent interest in the REE content of phosphorites), and dating the fossil assemblages preserved in the phosphorite interval. Furthermore, they improve our understanding of the formational mode of the Annopol concentration Fossil-Lagerstätte which provides, with its rich vertebrate and invertebrate material, an important mid-Cretaceous palaeobiological archive. On a broader scale, the new data question some common presumptions on the formation of stratiform phosphorite deposits, as such accumulations have usually been linked to transgressive and highstand system tracts of depositional sequences with maxima centred around the maximum flooding surfaces.

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A NEW LATE MAASTRICHTIAN ZONE BASED ON BENTHIC AGGLUTINATED BENTHIC FORAMINIFERA: THE GOESSELLA RUGOSA/ REMESELLA VARIANS ZONE

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The majority of samples from the Upper Cretaceous turbiditic series of the Skole and Subsilesian units contain benthic agglutinated foraminifera, some of which are important for biostratigraphy. Besides *Caudamina gigantea* and *Rzehakina inclusa*,which are used as marker taxa in some zonal schemes (e.g., Geroch and Nowak 1984; Olszewska 1987), several other taxa are important for and characteristic of Upper Cretaceous flysch deposits. Remesella varians has been used for the definition of the Middle/ Upper Maastrichtian interval in the Magura Nappe (Malata et al. 1996), while the same species characterizes a bioevent in the uppermost Maastrichtian of northern Spain (Kuhnt and Kaminski 1997). *Goesella rugosa* is also stratigraphically important. Its last occurrence (LO) is indicative of the latest Maastrichtian and coincides with the K-Pg boundary (Geroch and Nowak 1984; compare Machaniec et al. 2020). The co-occurrence of *G. rugosa* and *R. varians* allows to distinguish a concurrent range zone (CRZ; *sensu* Wade et al. 2011). The lower boundary of the *G. rugosa/R. varians* Zone is defined by the concurrent ranges of the nominate taxa from the FO of *R. varians* (younger than *G. rugosa*) and the upper boundary by the LO of *G. rugosa.* This zone embraces the interval between the FO of *R. varians* and the LO of *G. rugosa* and points to the latest Maastrichtian. Due to the fact that both species are calcareous-cemented agglutinated taxa typical of slope marls, the *R. varians* Zone can be applied only for deposits above the calcite compensation depth.

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AN ESTUARINE EXPLANATION FOR CONSISTENTLY LOW OXYGEN ISOTOPIC VALUES IN INOCERAMID BIVALVES AT IODP SITE U1512 (GREAT AUSTRALIAN BIGHT)

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Coring at International Ocean Discovery Program Expedition (IODP) Site U1512 in the Great Australian Bight recovered an expanded, ~700-m-thick sequence of Turonian–Santonian claystones and silty claystones. Microfossil and geochemical data suggest the sequence can be divided into five intervals, two with strong terrestrial input and three with more of a marine character. These conditions are consistent with the palaeogeographical and tectonic setting of Site U1512 which was located within a narrow, east-west-trending seaway that widened and deepened through time as Australia separated from Antarctica. Foraminifera are present in the cores and are generally well preserved. However, foraminiferal abundances are low,

and many samples lack calcareous taxa. In contrast, inoceramid bivalves are common in many intervals. In the hopes of generating a high-resolution benthic palaeotemperature record and to examine regional palaeoceanography and palaeoecology, we measured the $\delta^{18}O$ and $\delta^{13}C$ values of inoceramid shell fragments and of planktic and calcareous benthic foraminifera where they were present in sufficient numbers. We also estimated palaeotemperatures from clumped isotope (D_{47}) measurements on the calcitic portion of 12 inoceramid shells. The stable isotopic values for Site U1512 foraminifera match well with values measured on contemporary foraminifera from Sites U1513 and U1516 deposited at similar palaeolatitudes, but ~2,000 km to the west. Assuming a seawater $\delta^{18}O$ value of – 1‰$_{V\text{-}SMOW,}$ the foraminiferal results suggest regional surface temperatures of 22–28˚C and seafloor temperatures of 15–20˚C. Using the same seawater value, inoceramid $\delta^{18}O$ values yield palaeotemperature estimates of 15 to 45˚C with Turonian estimates consistently warmer than 30˚C. Such hot seafloor temperature estimates are difficult to reconcile with much cooler estimates from co-occurring benthic foraminifera or modelling results for such a high-latitude site (~60˚S). The Turonian D_{47} palaeotemperature data seem to confirm extremely high seafloor temperatures but suggest seawater $\delta^{18}O$ values from – 2 to +1‰$_{V\text{-}SMOW}$. The $\delta^{18}O$ values of all taxa could be explained if a relatively steeply dipping interface between fresher, low $d^{18}O$ waters in which the inoceramids lived and normal marine seawater in which the calcareous foraminifera lived migrated back and forth across Site U1512 at a relatively high frequency (i.e., faster than the long-term terrestrial vs marine dominated interval shifts suggested by microfossil assemblages). This palaeoceanographical model implies that the inoceramid D_{47} values do not accurately reflect depositional temperatures as the model proposes low seawater $d^{18}O$ values, not extreme warmth, explains low inoceramid $\delta^{18}O$ values.

THE LAST OF THE CRETACEOUS ANOXIC EVENTS, OAE 3: CONIACIAN-SANTONIAN EARTH SYSTEM CHANGES

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The Coniacian–Santonian was a time of significant and diverse marine sedimentation and environments, characterized on the one hand by organic carbon-rich black shales and dark limestones interpreted as the last oceanic anoxic event, OAE 3, and on the other by organic carbon-poor white and reddish limestones, chalk and claystones termed the Cretaceous Oceanic Red Beds (CORBs) (Wagreich 2012). Based on compiled geochemical and isotope proxy data, a stack of two high-resolution global carbon isotope curves for carbonate and organic matter were reconstructed based on statistical analysis (Mansour and Wagreich 2022). Three main levels of short-amplitude carbon isotope excursions were identified. These excursions of durations of 0.4 to 0.7 myr, were characterized by regionally restricted benthic anoxia and sea level highstands that controlled regional organic matter accumulation. These carbon isotope excursions define globally distributed subevents within an episode of more regional anoxia: OAE 3a (late mid-Coniacian, c. 86.9 Ma, Kingsdown Event), OAE 3b (late mid-Santonian, c. 85.0 Ma, Horseshoe Bay Event) and OAE 3c (Late Santonian to the Santonian–Campanian Boundary Event, c. 83.5 Ma). Based on further compilation oxygen isotope temperature data and reconstructed pCO_2 trends, the Coniacian–Santonian was characterized by: 1) a steady state phase of warm greenhouse climate during the Coniacian, followed by (2) a hot greenhouse during the Early Santonian that might be consistent with activation of the Central Kerguelen large igneous province, and (3) a longer-term cooling of the warm greenhouse climate from the mid-Santonian onwards. Organic matter-rich deposition is largely restricted to the low-latitude Atlantic and adjacent epeiric and shelf seas. Areas of enhanced oceanic circulation systems, especially within the westwardly directed Tethyan current and regional eddies of water mass flow had a negative feedback on organic matter preservation resulting from well-developed water column oxygen content within the Tethys. This, in turn, oxidised OM and led to deposition of OM-poor facies and CORBs in large parts of the Late Cretaceous oceans.

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FIRST RECORD OF BOCHIANITES NEOCOMIENSIS (AMMONOIDEA) FROM ARGENTINA AND ASSOCIATED CALCAREOUS NANNOFOSSIL BIOEVENTS: STRENGTHENING THE EARLY VALANGINIAN CORRELATION OF THE ANDES WITH THE MEDITERRANEAN TETHYS

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*Bochianites neocomiensi*s, a long-ranging and widely distributed ammonoid species from the Tithonian to the Lower Barremian, is recorded for the first time from the Neuquén Basin, from the upper levels of the Vaca Muerta Formation at Cañada de Leiva, southern Andes of Mendoza, Argentina. A 40 m section encompassing the *Lissonia riveroi* and *Olcostephanus atherstoni* zones was sampled bed-by-bed for ammonoids and calcareous nannofossils. A total of 125 specimens of *B. neocomiensis*, either flattened or preserved as imprints, were retrieved from two levels of dark-brownish mudstones near the base of the section. The same beds yielded *L. riveroi*, an endemic Andean ammonite restricted to the Lower Valanginian (Aguirre-Urreta and Rawson 1999). The occurrence of *Eiffellithus windii* from the base of the studied section allowed the recognition of nannofossil subzone CC3-B (Applegate and Bergen 1988), which together with the co-ocurrence of *B. neocomiensis* and *L. riveroi*, enable the correlation of those levels with the *Neocomites neocomiensiformis* ammonite zone in the Western Mediterranean Province of the Tethyan Realm (Reboulet et al. 2014). In addition, in the last level yielding *O. atherstoni*, the FO of *Eiffellithus striatus* was noted, a calcareous nannofossil bioevent that indicates the base of nannofossil subzone CC4-A and correlates with the base of the Western Mediterranean Saynoceras verrucosum ammonite zone. This finding reinforces the correlation of the *O. atherstoni* Subzone with the *Karakaschiceras inostranzewi* ammonoid zone. The mix of a cosmopolitan ammonoid-like *B. neocomiensis* in association with endemic Andean ammonites and their calibration with new calcareous nannofossil data helps to refine the long-distance correlation between the west-central Argentina biozonal scheme and the ammonite standard zonation for the Valanginian.

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SYNCHRONISING THE TIMING OF CARBON CYCLE, VOLCANISM AND PACING OF THE EARTH'S ORBIT DURING THE EARLY CRETACEOUS

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The Weissert Event (mid-Valanginian), the Faraoni Event (latest Hauterivian), the mid-Barremian and Taxy events in the Barremian are referred to as Episodes of Environmental Change (EECs) (Föllmi 2012). These episodes are associated with accelerated hydrolysis cycles, increased levels of continental weathering and temperature-triggered fertilization of water masses. Other events were recognized in the Berriasian to Barremian, suggesting that these events punctuated the Early Cretaceous (Kujau et al. 2013; Charbonnier et al. 2016; Martinez 2018; Martinez et al. 2020). Uncertainties in the geological time scales, however, preclude the full understanding of the onset, unfolding and termination of EECs. Here, we analyze the amplitude modulation of precession cycles recorded in two Hauterivian sedimentary series in France and Spain to provide a comprehensive and accurate time scale of the Valanginian–Barremian interval based on the stable

405-kyr eccentricity cycle. The new time scale proposed here significantly differs from the Geologic Time Scale 2020 (GTS 2020) (Gradstein et al. 2021). According to our astrochonological framework, the Weissert Event started at 134.56±0.18 Ma, in perfect synchronicity with the peak of volcanic activity of the Paraná-Etendeka Large Igneous Province. The above-mentioned EECs are within a pacing of 2.40 myr of the detrital supply and carbon isotope variations recorded in bulk rock and belemnite rostra. Hence, long eccentricity cycles were key parameters in the regulation of climate and carbon cycles during the Early Cretaceous through changes in the detrital and nutrient supply, oceanic fertilization, organic carbon storage and global sea level. We also demonstrate that the humid peak related to the Weissert Event is driven by the pacing of the long orbital cycles, in spite of the emplacement of the Paraná-Etendeka province. Nevertheless, in comparison to other EECs of the Valanginian–Barremian, the Weissert Event appears to be a singularly long event with profound impact on climate and marine ecosystems. We posit that this is a consequence of the concomitant effect of the emplacement of the Paraná-Etendeka province and the long orbital cycles.

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JURASSIC–CRETACEOUS TRANSITION SEQUENCES IN EAST ASIA AND THE PACIFIC: RADIOLARIAN MARKERS AROUND THE J/K BOUNDARY

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The decision on where to place the Global Boundary Stratotype Section and Point (GSSP) of the Jurassic–Cretaceous boundary (JKB) is one of the most urgent tasks because the JKB is the last system boundary without a stratotype in the Phanerozoic (Gradstein et al. 2021). The author is a Berriasian Working Group member and is expected to review the radiolarian biostratigraphy and provide JKB-related data from the Pacific and Asian regions. Radiolarian-bearing transitional sequences from the uppermost Jurassic to lowest Cretaceous are exposed at inland sections in East Asia, including Japan (Matsuoka 1995), China, the Philippines and the Russian Far East. Shallow-marine sequences are represented by the Torinosu and Somanakamura groups in Japan. Pelagic and deep-marine sequences are represented by cherts embedded in accretionary complexes in the Russian Far East, Japan, the Philippines (Zamoras and Matsuoka 2001) and southern Tibet, China (Matsuoka et al. 2005). Coeval deep-marine strata are distributed on the sea floor of the north-west Pacific. As a result of an extensive review of radiolarian fossil records, several promising radiolarian bio-events as primary marker have been identified. These include the evolutionarily first appearance data of *Bistarcum irazuense, Cinguloturris cylindra, Eucyrtidiellum pyramis, Hsuum feliformis, Pantanellium berriasianum, Pseudoeucyrtis acus and Vallupus japonicus*. Radiolarians have a high potential for correlating deep – and shallow-marine sequences especially in the Tethys and Pacific. Their qualification as primary markers will be discussed.

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CHEMOSTRATIGRAPHICAL CHARACTERIZATION OF THE BARREMIAN–APTIAN BOUNDARY: A PROPOSED CHRONOLOGY BASED ON C-ISOTOPE STRATIGRAPHY

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The Aptian Stage initially defined on lithology was further confirmed with macrofossils (d'Orbigny 1840, 1850) and the Barremian-Aptian boundary was traditionally reported to characterize a major shift in facies.The lithological change often became the hallmark of the transition between these stages. Further comprehensive studies of the stratotype (Moullade et al. 1998) have provided additional clarification on the transitional stage. Subsequent studies have revealed that correlation based on diverse biostratigraphic criteria has often proved problematic on a global scale due to diachronous bio-events. Thus the need for a more consistent chronological proxy arose that can be universally applied. Like the successful use of palaeomagnetism, recent worldwide application of carbon isotope to correlate palaeoenvironmental events between stratigraphical sequences presents the potential to remedy these uncertainties. Carbon chemostratigraphy ($\delta^{13}C_{carb}$ and $\delta^{13}C_{org}$) allows for the recognition of a precise chronology of the Barremian–Aptian boundary (Föllmi et al. 2006; Sanchez-Hernandez and Maurrasse 2014) with a consistent reproducibility that has proved useful for stratigraphic correlation even when ambiguity occurs with the biochronology. The consistency of the carbon isotope curve showing a well-defined negative excursion coeval with magnetochron M0r provides a robust universal tool to identify the boundary. Here we recommend carbon isotope ($\delta^{13}C$) as a reliable tool to identify the Barremian–Aptian boundary because it is geologically instantaneous throughout ocean basins, and with minor effects of local or regional factors. Based on extensive studies of expanded sections in the Organyà Basin, Catalunya, Spain (Sanchez-Hernandez and Maurrasse 2014; Llaguno 2017; Herdocia and Maurrasse 2022), we propose the El Pui site as a reference section and as a potential candidate for the Global Boundary Stratotype and Point (GSSP).

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BITE MARKS OF A LARGE VERTEBRATE PREDATOR OF MOSASAUR TYPE (?) ON THE EARLY TURONIAN AMMONITE MAMMITES NODOSOIDES FROM THE CZECH REPUBLIC

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An unusual specimen of *Mammites nodosoides* from the Bohemian Cretaceous Basin shows signs of having been predated upon by a reptile, probably with a mosasaur-like dentition. Several bite marks are arranged in two convergent, straight rows – this rather excludes sauropterygians or fishes as predators. The margin of the jaws contours the ammonite aperture, suggesting a predatory attack on the apertural part (i.e., head and arm crown of the prey item). The lethal nature of the inflicted injury is also supported by the crushed anterior (albeit not anteriormost) portion of the body chamber. The spacing of the bite marks, their size and shape and angle of convergence between both rows makes it likely that the agent was a medium-sized (up to 6 m) member of the marine lizard family Mosasauridae, probably of the subfamily Tethysaurinae (Bardet et al. 2003). However, representatives of another closely related subfamily, the Yaguarasaurinae (which includes the genus *Romeosaurus*), cannot be ruled out (Palci et al. 2013). The bite marks on the present ammonite shell may contribute to a palaeoecological evaluation of tethysaurines (in particular with regard to food adaptations) and to a better picture of the palaeogeographical distribution of Early Turonian mosasauroids across the Central European shelves, where there are indications of the former presence of these marine lizards (Kear et al. 2014), similar to records from the Opole area in nearby south-west Poland (Sachs et al. 2018).

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UNSTABLE LIFE: THE DIVERSITY OF TURONIAN BENTHOS AND ITS STRATEGIES – A VIEW FROM OPOLE

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The soupy, limy bottom of many Late Cretaceous basins can be considered a hostile environment. Nevertheless, many groups adapted to it (Carter 1972). Infaunal, motile, iceberg, snowshoe, encrusting, boring and rooted/stalked modes of life are present in the Opole Cretaceous. Most bivalves started their lives attached to grains, and later became either free-living or encrusting. *Pteriomorphs predominate*. Some spondylids employed snowshoe strategy, while others modified their spines into attachment frills. Inoceramid benthic islands were homes to various borers, oysters, anomioids, spondylids, cyclostome and cheilostome bryozoans, serpulids and foraminifera. *In-vivo* interactions between encrusters seem to be uncommon. Land-derived wood was often bored by pholadoids. Among brachiopods, terebratulids predominate. In adult form, their pedicle opening was reduced and most lived as icebergs, but *Gyrosoria* had a rooted pedicle that was able to bore into hard substrates. Some of the crinoids were sessile and had a root system, while hexactinellid sponges generally had roots that specifically anchored them in the soft substrate (*Tremabolites* being a soft-bottom encruster). Hard-shelled infauna and semi-infauna was represented by atelostomate sea urchins and protobranch bivalves. Asteroids, vetigastropods and lobsters formed a motile element, while most cirripedes were stalked. Many taxa from the Opole Cretaceous, to be listed in the talk, were identified only recently and their formal description is in progress.

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BIOTIC AND PALAEOENVIRONMENTAL CHANGES IN THE ALBIAN–CENOMANIAN BOUNDARY INTERVAL OF THE TETHYS OCEAN

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Several oceanic anoxic events (OAEs) have been reported during the Cretaceous, mirrored by lithological changes, such as the occurrence of organic-rich black shales, modifications in marine assemblages and fluctuation of isotope $\delta^{13}C$ values. Most of OAEs have been observed within mid-Cretaceous times, in the Aptian–Turonian interval. One of these events is the OAE 1d, i.e., the Albian–Cenomanian Boundary Event (Jarvis et al. 2006), which was recognized both in Tethyan and Boreal realms (Coccioni 2001; Bornemann et al. 2017). The present paper discusses features of OAE 1d as encountered in two Tethyan sections, one from the Eastern Carpathians, in a turbiditic facies and one in southern Tibet, reflecting hemipelagic deposition (Yao et al. 2018). Both sections contain a positive excursion of isotope $\delta^{13}C$ related to OAE 1d, but the lithological overprint, i.e., organic-rich black shales, was identified only in the Carpathian section. The succession of nannofossil events, including the last occurrence of *Hayesites albiensis* and the successive first occurrences of *Cylindralithus serratus* and

Gartnerago chiasta, is similar in the sections investigated; the assemblages also contain a small group of high-latitude affinity taxa in the upper Albian. Several phases characterized the occurrence of OAE 1d, as a pre-excursion, with low $\delta^{13}C$ values, along with significant diversity and increase of nannofossil high fertility, followed by the onset of OAE 1d, when high-fertility taxa decrease in abundance. The Plateau Phase is characterized by a very low nannofossil abundance and diversity, along with highest percentages of *Watznaueria barnesiae*. Solution-susceptible taxa, such as *Biscutum constans*, *Zeugrhabdotus erectus* and *Cyclagelosphaera margerelii*, are present with very low values and temporarily disappear afterwards. Within this interval, the most anoxic conditions were established on the sea floor and in the water column. The recovery of the nannofossil assemblages is concomitant with the increase of $\delta^{13}C$ values.

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BIOSTRATIGRAPHY OF THE CENOMANIAN-LOWER TURONIAN IN THE TRANSCAUCASIAN INTERMOUNTAIN REGION (GEORGIA)

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The tectonics of the following territories have been studied: the Western molassic sinkage zone (rivers Chanistskali, Tekhuri and Tsachkhura) and the central uplift zone (Dzhikhvela, Zvarula, Moliti, Suramula, Shuagele and Buszhi rivers) (Gamkrelidze 2000). The Dzirula Massif (central uplift zone) is an exposed part of the pre-Alpine crystalline basement of the Black Sea–central Transcaucasian terranes. Active rifting and related processes of volcanic activation occurred at the Albian–Cenomanian boundary in the Crimean-Caucasian region. This was reflected in the nature of sedimentation. The terminal Albian, both in Crimea and the Caucasus, often contains impurities of tuffaceous material (Kopaevich and Khotylev 2014). ***Albian deposits in the central uplift zone are represented by greenish-grey, fine-grained tuff, tuffaceous sandstones and tuffaceous marls, as well as by sandy marls and marly clays with interlayers of tuff breccia and clayey cement. Cenomanian deposits are glauconitic sandstones with interlayers of quartz-glauconitic limestones, carbonate clays, blue-green carbonaceous sandstones, grey sandy marls with interlayers of creamy-grey limestones and calcareous marls.***The terminal Albian is also associated with the end of the Ocean Anoxic Event 1(OAE 1), which is also reflected amongst biota. The *Parathalmanninella appenninica* foraminiferal zone stands out here. In the Western molassic sinkage zone, Cenomanian deposits are represented by brownish-grey marls with rare interlayers of sandy marls and the upper part of the Cenomanian is represented by thick-layered, coarse-grained glauconitic sandstones with intercalations of highly sandy clayey limestones. Based on planktic foraminifera, levels with small *Murihedbergella* correspond to the macrofossil *Inoceramus orbicularis* and *Puzosia planulata* zones and to calcareous nannoplankton zones CC9 and the lower part of subzone CC10a (Sissingh 1977), as well as to UC3 and UC4 (Burnett 1998). The *Rotalipora cushmani* Zone stands out in the upper part of these layers. In the central uplift zone, the Cenomanian Stage is represented by quartz-glauconitic calcareous sandstones, sandy and pelitomorphic limestones, sandy-carbonate clays, greenish-grey, thin-layered tuff sandstones, tuff breccias and marls. In these levels *Inoceramus crippsi* and *I. tenuis*, as well as the small planktic foraminifera *Clavihedbergella simplex* and *Globigerinelloides bentonensis* have been identified. These indicate the upper part of subzone CC10a (Sissingh 1977) and UC5 (Burnett 1998). Lower Turonian deposits, in the western molassic sinkage zone, are represented by pelitomorphic clayey limestones with marl interlayers, siliceous pelitomorphic marl limestones with red and white flints, tuffaceous sandstones with limestone interlayers. The central uplift zone is represented by light grey limestones, with clay interlayers, marls, marly limestones, sandy and carbonate clays and clay marls. The *Inoceramus labiatus* Zone is distinguished at the Upper Cenomanian–Lower Turonian boundary, which corresponds to the *Whiteinella archaeocretacea* Zone. The *Helvetoglobotruncana helvetica* Zone is distinguished in the upper part of the Lower Turonian. The Cenomanian-Turonian boundary is situated between nannoplankton subzones CC10a and CC10b (= UC5 and UC6). The formation of complexes at the Cenomanian-Turonian boundary, both lithologically and in terms of microfossils, proceeded under the conditions of OAE 2 events.

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APTIAN AMMONITE BIOZONATION FOR THE CENTRAL ATLANTIC PROVINCE

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In view of its usually high-precision age calibration, ammonite biostratigraphy is one of the most widely used biozonations for dating Cretaceous strata. However, because of the presence of provincialism, this can be challenging, as is the case with Aptian ammonoids in the southern part of North America and Central America where the standard Aptian ammonite zonation for the Mediterranean Province (= MP) does not work. In order to address this issue, an Aptian standard ammonite zonation for the Central Atlantic Province (= CAP) is now being developed based on, essentially, the study of the Mexican ammonoid record (e.g., Moreno-Bedmar et al. 2013 and Barragán et al. 2021). The provincialism in Mexico is currently well studied and two degrees of endemism can be detected: endemic genera and endemic species. Among endemic genera we may mention *Burckhardtites, Huastecoceras, Kanzaskyella, Quitmanites, Immunitoceras* and the recently described genus, Sonoraceras. In contrast, some genera are present in both provinces, such as *Dufrenoyia, Pseudohaploceras, Colombiceras, Pseudosaynella, Cheloniceras, Epicheloniceras, Toxoceratoides, Caseyella and Acanthohoplites.* It is common for genera with a high evolutionary rate to develop endemic species, such as the index genus *Dufrenoyia* with the American endemic species *Dufrenoyia justinae* and *D. scotti*. This prevents the use of the Mediterranean ammonite zone *Dufrenoyia furcata* because this European index species is not present in America. For this reason, the *Dufrenoyia justinae* Zone is employed in the CAP instead. The second degree of endemism attributable to species also precludes the use of the MP biozonation, because it especially affects index species that are the building blocks of ammonite standard biozonations. Fortunately, a correlation between the standard MP and CAP ammonite biozonations is quite easily established. When the second degree of endemism is present, correlation is easily achieved by using the ranges of the index genus. The first degree of endemism can be more difficult, but it can also be simple in some cases, as with the endemic genus *Kazanskyella* and its Euro-Caucasian counterpart, Parahoplites. In such cases, we may assume that the ranges of both genera are the same or, at least, very similar. In more complex cases of ammonite correlation, we can use microfossils as independent elements of correlation. Microfossils such as planktic foraminifera or calcareous nannofossils have a lesser degree of endemism than ammonites and can be very useful for proper calibration of ammonite biozonations.

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IGNEOUS CLASTS IN THE OUTER NAPPES OF THE EASTERN CARPATHIANS: INDICATORS OF LATE CRETACEOUS BASIN SEGMENTATION

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Clasts of felsic igneous rocks occur within the Cretaceous of the Moldavide nappes which constitute the outer structures of the Eastern Carpathians. These clasts are common in the Lower Cretaceous of the Inner Moldavides, i.e., in the Teleajen, Audia and Macla nappes. U-Pb zircon ages determined on felsic clasts of the Aptian–Albian successions belonging to the Audia Nappe yielded ages of c. 600 Ma (Roban et al. 2020). A particular setting occurs in the southern part of the Eastern Carpathians Bend, where the Macla Nappe is thrust over a tectonic unit described as the Variegated Clay Nappe (Ştefănescu 1995). This unit is interposed between the northern Macla Nappe and the southern Tarcău Nappe. The Variegated Clay Nappe is composed mainly of grey, red and green clays, greenish marls and calcareous sandstones. Granite, granodiorite and felsic porphyry fragments occur as arkose, lens-like feldspar sands and gravels with fragments of felsic igneous rocks up to 10 cm in size. In the sediments of the Variegated Clay Nappe, enclosing lense-shaped feldspar sand and arkose intercalations, the nannofossils indicate an Early Campanian age. Zircon dating of the igneous clasts yielded ages close to 600 Ma, suggesting a source similar to the one of the clasts found in Lower Cretaceous successions of the Inner Moldavides (Roban et al. 2020). Seeing that the Moesian Platform was submerged from the Albian to the end of the Cretaceous, this cannot have been the source of the igneous rock clasts in the Campanian. The mineralogical and petrographic selectivity of the coarse material intercalated in the sediments of the Variegated Clay Nappe, i.e., 90% feldspar in the arenites, and similar proportions of granitoid and porphyry clasts in rudites, suggest a proximal location of the source. These features support the existence of an intrabasinal ridge, containing parts of a Cadomian/Panafrican basement largely dominated by granitoids (batholiths).

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THE CONTINENTAL HESSENREUTH FORMATION (DANUBIAN CRETACEOUS GROUP, BAVARIA, GERMANY): SYNTECTONIC DEPOSITION DURING LATE CRETACEOUS INVERSION

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The strata of the Danubian Cretaceous Group reflect dynamic depositional conditions in a peri-continental setting at the northern margin of the Alpine Tethys. Related to the rather proximal position close to the Bohemian Massif, sediments of highly variable facies and thickness accumulated, representing continental, marginal marine and neritic settings. Cenomanian–earliest Middle Turonian deposition was largely governed by eustatic sea level changes. However, from the mid-Middle Turonian onwards, tectonic inversion along the Franconian Lineament commenced, reflected by the deposition of coarse-grained and extremely immature siliciclastics of the continental Hessenreuth Formation. The >466 m thick Hessenreuth Formation of the Albenreuth–Parksteiner Senke comprises depositional sequences DS Tu 3–Co 2 (Middle Turonian–Middle Coniacian). The composite section consists of successions cored by the deep borehole Friedersreuth 10/1990, as well as by several shallow boreholes and outcrops. The >63 m thick Glashütte Member below 312 m ASL is characterized by beige-pink, massive or cross-bedded, coarse-grained, conglomeratic sandstones alternating with thin, clayey-silty, brick-red soil horizons. The Parkstein Member between 312–390 m ASL is dominated by several meters thick, partly inversely graded sandstone packages, interbedded by a few thin carbonaceous silt and clay beds with plant debris ('Weißarkose'); the upper 15 m belong to the brick-red 'Rotton-Eisensandstein'. The tripartite Friedersreuth Member starts with a cyclic conglomeratic-breccia debris flow unit (390–453 m ASL) followed by a chaotic mud flow unit (453–435 m ASL), and capped by predominately fine-grained, plant-rich siliciclastics ('Friedersreuther Pflanzenton', 495–562 m ASL). The uppermost c. 153 m comprise the Hesserberg Member. The mica-rich, coarse conglomerates include metre-scale boulders; after deposition, most of the crystalline pebbles and boulders pervasively decomposed. Overall, the succession of the Hessenreuth Formation displays a coarsening-upward trend. Characteristic of the Parkstein Member is the ultra-resistant zircon–tourmaline–rutile heavy-mineral spectrum (ZTR 'Weißarkose' Ø 83%, ZTR 'Rotton-Eisensandstein' Ø 77%). Noteworthy is the richness in mica and the high amount of weathering-prone, instable boulder-sized components of the following Friedersreuth (ZTR Ø 26%) and Hesserberg members (ZTR Ø 18%). These fluvial subunits can be correlated to the mixed marginal marine/continental succession of the Bodenwöhrer Senke, c. 60 km to the south, and the neritic deposits around Regensburg–Kelheim. Inversion phases during early Middle and latest Turonian times and across the Early/Middle Coniacian boundary resulted in strongly increasing sedimentation rates of the Hessenreuth Formation. Palynoassemblages include reworked spores of Triassic age and are dominated by angiosperm pollen of the *Normapolles* group. Below 515 m ASL, the Turonian marker *Complexiopollis christae* occurs, while above 555 m ASL, *Minorpollis minimus* characterises the Coniacian. Different gymnosperm pollen and fern spores suggest a river flood plain vegetation, most probably representing a *Normapolles*-related gallery forest with herbaceous angiosperm and fern-dominated undergrowth.

THE HISTORY OF TRANSGRESSIONS IN THE SAXONIAN CRETACEOUS REVISITED, OR, AN IMPERATIVE FOR A COMPLETE STRATIGRAPHICAL REAPPRAISAL (CENOMANIAN, ELBTAL GROUP, GERMANY)

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The Saxonian and Bohemian Cretaceous basins (SCB and BCB, respectively) are located along the northeastern margin of the Bohemian Massif. Contrary to prevailing views, sedimentation in both sub-basins started simultaneously during the earliest Cenomanian – both with continental facies (Niederschöna Formation/Peruc Member of the Peruc-Korycany Formation) and marine facies (Oberhäslich Formation/Korycany Member of the Peruc-Korycany Formation). Biostratigraphical support for this interpretation is provided by palynoassemblages from the two lower, fluvial, fining-upward cycles of the Niederschöna Formation (Lower Cenomanian; Krutzsch 1966) followed by the Oberhäslich Formation with abundant Middle Cenomanian ammonites characterizing the new Merbitz Member (Wilmsen et al. 2022). In Saxony, the five Cenomanian transgressions are dated as follows: depositional sequence DS Ce 1+2 and 3, Early Cenomanian; DS Ce 4, costatus Subzone of the *rhotomagense* Zone, early Middle Cenomanian (*primus* Transgression); DS Ce 5, *naviculare* Zone, early Late Cenomanian; DS Ce-Tu 1, *geslinianum* Zone, Mid-Late Cenomanian (*plenus* Transgression). The Cenomanian strata in Saxony reflect a major sea level rise that finally compensated for the pre-transgression topography, culminating in an earliest Turonian maximum flooding event characterized by the Lohmgrund Horizon, a fine-grained marker bed that can be traced across different formations. The oldest transgression of DS Ce 1+2 is indicated by thick, coarse-grained sandstones and conglomerates of the narrow, north-south elongated (over c. 40 km) Úštěk–Bad Schandau sea bight at the German/Czech border, and the lowermost fluvial cycle 1+2 of the Osterzgebirge and the Pirna Palaeovalley. In Cenomanian times the Úštěk–Bad Schandau sea bight was completely filled by more than 100 m of marine sediments, both on German and Czech territory (Uličný et al. 2009). The mid-Cenomanian *primus* transgression of DS Ce 4 is the most striking transgression with the largest onlap and highest magnitude. The former palaeovalleys and large areas of the Paleozoic substrate were inundated. The Cenomanian transgression continued in the early Late Cenomanian (DS Ce 5) with the widespread deposition of the Werksandstein Member of the Oberhäslich Formation (upper part of the former 'Unterquader'). The Mid-Late Cenomanian sequence boundary SB Ce 5 at the base of the *geslinianum* Zone forms a well-correlatable datum line across the entire SCB and BCB. Above, the *plenus* Transgression concluded the Cenomanian onlap cycle, indicated by overlapping fine-grained and/or calcareous deposition (Pennrich and Dölzschen formations).

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LARGE-SIZED LATE TURONIAN–EARLY CONIACIAN (LATE CRETACEOUS) INOCERAMID BIVALVES FROM GERMANY: TAXONOMIC ISSUES, TEMPORAL FRAMEWORK AND PALAEOECOLOGICAL IMPLICATIONS

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A systematic-stratigraphical revision of selected, large-sized Late Turonian–Early Coniacian inoceramids of the lamarcki group from Germany (Niebuhr and Wilmsen 2022) has shown that both historical specimens of Goldfuss (1836), introduced as *Inoceramus annulatus* and later becoming the types of the Late Turonian *Inoceramus lamarcki* stuemckei and the Early Coniacian I. *annulatus*, respectively, are of Late Turonian age. The large to very large *I. stuemckei*, which is characterized by a box-shaped to pentagonal outline and irregularly spaced, distant concentric rugae, is well represented by its lectotype. Bulky isolated hinges from Upper Turonian strata, used by Heinz (1932) to erect *Heroceramus hercules,* are just fragments of contemporaneous large shells of *I. stuemckei*; *H. hercules* is thus invalid. *Inoceramus stuemckei* is very common, occurring facies-independent from near – to offshore settings, and its first acme is an excellent marker for the base of the Upper Turonian Substage. The name *Inoceramus annulatus* was later applied to huge forms first appearing in the mid-early Coniacian. Thus, I. *annulatus* [*sensu* Walaszczyk and Wood, 1998] is poorly represented by its medium-sized latest Turonian lectotype of Goldfuss (1836) that we regard as being very close to the latest Turonian–earliest Coniacian species *I. lusatiae*. In central European sections, occurrences of large to very large *I. stuemckei* (Lower to mid Upper Turonian) and huge *I. annulatus* (mid-Lower to Middle Coniacian) are separated by an interval without inoceramids with shell lengths of >250 mm. However, in this interval the medium-sized *I. lusatiae* occurs, which is probably the phylogenetic precursor of *I. annulatus* (according to Walaszczyk and Wood 1998). *Inoceramus stuemckei* ($length_{max}$ 500 mm) and *I. annulatus* ($length_{max\ 1}$ m) are characterized by a stratigraphically abrupt shell enlargement and hinge buttressing across the Middle/Late Turonian boundary and within the Early Coniacian, respectively. This shift to larger sizes, a common passive defence strategy against predation, is accompanied by widespread evidence for increased Late Turonian predation pressure by marine durophages. We thus speculate that the size increase in Late Turonian–Early Coniacian inoceramid bivalves is part of an escalating arms race between prey and predators, ultimately triggering Late Cretaceous inoceramid gigantism.

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NEW STRATIGRAPHICALLY IMPORTANT DINOFLAGELLATE CYST SPECIES FROM THE UPPER CAMPANIAN–LOWERMOST MAASTRICHTIAN (UPPER CRETACEOUS) OF POLAND

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Four new organic-walled dinoflagellate cyst species, i.e., *Callaiosphaeridium bicoronatum*, *Odontochitina dilatata*, *Oligosphaeridium araneum* and *Samlandia paucitabulata*, have recently been described from the Campanian–Maastrichtian boundary interval of the Middle Vistula River section in central Poland (Niechwedowicz 2018, 2021 and in Niechwedowicz and Walaszczyk 2021). *Odontochitina dilatata* has additionally been documented from the Campanian of the Roztocze Hills (south-east Poland). *Callaiosphaeridium bicoronatum* is characterized by two, apical and antapical crown-like structures, formed by slender gonal processes connected by high sutural septa. *Odontochitina dilatata* is distinguished form other ceratioid species by its three-layered central body wall, reticulate wall appearance and widely divergent antapical and lateral horns, not connected by pericoel. The most distinctive features of *Oligosphaeridium araneum* are relatively slim and long (equal to, or slightly longer than the central body diameter) processes, the distal extremities of which terminate with perforate or fenestrate platforms. *Samlandia paucitabulata* differs from other species of the genus by its reticulate wall appearance, partially sutural alignment of wall ornament and relatively thick ectophragm which is regular in outline. The occurrence of these species is not limited to Poland; they are geographically widespread and have been shown to have biostratigraphical utility. *Oligosphaeridium araneum* appeared in the mid-Late Campanian (‘*Inoceramus*’ *altus* inoceramid Zone), while *Samlandia paucitabulata* and *Odontochitina dilatata* disappeared in the mid-Late Campanian (terminal ‘*Inoceramus*’ *altus* Zone), and in the latest Campanian (“*Inoceramus*” *costaecus* Zone), respectively. The last occurrence of *Callaiosphaeridium bicoronatum* is a relatively good proxy for the base of the Maastrichtian. The vertical ranges of *C. bicoronatum*, *O. dilatata* and *S. paucitabulata* were used by Niechwedowicz and Walaszczyk (2021) to develop a high-resolution biostratigraphical framework (bioevent and zonal/

subzonal schemes) that enabled a reliable correlation of the Polish sections with selected Boreal (Belgium and the Netherlands) and Tethyan Realm successions (southern Germany, northern Apennines and Tercis les Bains section in south-west France, the Global Boundary Stratotype Section and Point for the base of the Maastrichtian Stage).

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DISTRIBUTION PATTERN AND PALAEOENVIRONMENTAL SIGNIFICANCE OF PALYNOMORPH ASSEMBLAGES FROM THE MIDDLE CAMPANIAN (UPPER CRETACEOUS) DELTAIC SUCCESSION OF SZOZDY (ROZTOCZE HILLS, SOUTH-EAST POLAND)

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The Middle Campanian siliciclastic succession exposed at Szozdy in the Roztocze Hills (south-east Poland), characterized by a well-expressed cyclicity of lithofacies (calcareous gaizes – calcareous mudstones – calcareous sandstones), has recently been discovered by Remin et al. (2015), who suggested a deltaic origin for it. A palynological analysis of the Szozdy section has revealed the presence of rich and well-preserved palynomorphs originating from marine and terrestrial environments. The palynomorph assemblages were found to contain increased quantities of gonyaulacoid (particularly spiniferate) dinoflagellate cysts, and moderate to high abundances of sporomorphs (spores, non-saccate and saccate pollen grains), peridinioid dinoflagellate cysts, foraminiferal organic linings, the nearshore algal species *Paralecaniella indentata*, and estuarine (dinogymnioid) dinoflagellate cysts, accompanied by rare open-marine forms. The entire assemblage points to a deltaic environment (see e.g., Wall et al. 1977; May 1980; Powell et al. 1996). The relative proportions of particular palynomorph groups significantly vary throughout the succession. Calcareous gaize levels are characterized by the lowest recorded percentages of peridinioid dinoflagellate cysts, accompanied by abundances of gonyaulacoid dinoflagellate cysts, non-saccate pollen grains and by a significant content of foraminiferal organic linings. The two latter groups are dominant constituents in calcareous mudstones. Foraminiferal organic linings are absent from calcareous sandstones; this lithofacies, however, contains increased proportions of dinoflagellate cysts (the concentration of peridinioids and gonyaulacoids being almost equal) and sporomorphs (particularly spores and saccate pollen grains). In addition, dinogymnioid dinoflagellate cysts are generally the most frequent in calcareous sandstones, as compared with gaizes and mudstones. This suggests a different palaeoenvironmental interpretation for particular lithofacies – calcareous gaizes must have been deposited in a relatively shallow-marine basin, while calcareous mudstones most likely represent a prodelta setting. The deposition of calcareous sandstones apparently was associated with a delta front environment, the most proximal setting recognised in the Szozdy section.

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EVIDENCE FOR OXIC CONDITIONS AND HYDROTHERMAL INFLUENCE DURING OCEANIC ANOXIC EVENT 2 IN THE MEXICAN INTERIOR BASIN

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Redox changes and hydrothermal influence during Oceanic Anoxic Event 2 (OAE 2) are reported for two successions in the northern (IR2 core, Sabinas Basin) and central (Tlacoula section, Tampico-Misantla Basin) portions of the Cretaceous Mexican Interior Basin, based on geochemical analysis. At both sites, OAE 2 was recognized by the presence of the characteristic positive carbon isotope excursion in organic matter (c. 3 to 4‰) within the *Rotalipora cushmani* and *Witheinella archaeocretacea* biozones. At the IR2 core location, the onset of the anoxic event coincides with a phase of oxygenation, as evidenced by a decrease in TOC and redox-sensitive trace metals contents (U, V and Mo). This higher oxygen level is supported by an increase in the Mn content and a negative cerium anomaly. Higher Cr/Th, Y/La, Lu/La and Eu/Eu* values, coupled with enrichments in Co, Cr and Sc occurring before the peak 'b', point towards an enhanced hydrothermal or mafic influence. At Tlacolula, oxic conditions during the negative carbon isotope excursion between peaks 'a' and 'b' are indicated by a drop in TOC content and the appearance of bioturbated limestone levels. Low Al/(Al+Fe+Mn) and positive Eu/Eu* values support a hydrothermal influence. Altogether these changes are interpreted as the result of circulation of a boreal water mass through the Mexican Interior Basin during the peak

of the Late Cenomanian transgression. This incursion ventilated the sea floor and increased the hydrothermal influence possibly associated with emplacement of the High Arctic Large Igneous Province.

CLIMATE AND OCEANOGRAPHIC CONDITIONS ASSOCIATED WITH THE ACCUMULATION OF ORGANIC MATTER DURING OAE 1A AND OAE 1B IN CENTRAL MEXICO

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Organic-rich sediments deposited in central Mexico during the Aptian–Albian have been previously associated with the occurrence of the early Aptian OAE 1a and the Late Aptian–Early Albian OAE 1b (Gutiérrez-Puente et al. 2021). In the present study, palaeoenvironmental conditions during these events are reconstructed based on geochemical data. The Chemical Index of Alteration (CIA) was used to estimate the degree of weathering in the source areas and climate conditions. Furthermore, a data set composed of the contents of major elements (K, Al, Zr, Na and Mg) and the enrichment factors of redox (U, V and Mo) and productivity (Ni, Cu, Cd and Zn) sensitive trace elements was analyzed through a principal component analysis to identify the main drivers for organic matter accumulation. Changes in the abundance of carbonate and detrital/terrigenous components and fluctuations between oxic-oligotrophic and anoxic-eutrophic marine conditions were the primary controls on the deposition of the sediments studied. The intervals equivalent to the Selli, Jacob and Paquier levels accumulated during times of increased detrital input prompted by high chemical weathering rates under warm and more humid conditions. This caused a higher flux of nutrients (including biolimiting Fe and P) into the basin, increased primary productivity rates in surface waters and induced a reduction in bottom water oxygenation. Enhanced P recycling and

regional upwelling reinforced eutrophic conditions during OAE 1a. Rock-Eval parameters indicate that the preserved organic matter is mixed marine and terrestrial in origin and is immature to early overmature.

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EXTREME WARMTH AND RAPID AND DRASTIC TEMPERATURE CHANGE IN THE CANADIAN ARCTIC DURING THE LATEST CRETACEOUS AND EARLIEST PALEOGENE

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The Cretaceous–Paleogene (K/Pg) boundary was a period of major environmental and biological upheaval. The boundary marks one of the five major mass extinctions of the Phanerozoic, coincident with a bolide impact and flood volcanism, which are both hypothesised to have driven extreme perturbations of the Earth system (Raup and Sepkoski 1982). Bolide impact models suggest an 'impact winter' lasting months to millennia, due to atmospheric loading of dust, soot and sulphate aerosols and/or greenhouse heating caused by CO2 from impact-volatilised carbonates beginning 103 years after impact. Simulations of Deccan volcanism imply global warming of 1.5°C over a period of 400 kyr bracketing the K/Pg boundary owing to CO_2 release. However, tests of these hypotheses are hampered, in part, by a lack of sufficiently resolved temperature records over this interval, especially from the terrestrial polar realm. Here, for the first time, we apply organic geochemical methods to generate a high-resolution terrestrial palaeotemperature record from the Canadian High Arctic (palaeolatitude

~75°N). We use the distribution of branched tetraether lipids (brGDGT) in fossil peats spanning the latest Cretaceous to earliest Paleogene. Using best estimates of peat accumulation rates based on radiometric dating of tuffs at a contemporaneous coal-bearing K/Pg site in northern USA, it is possible to place bounds on the duration of time represented by the records. We estimate that our record spans the last ~100 kyr of the Cretaceous and first ~400 kyr of the Paleogene. Analyses indicate that mean annual air temperatures (MAAT) ranged from – 0.3 to 21°C at this site indicating that the Arctic experienced relatively high terrestrial temperatures over this interval. When compared to MAAT of 13 to 27°C at contemporaneous sites in Saskatchewan (southern Canada; palaeolatitude ~55°N; O'Connor et al. sub.), our results clearly demonstrate that the K/Pg interval saw a well-defined latitudinal temperature gradient of ~1°C per degree latitude. Intriguingly, our novel record shows no evidence of drastic change at or immediately after the K/Pg boundary at any of the sites, suggesting that the bolide impact had no effect on MAAT at a millennial scale. However, we do observe drastic and rapid drops in temperature in our Arctic record at either side of the boundary – up to 14°C in just 14 kyr. Critically, these periods of drastic change do not appear to coincide with known climatic events. Further, there are intervals in which the temperatures are in-phase with the carbon cycle, and other periods where the two are anti-phase, suggesting that the drivers of climate at this time are more complex than previously thought. These dramatic temperature fluctuations observed in the Canadian Arctic are evident because of the unprecedented resolution of our record. However, the origin of such climate variability remains enigmatic, and points to the need for a greater understanding of their origin and distribution in both terrestrial and marine records.

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THE PONS FORMATION OF THE INFIERNO UNIT IN NORTH-WESTERN CUBA: ITS RELATION TO EARLY CRETACEOUS ANOXIC EVENTS

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Organic matter-rich intervals in Cretaceous marine sediments are well documented worldwide and interpreted to represent ubiquitous oceanic anoxic events (OAEs). These deposits are emblematic of settings with extensive modification of the global carbon reservoir concomitant with acute oxygen deficiency in the water column (Schlanger and Jenkyns 1976). Such a record has not yet been documented from the Greater Antilles in the western Tethyan domain. Within this context, our work investigates 30 m of the section exposed at the 'Pan de Azúcar quarry' (Pons Formation), Sierra de Chichones (western Cuba). This outcrop includes medium dark grey (N5) (Goddard et al. 1963) limestones intercalated with greyish black (N2) carbonaceous marlstones, shales, and laminar cherts. The succession developed on a passive margin bordering the Maya Block during the mid-Mesozoic expansion of the Proto-Caribbean seaway. Subsequently it became attached to the Cuban archipelago within the Infierno tectonic unit of the Guaniguanico Terrane, Sierra de Los Órganos belt (Estratigrafía y Paleontología GEO2-O10). Thin sections and electron microscopy imaging (SEM-EDS) of the basal unit reveal a lighter limestone microfacies with isotropic fabric and a bioturbation index (BI) above 3 (Taylor and Goldring 1993), composed of fine micrite with less than 20% allochems, including coccolith fragments, low diversity planktic foraminifera and calpionellids. The carbonaceous levels are also micritic (BI < 2), with a sub-anisotropic fabric, mostly barren or with very rare microfossils, single framboids and bundles of cubic pyrite. SEM imaging has revealed the presence of altered coccolith plates and clay minerals in a carbonate matrix. The samples studied include mostly Globigerinelloides paragottisi, Hedbergella spp. and calpionellids such as Tintinnopsella cf. carpathica. These taxa suggest a latest Valanginian date (Pszczółkowski 1999). Thus, the intercalated carbonaceous shales and marlstones that are barren of microfossils and benthic foraminifera attest to severe oxygen deficiency in the water column, which was likely comparable to the first Cretaceous OAE (Cecca et al. 1994).

Our preliminary study thus provides evidence of the widespread occurrence of oxygen-deprived oceanic conditions related to the earliest Cretaceous OAE in the western Tethys Ocean.

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SEQUENCE STRATIGRAPHY OF UPPER APTIAN–?MIDDLE TURONIAN SEDIMENTS IN THE CAUVERY BASIN, ARIYALUR AREA (TAMIL NADU, INDIA)

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In the Cauvery Basin, the southernmost basin along the Eastern Continental Margin of India (ECMI), Upper Aptian to ?Middle Turonian sediments of the Uttatur Group represent the first major sedimentation cycle of the postrift period (Paranjape et al. 2015; Sinha et al. 2015). Four traverses (Karai-Kulakkalnattam, Kalpadi-Kurumbpalaiyam, Maruvattur-Kunnam and Andhur-Varagur) and five quarry sections (located near the villages of Paravai, Tirupattur, Kalpadi and Kovandankurichchi) were investigated in order to understand the facies associations, establish depositional trends, and identify sequences and sequence-stratigraphical surfaces. The traverses provide a broader insight into the trends, while the quarry sections provide a higher level of detail. From the traverses, a complete third-order sequence is identified within these sediments. Basin floor and slope environments dominate for most of the thickness in the lower part of the sequence (Upper Aptian–Middle Cenomanian). Backstepping of deeper basin floor facies onto relatively shallower, proximal to distal slope facies is seen, indicating a deepening of the basin. This represents a retrograding Transgressive Systems Tract (TST) corresponding with the worldwide mid-Cenomanian transgressive event. The thick TST is attributed to continuity of sediment supply and availability of accommodation in the slope-basin floor environs, accompanied by the relatively rapid subsidence of the ECMI during the initial phase of thermal subsidence. Five 4^{th} order sequences have been identified from the quarry sections corresponding to the TST in the Upper Aptian to Cenomanian. These quarry sections show a coeval development of bioherms on basement highs, followed by cessation of biohermal growth due to drowning and backstepping of deeper basinal facies such as slope talus, proximal and distal splays and stacked channels. The majority of depositional trends indicate deposition in either Falling Stage Systems Tract (forced regression due to relative sea level fall) or the Lowstand Systems Tract (subsequent normal regression) in the early stages of relative sea level rise. The mid-Cenomanian, top of the TST and marked as a condensed section on the basis of nannofossils (Kale and Phansalkar 1992), is identified as the Maximum Flooding Surface. Following the TST, deposition continued on the slope/basin-floor with vertical aggradation (Upper Cenomanian). A gradual shift to outer shelf and offshore transition with increase in amount and frequency of coarse clastic components is seen in the Lower Turonian, wherein storm deposits predominate. These are overlain by strata of upper shoreface/delta front environments. The accommodation space available was thus rapidly filled by inflowing sediment, shifting the facies basinwards, resulting in progradation. This stacking pattern resulting from a combination of initial aggradation and a later rapid progradation represents the Highstand Systems Tract (HST).

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MICROFOSSIL ASSEMBLAGES AND PALAEOENVIROMENTAL CHANGES IN THE MAASTRICHTIAN EPICONTINENTAL SEAS OF NORTHERN SOUTH AMERICA

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During the Late Cretaceous, northern South America was characterized by extensive epicontinental seas, which gradually disappeared due to sea level fluctuations and the onset of the Andean orogeny since the Maastrichtian. In order to track those palaeoenvironmental changes, we conducted micropalaeontological (foraminifera, ostracods and calcareous nannofossils) and geochemical (elemental ratios derived by X-ray fluorescence) analyses at two localities with Maastrichtian rocks in Colombia, namely the Cesar-Ranchería Basin and the Middle Magdalena Valley. Overall, foraminiferal assemblages are dominated by benthic taxa (Maastrichtian *Siphogenerinoides bramletti* and *Ammobaculites colombiana* local biozones), while planktic foraminiferal assemblages comprise Guembelitria cretacea and biserial forms (*Planoheterohelix, Laeviheterohelix*). Ostracod assemblages, only present at the Cesar-Rancheria locality, correspond to moderately preserved valves assigned to the genera *Veenia, Cytherella, Paracypris* and *Cythereis. Nannofossil* assemblages, also presenting a moderate preservation, comprise typical Late Cretaceous taxa (e.g., *Micula staurophora, Kamptnerius magnificus* and *Cervisiellla operculata*). The present study constitutes the first detailed report of ostracod and nannofossil assemblages from the Maastrichtian of northern South America. In general, microfossil assemblages and sediment elemental ratios (Zr/Rb, Fe/Ca, V/Cr and Sr/Ba) indicate a transition from inner

platform settings, with moderately oxygenated bottom waters, to sublittoral conditions, characterised by an increased input of terrigenous material and weathering intensity. The integration of micropalaeontological and geochemical analyses for the new Maastrichtian localities in the area, will improve our knowledge of palaeoenvironments and sedimentation patterns that characterized epicontinental seas in the tropical Tethyan Realm.

AN INTEGRATED STUDY (CALCAREOUS NANNOFOSSILS, DINOFLAGELLATE CYSTS, INOCERAMID BIVALVES, CARBON ISOTOPES) OF THE CAMPANIAN IN THE PETRICH SECTION, CENTRAL SREDNOGORIE ZONE (BULGARIA)

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The Panagyurishte strip of the Central Srednogorie Zone in Bulgaria forms part of the eastern Tethyan Upper Cretaceous basin system. The exposed Petrich section records a continuous epiclastic, pelagic and turbiditic Upper Cretaceous succession, from the Coniacian to the lowermost Maastrichtian. The section provides high-resolution multistratigraphical data to correlate calcareous nannofossil, dinocyst and inoceramid data, especially in the Campanian interval. The base of the Campanian is defined by the FO of *Broinsonia parca parca* (*Aspidolithus parcus parcus* of other authors) together with a special morphotype of *Calculites obscurus* in bed 11, within the upper part of the Mirkovo Formation. The standard nannofossil zone (Burnett 1998) intervals have been identified in the section: UC10 – UC11ab, Middle to Upper Coniacian; UC11c – UC12 – UC13, uppermost Coniacian to Santonian, including the Coniacian–Santonian boundary interval; UC14a, lowermost Campanian; UC14b – UC15c, Lower Campanian to 'Middle' Campanian; UC15d – UC15e, Upper Campanian; UC16a (of Thibault et al. 2016), upper part of the Upper Campanian; UC16b, Campanian–Maastrichtian boundary interval to base of the Maastrichtian. The dinocyst record of the Petrich section indicates the *Areoligera coronata* Zone with a stratigraphical range from the upper parts of the Lower Campanian to the Upper Campanian, and direct calibration to the UC14b–UC16a nannofossil zones. The collected inoceramid assemblage, as well as the inoceramid-bearing level in the lower part of the Chugovitsa Formation, are within the interval of nannofossil subzones UC15d and UC15e of the lower Upper Campanian, corresponding to the Middle Campanian in the North American three-partite subdivision. Palynological results based on the dinocyst assemblages suggest a low-energy depositional environment with normal marine productivity and nutrient levels and the development of a comparatively less oligotrophic water mass within a distal neritic to open marine depositional environment during the Campanian. Palynofacies data corroborate well, pointing to the presence of an oxic distal depositional environment that is located further away from the continental source area. Nannofossil assemblages show a mixture of low-latitude and mid-latitude nannofossils and warm-water species, and may be regarded as peri-Tethyan. Largely primary isotope signatures of $\delta^{13}C$ have been detected and calibrated to the biostratigraphical framework, providing an additional basis for the global correlation of the Campanian in the section with the probable identification of the negative Late Campanian Event and the underlying Base Calcarata Event. Palaeotemperatures based on $\delta^{18}O$ indicate a general cooling into the Late Campanian.

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PLANKTIC FORAMINIFERAL BIOSTRATIGRAPHY OF THE UPPER CRETACEOUS IN THE CENTRAL EUROPEAN BASIN

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Planktic foraminifera rank amongst the stratigraphically most important groups of organisms for the Late Cretaceous, with a high correlation potential. Standard foraminiferal zonation mostly utilises tropical/subtropical taxa and thus this is hardly applicable in temperate and boreal regions, such as the central European Basin, where index taxa are scarce or lacking. Our study of planktic foraminiferal assemblages from the uppermost Albian through to the Maastrichtian of central, eastern and south-eastern Poland and western Ukraine made it possible to update and refine the foraminiferal zonation proposed for extra-Carpathian Poland (Peryt et al. 2022). These assemblages were recorded in macrofaunally well-dated strata cropping out in a series of small to large natural exposures, several quarries and three boreholes. During the Late Cretaceous, the study area was located in the central part of the European Epicontinental Sea and belonged to the North Transitional Foraminiferal Bioprovince. Because Tethyan taxa used as zonal markers in the standard planktic foraminiferal zonation are lacking or occur sporadically, we developed a local zonation which, when calibrated with the macrofossil zonation, could be applied for regional or even interregional correlations. We distinguish 15 planktic foraminiferal zones from the Upper Albian up to the uppermost Maastrichtian. In the interval from the Upper Albian through to the MiddleTuronian, the zones were the same as in the standard zonation and they were based on warm-water, deep-dwelling species of planktic foraminifera, such as *Thalmanninella appenninica, Th. globotruncanoides, Th. reicheli, Rotalipora cushmani, Whiteinella archaeocretacea and Helvetoglobotruncana helvetica*. The biozonation of the Upper Turonian through to the Maastrichtian is based on more cosmopolitan planktic foraminifera. This interval comprises

the following zones: *Marginotruncana coronata, M. sinuosa, Pseudotextularia nuttalli, Globotruncana linneiana, G. arca, Contusotruncana plummerae, Rugoglobigerina pennyi, Globotruncanella petaloidea and Guembelitria cretacea* (Peryt et al. 2022). The biozonation proposed was calibrated by macrofaunal biozonations developed in the study area and correlated with the standard planktic foraminiferal zonation.

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EXPLORING THE PALAEOCEANOGRAPHICAL CHANGES REGISTERED BY PLANKTIC FORAMINIFERA ACROSS OCEANIC ANOXIC EVENT 2 AT IODP SITE U1516 (MENTELLE BASIN, SOUTH-EAST INDIAN OCEAN)

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Planktic and benthic foraminiferal and radiolarian distributions, combined with $\delta^{13}C$ and $\delta^{18}O$ measurements of bulk carbonate and foraminifera, provide clues concerning the palaeoceanographical changes across the Cenomanian–Turonian boundary interval and Oceanic Anoxic Event 2 (OAE 2) at southern high latitudes. Samples analysed here are from Site U1516 in the Mentelle Basin that was located at about 60°S palaeolatitude during the mid-Cretaceous, and it is the first high latitude locality in the Southern Hemisphere where planktic foraminifera are consistently recorded across the OAE 2 interval and its associated positive $\delta^{13}C$ excursion. The correlation between $\delta^{13}C$ and $\delta^{18}O$ profiles at Site U1516 and the European reference section at Eastbourne (England), coupled with the integrated calcareous plankton biostratigraphy and stable isotopic data at Site U1516, indicate that a complete record of OAE 2 at Site U1516 was recovered. Below and in the lower part of OAE 2, the planktic foraminiferal assemblages are dominated by small-sized (125-138 mm) opportunistic species and by radiolarians indicating a predominantly eutrophic regime. The middle part of OAE 2 at the initiation of the plateau phase of the $\delta^{13}C$ profile is masked by the absence of carbonate, by the highest TOC values and predominance of radiolarians indicating that this interval corresponded to a time of highly stressed eutrophic conditions with possible shoaling of the Carbonate Compensation Depth (CCD). Above this interval, bulk isotopic results yield lower $\delta^{13}C$ values, and the $CaCO_3$ increases are associated with the presence of even smaller-sized taxa indicating predominantly eutrophic conditions. Towards the top of OAE 2, the planktic foraminiferal assemblages show changes in composition, with species occupying relatively deep ecological niches appearing and an overall increase in diversity is observed. These features, coupled with the foraminiferal species-specific $\delta^{13}C$ and $\delta^{18}O$ patterns, reveal that Site U1516 occupied a palaeoceanographical setting still affected by eutrophy likely related to enhanced input of nutrients, but with episodes of stability with ecological/thermal separation in surface waters. This interval also records the highest sea surface water palaeotemperature values estimated at 20–23°C based on $\delta^{18}O$ values of foraminiferal tests and assuming seawater $\delta^{18}O$ values of – 1‰$_{V\text{-}SMOW.}$ Mesotrophic to oligotrophic conditions persisted after OAE 2 and throughout the Turonian as evidenced by a diverse planktic foraminiferal assemblage with different species occupying separate ecological niches in the mixed layer and thermocline.

LATE CRETACEOUS PALAEOCEANOGRAPHICAL CHANGES AND ONSET OF SANTONIAN COOLING REVEALED BY PLANKTIC FORAMINIFERA AND STABLE ISOTOPES AT SOUTHERN HIGH LATITUDES

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The latest Cenomanian to Santonian sedimentary record recovered at IODP Expedition 369 Site U1513 in the Mentelle Basin (eastern flank of the Naturaliste Plateau, south-east Indian Ocean, palaeolatitude 60°S at 85 Ma) has been studied to interpret the palaeoceanographical evolution in the Southern Hemisphere. The changes in planktic foraminiferal assemblages, considering depth ecology preferences of different species and surface, and sea floor temperatures inferred from the stable isotopic values measured on foraminiferal tests provide a valuable perspective on Late Cretaceous climate. The hothouse climate during the Turonian–Santonian, characterized by weak latitudinal temperature gradients and high atmospheric CO_2 concentrations, is followed by a progressive cooling during the Campanian. At Site U1513 the beginning of this climatic transition is well recorded within the Santonian, as indicated by an ~1‰ increase in $\delta^{18}O$ values of planktic foraminifera suggesting a significant decline in surface water palaeotemperatures of 4°C. The onset of cooling also recorded changes in planktic foraminiferal assemblages including extinctions among surface – (*Marginotruncana*) and deep-(*Planoheterohelix papula*) dwellers, appearances (*Archaeoglobigerina cretacea*) and diversification of newly evolving taxa (*Globotruncana*), and changes from predominantly epifaunal oxic to infaunal dysoxic/suboxic taxa among co-occurring benthic foraminifera. Overall, the data presented here document an interval in the Santonian, during

which the rate of southern high latitude cooling increased. Both surface and bottom waters were affected, although the cooling signal is more evident in the data for surface waters. This pattern of cooling is in agreement with model simulations and palaeotemperature reconstructions, and ascribes the deterioration of the Late Cretaceous climate to decreased CO_2 in the atmosphere and changes in the oceanic circulation correlated with enhanced meridional circulation.

REVISED CALPIONELLID STRATIGRAPHY AND MICROFACIES OF THE TORRE DE' BUSI SECTION (LOMBARDY BASIN, J/K BOUNDARY)

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A revision of calpionellid taxonomy and documentation of their succession in the Upper Tithonian–Lower Berriasian sequences of Torre de' Busi section (northern Italy) have allowed to determine four standard zones and six subzones as follows: *Chitinoidella* Zone (*boneti* Subzone), *Praetintinnopsella* Zone, *Crassicollaria* Zone (*remanei*, *intermedi*a and *colomi* subzones) and *Calpionella* Zone (*alpina* and *ferasini* subzones). Generally, calpionellids are poorly preserved, and not very abundant; redeposition has been documented locally. Correlation with previously published magnetostratigraphy (Channell et al. 2010), calcareous nannofossil biostratigraphy (Casellato and Erba 2021) and chemostratigraphy (new data) was performed. Calcified radiolarians and spicules dominate in the majority of microfacies observed along the interval studied. *Spiculite*-radiolarian wackestone/packstone, radiolarian wackestone/packstone, *Saccocoma*-spiculite-radiolarian wackestone and *Saccocoma*-radiolarian wackestone occur in the Kimmeridgian and Lower Tithonian. The Rosso ad Aptici Unit contains calpionellid index species of the *Chitinoidella* and *Praetintinnopsella* zones, from the lower half of CM21n

up to uppermost CM20n2n. Calpionellids start to become more frequent in microfacies from the onset of the *Crassicollaria* Zone onwards, just below the CM20n1r. Calpionellid-spiculite wackestone/mudstone and Calpionellid-spiculite-radiolarian wackestone with index species of the *remanei* Subzone dominate in deposits of the transition interval between Rosso ad Aptici and Maiolica. In the Maiolica limestones, calpionellid index markers of the Upper Tithonian *intermedia* and *colomi* subzones correlate with magnetic intervals CM19r and the lower half of CM19n2n. Spiculite-calpionellid wackestone, calpionellid wackestone, calpionellid-radiolarian wackestone and radiolarian-calpionellid wackestone prevail in the Lower Berriasian alpina and ferasini subzones (upper part of CM19n, CM18r and CM18n). The revised calpionellid data in Torre de' Busi section, correlated with magnetozones and nannofossil biostratigraphy, are consistent with the majority of Tethyan sections documented in the literature (Casellato and Erba 2021).

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PALAEOENVIRONMENTAL AND PALAEOGEOGRAPHIC IMPLICATIONS OF THE VALANGINIAN IN THE POLISH BASIN BASED ON AMMONITES AND DINOFLAGELLATE CYSTS

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The richly fossiliferous Wąwał section located in central Poland (NE limb of the Tomaszów Syncline within the Mid-Polish Anticlinorium) is a source of valuable information about life during the Valanginian in the Polish Basin. During the Valanginian, the Polish Basin was a pathway between the Tethys and Boreal realms and a large number of fauna and flora migrated here from the Tethys and Boreal realms, which resulted in interfering influences of both provinces (Kutek et al. 1989). The most accurate stratigraphic subdivision is provided by abundant and well-preserved ammonites. The age of the studied upper Valanginian samples encompasses the *verrucosum, crassus/polytomus* and *triptychoides* ammonite zones. In our study, we used dinoflagellate cysts collected from the same samples as the ammonites. In this way, we were able to compare information from both groups of fossils. The ammonite mode of life found in the Wąwał section is interpreted as planktonic, demersal or pelagic free-swimming. Therefore, the palaeotemperatures obtained from ***d18*** O analyses of ammonite shells concern the lower and upper part of the water column, and also provide possible information on seasonal variability (Ploch submitted). Such information about the palaeoenvironment compared with results of the analysis of dinoflagellate cysts provided a more detailed view about the specifics of the Polish Basin. Preliminary study of well-preserved dinoflagellate cyst assemblages from the Wąwał section revealed that they are similar to those from England and the North Sea area (Duxbury 2018). So far, ammonites and microfossils have indicated the exchange of fauna and flora with the German Basin (Dziadzio et al. 2004, 2021), but the present finds clearly indicate connections also with the Boreal basin in England during the Valanginian.

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PALAEONTOLOGY AND BIOSTRATIGRAPHY OF BIVALVES AND GASTROPODS FROM THE LO VALDÉS FORMATION (TITHONIAN–HAUTERIVIAN) IN CENTRAL CHILE

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The Jurassic–Cretaceous (J/K) boundary is the last of the system that remains to be defined, since it still lacks international consensus (e.g., Granier 2020). In central Chile, the Lo Valdés Formation is a continuous Jurassic–Cretaceous section, with an abundant record of invertebrates (e.g., Salazar et al. 2020). This lithological unit has been defined as a sedimentary marine, fossiliferous unit (Salazar and Stinnesbeck 2015). The lithological composition and faunal content of the Lo Valdés Formation allow us to differentiate these environments: shoreface, offshore transition and offshore (Salazar and Stinnesbeck 2015). In the present study, we analysed 813 fossils from the Lo Valdés Formation, i.e., 705 bivalves and 108 gastropods. The preservation varies from poor to very good; some specimens can only be identified to the family level. *Aetostreon pilmatuegrossum, Anopaea bassei, Ceratostreon cf. minos, Lima peroblicua* and *Neocomiceramus curacoensis* are recorded from Chile for the first time. The biostratigraphy, based on a diversity analysis of alpha and beta taxonomies, also together with an analysis of the Jaccard and Bray-Curtis similarity index, shows two bioevents in the during the Tithonian–Hauterivian. The first bioevent presented an abrupt decrease in relative abundance and richness between the Lower and Upper Berriasian. The individual rarefaction index shows that, regardless of the number of specimens, richness is high during the Lower Berriasian, with a decrease between the Upper and Lower Berriasian. There also is a peak of uniformity in the Middle Berriasian. The Shannon index shows that the diversity between the Upper and Lower Berriasian is low; the Bray-Curtis index is low between the Upper and Lower Berriasian. A second bioevent is recognised between the Upper Berriasian and Lower Valanginian, characterized by a decrease in relative abundance and richness. Based on the individual rarefaction index a decrease in richness

during the Valanginian is seen. The uniformity in the Valanginian presents a progressive increase during the Upper Berriasian. The Shannon and Jaccard index shows a low diversity between the Upper Berriasian and Lower Valanginian.

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BARREMIAN–APTIAN FACIES DIVERSITY AROUND THE TETHYS REALM: GLOBAL OCEANIC FACTORS VS LOCAL PHYSIOGRAPHICAL CONDITIONS

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Mid-Cretaceous oceans are known for their apparent widespread oxygen-poor conditions (e.g., Schlanger and Jenkyns 1976; Hay 2017), illustrated by the common occurrence of organic-rich ($C\text{-}_{org}$) pelagic and hemipelagic sediments in the stratigraphical record of that time. During the Early Aptian, enhanced carbon sequestration triggered a perturbation of the global carbon cycle (Bottini and Erba 2018; Beil et al. 2020), resulting in Oceanic Anoxic Event 1a (OAE 1a). Here we compare the sedimentary records of two carbonate platforms located at opposite sides of the Tethys Seaway during the Barremian/Aptian transition related to OAE 1a. The sections crop out in north-eastern Mexico and south-eastern France. It is evident that low-oxygen conditions developed at both localities as supported by instances of $C\text{-}_{org}$ values up to 2.63%, petrographical observations, molecular biomarkers, as well as benthic and planktic foraminiferal assemblages. The north-eastern Mexican basin consists mostly of dark grey C_{org}-rich shales and marly limestones with an average $CaCO_3$ content of 68.74 wt%. This succession also includes intercalated red layers, relatively poor in $CaCO_3$ (17.04 wt%), implying periods of local variations to well-oxygenated conditions within the recurrent low-oxygen waters. By contrast, in south-eastern France, the Barremian–Aptian Urgonian facies exhibits thick packages of white to light-yellow rudist limestones with a discontinuous and locally diachronous marly interval (Masse 1993), a weak indication of an explicit relation with the worldwide anoxic event. The Bedoulian to Clansayesian facies are grey limestones and marls (Moullade et al. 2015), more consistent with low oxygen conditions. Although there is an overall facies change marked by increased terrigenous material in the lower Aptian in both study areas, the net characteristics associated with organic carbon-rich deposits are expressed differently as compared to the characteristic common shaly facies associated with OAE 1a elsewhere. This comparison highlights the fact that significant spatial heterogeneity occurred in sub-Tethyan basins during the same global oceanic conditions. In addition, the recurrence of facies characteristic of oxic conditions implies that in certain areas, local physiographical factors controlled sediment type and overprinted global forcing mechanisms that caused anoxia elsewhere.

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MODE AND TIMING OF THE CRETACEOUS TRANSGRESSION IN CENTRAL IRAN: DEPOSITIONAL ENVIRONMENTS AND STRATIGRAPHICAL EVOLUTION

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Following a major erosional stage post-dating the Cimmerian events, central Iran is characterized by a widespread marine transgression and deposition of a basal mixed siliciclastic-carbonate unit covered by carbonate facies (Wilmsen et al. 2009, 2013, 2015, 2018; Gheiasvand et al. 2021; Raisossadat et al. 2021). To reconstruct the stratigraphical evolution of the Cretaceous successions, an integrated sedimentological and biostratigraphical study was performed on outcrops in three areas of central Iran (Arousan, Chahdegan, Esfahan north). Fieldwork, facies and biostratigraphical analyses have supported the correlation of stratigraphical logs and the reconstruction of their vertical evolution. The three areas are characterized by a roughly synchronous onset of sedimentation, with a few metres of conglomerate and sandstone with carbonates, unconformably covering metamorphic rocks or older, tilted sedimentary successions. The transgressive unit rapidly evolves to massive carbonates with rudists and orbitolinid foraminifera. This carbonate unit shows in the three study areas remarkably comparable facies and biostratigraphical assemblages, consisting mainly of orbitolinid-rich packstones of Late Bedoulian age (i.e., Early Aptian), associated with abundant rudists. After the deposition of this first carbonate unit (i.e., Shah Kuh or Taft Formation), a stratigraphical differentiation is observed in the three study areas. A general deepening trend is seen, albeit with local return to shallow-water, skeletal carbonate platform facies in different time intervals. A gradual transition to alternating marls and limestones with chert nodules and silicified fossils (ostreids) that suggests a rapid deepening trend can be observed in the Chahdegan area.

No later shallowing is documented, although the occurrence of resedimented limestone rich in orbitolinids, ostreids and rudists within the open-sea marls document the existence of shallow-water conditions in the areas surrounding Chahdegan. Deepening events (locally marked by glauconitic hardgrounds) have also been observed in the Arousan area, but the return to carbonate platform conditions is here recorded in the Campanian–Maastrichtian (i.e., Haftoman Formation) with an intercalation of shallow-water skeletal limestones rich in rudists, ostreids and orbitoidids at diverse stratigraphical intervals. In the Esfahan north area, the deepening trend ends instead in the Middle Cenomanian with the development of a prograding carbonate platform, which is older in comparison to the Arousan area. The integration of sedimentological and biostratigraphical data has allowed the identification of a coeval transgressive event, widespread and likely controlled by common processes all across central Iran. This regional transgression was followed by a differentiation of the depositional settings in the study areas which presumably reflects significant tectonic events related to the opening of seaways in central Iran during the Late Cretaceous.

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CRETACEOUS PALAEOGEOGRAPHY OF THE CENTRAL MEDITERRANEAN AND DINOSAUR DISPERSAL TOWARDS ADRIA: A CASE STUDY FROM NORTH-WEST SICILY, SOUTHERN ITALY

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During the last four decades, several contributions have addressed the geodynamic history and the Mesozoic palaeogeography of the Mediterranean area (Biju-Duval et al. 1976; Channell et al. 1979; Finetti 1982, 2005; Masse et al. 1993; Bosellini 2002; Patacca and Scandone 2004; Rosenbaum et al. 2004; Zarcone et al. 2010; Frizon de Lamotte et al. 2011). According to the classic palaeogeographical reconstructions, deep seaways separated Gondwana and Laurasia and many restricted and isolated shallow-water areas punctuated the peri-Adriatic region during Cretaceous times (Biju-Duval et al. 1977; Finetti 1985; Dercourt et al. 1986; Stampfli and Mosar 1999; Catalano et al. 2001; Stampfli and Borel 2004; Passeri et al. 2005; Patacca and Scandone 2007). However, the Italian dinosaur record (mostly tracksites and some exceptionally preserved specimens) often reveals a Gondwanan affinity, questioning these assumptions and suggesting that Gondwana and Adria were connected during Cretaceous times (Nicosia et al. 2000, 2007; Petti 2006; Petti et al. 2008, 2020; Zarcone et al. 2010; Frizon de Lamotte et al. 2011; Citton et al. 2015; Dal Sasso et al. 2016). Among the rich dinosaur record of Italy, a bone fragment of a theropod discovered in north-west Sicily (Capaci) deserves to be mentioned. It comes from a carbonate succession (i.e., Pizzo Muletta) pertaining to the Panormide Carbonate Platform (PCP) and has previously been ascribed to the Cenomanian. Apart from being the only known documentation of dinosaurs in Sicily, its occurrence strongly supports the hypothesis of a land bridge connecting Africa and Adria via PCP. Novel sedimentological and biostratigraphical data from the bone-bearing carbonate succession have allowed to establish the age of this dinosaur bone as Late Aptian–Early Albian and to trace a detailed Aptian–Cenomanian evolution for this sector of the PCP. In particular, a karstic overprint has been observed which indicates subaerial exposure of the platform that preceded its drowning at the end of the Cenomanian. The results obtained, coupled to recent new data on the Cretaceous dynamics of the PCP, point to (i) a longer-lasting function (from Aptian to Cenomanian times) for this Sicilian palaeodomain as a connection between Gondwana and Adria, and (ii) highlight the key role of regional tectonics on its progressive dismantling during the Late Cretaceous.

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PLAUSIBILITY OF MILANKOVITCH CYCLES IN AN ULTRA-GREENHOUSE WORLD: STRATIGRAPHIC CORRELATION AND SEA LEVEL RECONSTRUCTION OF THE TURONIAN WESTERN INTERIOR SEAWAY USING TEPHROCHRONOLOGY AND BIOSTRATIGRAPHY

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The Turonian (93.9 ± 0.8 Ma to 89.8 ± 1 Ma) has been regarded as the peak of a long-lasting hothouse period in the Late Cretaceous, during which the average global sea surface temperatures were estimated to be ~35°C (O'Brien et al. 2017). However, despite these elevated temperatures, a debate exists as to whether ephemeral ice sheets could have been present in Antarctica during this period, with the freezing and thawing of glaciers being the primary driver of global eustatic sea level change. The presence of ice sheets during this period has previously been supported by the frequency of parasequence sets and the synchroneity of short-term glacio-eustatic cycles (Miller et al. 2005; Zhu et al. 2012; Lin et al. 2021). The presence of ice during the Turonian is interesting since not only does it suggest the possibility of polar ice during an ultra-greenhouse period, but it also provides a mechanism controlling sea level fluctuations (and thus parasequence deposition) via glacio-eustasy which can increase sea-level by ~200 m (Ray et al. 2019). We have applied backstripping calculations for five Turonian-aged formations along the Cretaceous Interior Seaway of North America, to isolate eustatic effects from the influence of tectonic activity and sediment compaction. These formations are distributed over a distance of about 1,500 km from Alberta (Canada) to New Mexico (USA) and include the Cardium Formation in Alberta, the Last Chance and Notom Deltas of the Ferron Sandstone (Mancos Formation) in Utah, and the Gallup Sandstone and Juana Lopez Member of the Mancos Formation in New Mexico. The timing of eustatic cycles is constrained by newly acquired U-Pb and $^{40}Ar/^{39}Ar$ ages from the Ferron Notom Delta, Gallup Sandstone and Juana Lopez Member using sanidines in bentonites, as well as ages from the literature and biostratigraphical correlations for the Last Chance Delta and Cardium Formations. We subsequently reconstructed and correlated sea level curves based strictly upon our estimated effect of glacio-eustatic processes with the intent of determining whether evidence of multiple locations within the WIS shows evidence of a glacio-eustatic influence. Our results show a sea level change of 10 to 100+m in each of the studied locations. Alternate causes of sea level change, such as steric/thermo – and aquifer-eustasy, can only explain up to 10 m and 5 m of sea level change, respectively. Additionally, aquifer – and glacio-eustasy cannot influence sea level at the same time. As such, any sea level change above 15 m at the very least suggests an influence of steric/thermo – and glacio-eustatic effects, with the influence of glacio-eustasy increasing with increasing sea level rise. Our observations through backstripping calculations illustrate a plausible influence of glacio-eustasy in multiple areas within the WIS. Consequently, our reconstructed sea level curves based upon the timing of the parasequences in our studied locations also provide evidence of Milankovitch cycles as the main driver of sequence-scale sea level change in the WIS and show that suggest that ephemeral ice sheets were present within Antarctica during the Turonian.

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TRACKING ABNORMALITIES IN THE CEPHALOPOD FOSSIL RECORD: ON THE ORIGIN OF THE LATE CRETACEOUS BELEMNITE FUSITEUTHIS POLONICA AND ITS RELATIONSHIP WITH OTHER DIVERSIFIED CEPHALOPODS

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Late Cretaceous cephalopods, including ammonites and belemnites, constitute major components of the marine biota. Their rate of evolutionary transformation was highly elevated on account of their rather short lifespans, which makes Late Cretaceous cephalopods textbook examples of index fossils. However, within the belemnite clade, there is a taxon that stands out in stark contrast to this phenomenon: *Fusiteuthis polonica*. The absence of any known ancestor, the unusual shape of its guard, unlike any other belemnite, the unexpected distribution pattern, the rarity and morphological stability for almost 6 myr, lead to questions regarding the origin of this species, one of the rarest among Late Cretaceous belemnites (Christensen 1997). Four possible hypotheses on its origin are discussed: 1) it constitutes a distinct species; 2) it is an expression of atavistic morphology; 3) it reflects chromosomal aberration, referred to here as the *Cephalopod Down Syndrome*, and 4) it is an intergeneric hybrid, referred to here as a *Cephalopod Mule*. The spatial and temporal distribution patterns of all known specimens of *F. polonica,* along with their external morphology and internal characters (examined here for the first time), are analysed and discussed with regard to the above hypotheses. Chromosomal aberration or intergeneric hybridization are the most consistent hypotheses with these characteristics, and as such are the most reasonable explanations for the origin of *Fusiteuthis.* Additionally, comparisons are made with co-occurring genera such as *Belemnitella, Belemnella* and *Neobelemnella.* It is possible – although speculative – that cephalopod hybridization

(*Cephalopod Mule*) or chromosomal aberration (*Cephalopod Down Syndrome*) could be more common in the fossil record than previously thought and has been hitherto overlooked and unexplored. There are several examples of transitional forms between well-documented fossil cephalopods. Such intermediate forms have been typically related to polymorphism, as in the case of Oxfordian (Late Jurassic) ammonites, or phenotypic plasticity, as exemplified for Maastrichtian (Late Cretaceous) scaphitid ammonites. An obvious question is whether the extremely high morphological variability (more than 50 forms) and full intermediacy present in the ammonite *Schloenbachia varians* (Cenomanian, Upper Cretaceous) can be explained by hybridization: traditional explanations related to this remarkable variability with phenotypic plasticity, life mode or the occupation of ecological niches by different forms. Elevated variability in particular lineages can be easily ascribed to hybrid swarms – that is, a term used to describe the interbreeding and backcrossing of hybrids with parental forms. Therefore, hybrid swarms can have superior genetic fitness relative to their progenitors, blurring the boundaries between them and giving rise to a wide spectrum of forms. In the three cases mentioned above, the existence of hybrid swarms offers a reasonable explanation for the diversity of forms without the need to resort to sophisticated, complex rationalizations and assumptions. In conclusion, *Fusiteuthis* does not appear to be a separate and valid species but instead represents a ***Cephalopod Mule*** hybrid – as referred to herein – with comparatively lower fitness than its parental taxa. It was strong enough to thrive and leave fossils, yet too weak to breed (shooting blanks) and thereby transfer its genome to successive generations.

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THE K/PG BOUNDARY SECTION AT NASIŁÓW, POLAND – NEW DATA ON BIOSTRATIGRAPHY AND PALAEOMAGNETISM

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The Nasiłów section represents the uppermost part of the Middle Vistula River succession, a classic extra-Carpathian Cretaceous section in Poland, and accesses the Cretaceous–Paleogene boundary interval. Despite many valuable papers that have been published so far, our recently collected data shed new light on the completeness of biostratigraphical and sedimentary records across the K/Pg at the site. The Nasiłów section encompasses the Upper Maastrichtian regional foraminiferal assemblage zones XII and XIII and lower Danian P0–P standard planktic foraminiferal zones. The K/Pg boundary is placed at the top of a phosphatic layer (Remin et al. 2021). The grey marly chalk unit, never subjected to examination of biostratigraphically important taxa, displays blooms of guembelitrids, indicative of the uppermost Maastrichtian (foraminiferal assemblage zone XIII), as well as of planktic and benthic foraminifera of reduced test sizes. Such foraminiferal dwarfism is commonly observed near the end of the Cretaceous and interpreted as a response to Deccan volcanism (possibly 2nd phase), which caused climate changes and ocean acidification. The terminal Maastrichtian age of the marly chalk unit is additionally supported by an acme of the dinoflagellate cyst *Palynodinium grallator*, together with *Thalassiphora pelagica* and *Disphaerogena carposphaeropsis.* The 'Greensand', a distinct glauconite-quartz sand unit, contains exclusively terminal Maastrichtian planktic foraminifera and dinoflagellate cyst assemblages. Single specimens of Danian age are interpreted to be either the result of contamination or as having been piped down by burrowers into the Greensand. The lowermost portion of the Siwak unit demonstrates an Early Danian age, as based on the *co-occurrence of the common planktic foraminifera Globoconusa daubjergensis*, *Guembelitria cretacea*, *Muricohedbergella monmouthensis*, *M. planispira*, *Planoheterohelix globulosa, Parvularuglobigerina extensa and P. alabamensis.* The last occurrence of

Palynodinium grallator and the first occurrences of *Carpatella cornuta* and *Senoniasphaera inornata*, recorded directly above the phosphatic layer, support the same age assignment. New palaeomagnetic data cannot prove the remagnetisation at the boundary interval, which contrasts with previous research that supported a hiatus in the critical interval. All this is in line with new biostratigraphic data (Remin et al. 2021).

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THE DEVELOPMENT OF THE SZOZDY DELTAIC SYSTEM – THE EFFECT OF ACTIVE LATE CRETACEOUS INVERSION TECTONICS OF THE AXIAL PART OF THE POLISH BASIN: ROZTOCZE HILLS, SOUTH-EAST POLAND

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The Polish Basin, together with its axial most subsiding part – the Mid-Polish Trough formed the eastern part of the Permian-Mesozoic system of epicontinental basins of western and central Europe, the so-called Central European Basin System. This large Trans-European sedimentary basin stretching from Denmark, through Germany, to south-eastern Poland and further to the south-east into western Ukraine, had undergone uplift during the Late Cretaceous, which in consequence resulted in the inversion of its axial part (i.e., the Mid-Polish Trough) and transformation into the Mid-Polish Anticlinorium. In many existing palaeotectonic interpretations, southeast Poland – i.e., the present-day Roztocze Hills and the subsurface San

Anticlinorium (south-eastern part of the Mid-Polish Anticlinorium) was included into the Mid-Polish Trough, representing its axial, most subsiding part (see Remin et al. 2022 for overview). Accordingly, the Upper Cretaceous strata, deposited within the axial part of the basin (e.g., Roztocze Hills), constituted the deepest facies. Recent data, however, suggest that this area (south-east Poland) was already a landmass (Łysogóry-Dobrogea Land) by the Coniacian and Santonian – and certainly in the Campanian and Maastrichtian – rather than forming the deepest part of the Polish Basin. The Campanian, shallow marginal marine, cyclic, marly to sandy deposits of the Roztocze Hills area are interpreted to be of deltaic origin (Szozdy Delta system; Remin et al. 2022). The proposed facies and bathymetric models imply the presence of a landmass in the place where, in prior frameworks, the deepest and most subsiding part of the Polish Basin (i.e., the Mid-Polish Trough) was located. The Middle Campanian deposits crop out extensively in the Roztocze Hills region, close to the village of Szozdy, and exhibit coarsening-upward tripartite cyclothems. Three facies associations have been distinguished: 1) dark grey calcareous mudstones, 2) a yellow calcareous sandstone, and 3) calcareous gaize lithofacies. The sequence, as a whole, accumulated via the repeated progradation and abandonment of deltaic complexes on a delta front platform setting, with the primary transport direction originating from the axis of the inverting Mid-Polish Trough (thus from the subsurface San Anticlinorium) towards the north-east. This interpretation is supported by a suite of sedimentological, palynofacies and heavy mineral data. The development of the Szozdy delta system (Remin et al. 2022) is framed in the context of the dynamic tectonic processes operating contemporaneously in south-east Poland: that is, tectonic inversion (uplift) on the one hand and the generation of new accommodation space via enhanced subsidence on the other. This discovery sheds new light on our understanding of Late Cretaceous facies distribution, bathymetry, palaeogeography and potentially might suggest a different burial history than assumed so far.

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CONSTRAINING THE ONSET OF SUBDUCTION THROUGH SEDIMENT PROVENANCE CHANGES: THE CEAHLĂU-SEVERIN OCEAN OF THE EASTERN CARPATHIANS

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The Ceahlău-Severin Suture (CSS) is part of the Alpine Eastern Carpathians orogen bounded to the west by the thick-skinned Getic-Bucovinian nappe system (Dacia mega-unit) and to the east by the thin-skinned nappes of the Moldavides tectonic unit system. The Ceahlău-Severin Ocean opened due to Middle Jurassic – Early Cretaceous extension which separated the Dacia Block from the European realm, a collage of the Moesian (including the Danubian unit), the East European Platform, and the North Dobrogea Orogen. The extension led to the development of a deep and narrow marine basin floored by a hyperextended continental and oceanic crust. On the margins of the extensional basin, deep-water sediments (i.e., the Sinaia Formation) accumulated during Tithonian – Hauterivian times. Previous studies (Lăzărescu and Dinu 1983), suggested that the turbidites of the western margin (the upper plate with respect to the later subduction system) were subsequently incorporated into the CSS during the Late Cretaceous. Barremian – Lower Aptian deep-water sediments are documented but it is not clear in which tectonic settings their deposition took place. Quantitative provenance studies could provide a clue regarding the syn-compressional regime of sedimentation, thus constraining the onset of subduction. U-Pb detrital zircon (DZ) data of two pilot samples taken from the northern and southern areas of the Sinaia Formation indicate a dominant westerly source (i.e., the Dacia mega-unit), yielding ages between 430 and 600 Ma. Age peaks of ~310 Ma and ~600 Ma suggest their probable provenance from the Danubian Unit, especially in the southern sector of CSS. The provenance of the Sinaia Formation sediments, therefore, provides potential evidence for deposition prior to the convergence involving sources situated on both margins of the extensional basin (Danubian to the south and east and Dacia to the west). Albian deposits from the units of the Outer Moldavides nappes have an easterly source, (post-Variscan magmatic, Neoproterozoic, and Archaic DZ), except for the innermost Moldavides nappe (Teleajen), where DZ reveal a predominately westerly Dacia origin (Ordovician peak at 460 Ma). This finding suggests that at least during the Albian, subduction had already been initiated. A similar provenance (i.e., Dacia block) of Barremian-early Aptian deep-water clasts based on the next U-Pb data (DZ) could indicate a pre-Albian onset of convergence.

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THE LATE CENOMANIAN PLENUS EVENT IN THE WESTERN INTERIOR SEAWAY, USA/CANADA

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The Plenus Cold Event (PCE) is one of the most enigmatic paleoclimate episodes in Earth's history and has potential to inform our understanding of global climate system variability under greenhouse warming conditions, as well as internal feedbacks that modulate such variability (Jenkyns et al. 2017; O'Connor et al. 2020). Following an interpreted massive addition of volcanic CO_2 to the atmosphere and warming that was associated with development of one of the most profound ocean anoxic events of the Cretaceous (OAE 2), there was a brief interval of cooling that has been recorded in oxygen isotope and biogeographical data in Europe and other areas (Jefferies 1963; Gale and Christensen 1996). Here we present evidence that the cooling was not consistently developed across all geographical regions – specifically, faunal and geochemical evidence indicate that the Western Interior Seaway of North America maintained pervasively warm and tropical conditions during the PCE, reflecting a unique paleoceanographical and climatic response to the event. In the present study, we compile geochemical and fossil data reflecting the absence of cooling and employ GCM model simulations to illustrate how ocean gateways and climatic thresholds (i.e., onset of sea ice formation at the northern aperture of the seaway) can modify regional climates and ocean circulation patterns in predictable ways. We argue that improving our understanding of the biogeochemical feedbacks that modulate climate, as well as the underlying causes of geographical variability, are critical to past and future climate system prediction.

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BARREMIAN TO TURONIAN CARBON AND OXYGEN ISOTOPE DATA FROM THE SINAI PLATFORM, EGYPT

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Stable oxygen and carbon isotope data for Barremian–Turonian successions in north Sinai provide evidence of the existence of Oceanic Anoxic Events during this time interval. In this area, the $\delta^{13}C$ curve can be subdivided into 36 characteristic carbon isotope segments. The $\delta^{13}C$ record for the Sinai Platform during the Barremian to Turonian is here compared to the carbon isotope record from the Middle East and Europe. This correlation places the Barremian–Aptian boundary at the negative shift in $\delta^{13}C$. The Oceanic Anoxic Event 1a (OAE 1a) is recognized below the Lower/Upper Aptian boundary, as has been documented for different Tethyan sections. The Upper Aptian–Lower Albian interval is characterized by the presence of a negative carbon peak preceding the positive carbon excursion at Oceanic Anoxic Event 1b (OAE 1b). During the early Late Albian, the positive carbon excursion at the topmost of C15 to C17 carbon isotope segments shows similarities to those carbon segments in Italy and corresponds to the Oceanic Anoxic Event 1c (OAE 1c). Moreover, the Cenomanian–Turonian boundary is placed at the onset of $\delta^{13}C$ values dropping from 2.61‰ to – 0.25‰ in the upper part of OAE 2.

MICROFACIES AND SEQUENCE STRATIGRAPHY OF THE JURASSIC–CRETACEOUS TRANSITION IN CENTRAL CHILE

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The Lo Valdés Formation is a marine unit demonstrating a mixed carbonate-siliciclastic ramp in a back-arc basin context (Salazar and Stinnesbeck 2015). This unit represents a transgressive system of the western margin of Gondwana during the late Tithonian – late Hauterivian (Charrier et al. 2007; Salazar and Stinnesbeck 2015). This work reevaluates the genesis, evolution and dynamics of the basin through microfacies analysis that consisted of the description of 240 thin sections from four sections of the Lo Valdés Formation, which from north to south are: Cajón del Morado (75), Laguna Ruhillas (48), Norte Río Volcán (56) and Lo Valdés type locality (61).

The results indicated that 10 microfacies are represented by: (1) rounded coarse sandy wackestone; (2) subrounded coarse sandstone; (3) medium sub-rounded sandstone; (4) grainstone with abundant cortoides and ooides, (5) muddy fine packstone – fine sandstone; (6) calcareous mudstone – bioclastic wackestone; (7) float-wackestone with fragments of trigoniids; (8) bioclastic pack-grainstone – bioclastic rudstone; (9) fine bioclastic packstone; and (10) wackestone – calcimudstone without fossils.

Additionally, the interpretations indicate that during the late Tithonian there was a relative increase in sea level, establishing an internal ramp environment and possible closer median ramp in the Cajón del Morado section. In the Berriasian, a progressive deepening is suggested such as a middle ramp that extends to the end of the Berriasian. Then, at the base of the Valanginian, a shallowing would have been registered possibly by an internal ramp characterized by the decrease of pelagic material and an increase in the size of selection and rounding of the facies. Upsection, in the Hauterivian, the pelagic material increases progressively again, with a significant decrease in the content of bioclasts, representing a deepening and establishing an external ramp sub-environment and therefore an increase in the relative level of the sea in the late Hauterivian.

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FIRST RECORD OF RUDIST-DERIVED LITHIUM ISOTOPE DATA ACROSS OCEANIC ANOXIC EVENT 1A

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The lithium isotopic composition (δ^7Li) of marine carbonates is considered to serve as a proxy for weathering intensity given by the ratio of congruent to incongruent weathering. Congruent weathering describes the complete dissolution of silicates driving the δ^7Li of river waters towards the values of the upper continental crust (~1‰). Incongruent weathering on the other hand results in the neoformation of secondary clays which preferentially incorporate the light ^6Li isotope leaving the fluid enriched in ^7Li. The weathering intensity is hypothesised to increase with temperature due to the acceleration of the hydrological cycle and is understood to act as feedback mechanism of the global carbon cycle in order to reduce atmospheric CO_2. Reconstructing weathering intensities during short-term carbon cycle perturbations such as the Oceanic Anoxic Events (OAEs) is therefore of great interest. We have analysed well-preserved rudist shells in order to reconstruct relative changes in δ^7Li from the mid-Barremian to the Early Aptian covering OAE 1a. Our samples comprise mainly requieniid rudists from the sample locations Sausset (Urgonian Limestone Formation, France), Ericeira (Crismina Formation, Portugal), Kanfanar (Kanfanar unit, Croatia) and Miravete (Villarroya de los Pinares Formation, Spain) which have been previously analysed for their stable and strontium isotope composition (Huck and Heimhofer 2021). The aim of our study is first to assess the presence of vital effects among rudists as they typically occur in modern molluscs, and secondly, to reconstruct relative changes in δ^7Li across OAE 1a. The δ^7Li composition of rudists shows a systematic offset (3–8‰) towards heavier values compared to the published bulk-carbonate data (Lechler et al. 2015), thus fitting well into the range of vital effects known for modern calcitic bivalves. The rudist-derived δ^7Li curve shows an increase from 25‰ to 35‰ from the mid – to Late Barremian and remains relatively stable during the Late Barremian. In the Early Aptian, rudist-δ^7Li data of ~25‰ display a distinct minimum before the C3-minimum of the OAE 1a carbon isotope excursion and a subsequent recovery to 30–35‰ throughout OAE 1a. Interestingly, the increase in δ^7Li values throughout the mid-Barremian correlates inversely with sea surface temperatures reconstructed from $\delta^{18}O$ of the same rudist shells (Huck and Heimhofer 2021) suggesting an increase in incongruent weathering. The early Aptian δ^7Li minimum, however, is positively correlated with temperature suggesting a link to pronounced basalt weathering in the advent of OAE1a.

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BIOSTRATIGRAPHY AND MAGNETOSTRATIGRAPHY OF THE BERRIAS SECTION, FRANCE

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Detailed magnetostratigraphic and micropalaeontologic investigations of the Jurassic/Cretaceous (J/K) boundary are focused on precise determination of the boundaries of magnetozones and narrow reversed subzones, and on the search for global correlation across the J/K boundary and links to the recently defined GSSP (Global Stratotype Section and Point) section. The main goal of the current study on the Berrias section in Ardèche (France) is a revision of the apparently anomalous magnetosubzone M16n.1r, which was interpreted by Galbrun and Rasplus (1984) and Galbrun (1985). The Berrias section spans the *Alpina* to *Oblonga* calpionellid zones, and the main lithology is a well-bedded, blue-grey pelagic micritic limestone. Regarding the intensity of sediment mixing by organisms, the most common grade of bioturbation is BI = 1, showing that 1% to 4% of the matter was transferred to the current position by bioturbation. This value corresponds to 65% of samples in the present study. Approximately 30% of the samples lack any bioturbation structure (BI = 0); the remaining 5% are samples with a bioturbated mass greater than 4% and less than 30% (BI = 2). Due to simultaneous global changes of magnetic field polarity changes, high-resolution magnetostratigraphy is one of the most efficient tools for J/K boundary correlation. However, the interpreted polarity zones have to be calibrated with macro – and microfauna. Ammonite biostratigraphy at Berrias defines seven subzones, from *Jacobi* to *Callisto*. The lower part of the Berrias section is also well defined by calcareous nannofossils, with a precise record from the *Alpina* to *Elliptica* subzones. The detailed magnetostratigraphy shows seven normally and seven reversely polarised magnetozones, interpreted to span magnetozones M19n to M14r. The rare subzone M16n.1r ('Berrias') was documented in one of the three parallel sections studied. The main palaeomagnetic directions are D = 10°, I = 44° for the normal polarity and D = 161°, I = – 43° for the reversed polarity.

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THE TITHONIAN–BERRIASIAN BOUNDARY INTERVAL IN THE ROPICE SECTION (CZECH REPUBLIC) FROM THE PERSPECTIVE OF PALAEOMAGNETISM AND BIOSTRATIGRAPHY

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The Tithonian–Berriasian boundary interval in the Ropice section is situated near Český Těšín (Czech Republic). The strata belong to the Silesian Nappe Unit of the Outer Flysch Carpathians. The boundary interval comprises turbiditic limestones (grainstones, packstones and wackestones) interbedded with marlstones (mudstones). Results of magnetic studies of limestones show only normal polarity magnetisation components, indicating an extensive remagnetization of the whole section. The presence of the weathering product goethite was documented alongside with magnetite. Average magnetic susceptibility and natural remanent magnetisation show low values, 48 E-6 SI and 0.17 mA/m, respectively. The study of biota reveals that limestones contain calpionellids, calcareous foraminifera and calcareous dinoflagellate cysts. The mudstones yield calcareous nannofossils, siliceous agglutinated foraminifera and organic-walled dinocysts. Nannofossils are mostly etched by dissolution. Characteristic is the abundance of *Watznaueria* (65–92%) and *Cyclagelosphaera* (6–37%), forming the main components of the assemblage. Stratigraphically important nannoconids, such as *Polycostella backmanii*, *Helenea chiastia* and *Cruciplacolithus cuvillieri* were found rarely. The FO of *Nannoconus wintereri* in sample 7/2 confirms the NC0a Subzone, the base of the Berriasian (Casellato and Erba 2021). Small calcareous foraminifera (*Spirillina*, *Trocholina* and *Lenticulina*) and agglutinated foraminifera (*Pseudoreophax cisovnicensis*, *Pseudonodosinella troyeri*, *Ammogloborotalia quinqueloba* and *Caudammina silesica*) are of rather low biostratigraphical value.

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FOUNDATION FOR THE NEXT GENERATION OF PALAEOCEANOGRAPHICAL AND BIOGEOCHEMICAL STUDIES: DEVELOPING A NEW LOWER CRETACEOUS TIME SCALE

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During unusually warm greenhouse conditions of the Aptian to Cenomanian, several major perturbations in the global carbon cycle are reflected by organic-rich sedimentary deposits and/or carbon isotope excursions (OAEs; Schlanger and Jenkyns 1976; Jenkyns 2010). To understand the ocean-climate dynamics of this greenhouse world and the mechanistic drivers that propel ocean anoxia and deterioration of ecosystems fully, new radioisotopic dating, in parallel with a more geographically dispersed array of high-quality Cretaceous sedimentary records are essential. The Yezo Group (YG) in Hokkaido (Japan) comprises Barremian to Paleocene sediments deposited in a high-latitude Pacific Ocean-facing fore-arc basin (Takashima et al. 2004; 2019). Unlike other well-studied Lower Cretaceous sequences, e.g., the Vocontian Basin in France (VB), the YG contains rhyolitic tuffs amenable to precise U-Pb and 40Ar/39Ar dating. Our international collaboration aims to: (1) determine U-Pb and 40Ar/39Ar ages of rhyolitic tuffs in the Aptian–Cenomanian strata of Japan, (2) integrate these new age determinations with new and existing Os – and C-isotope chemostratigraphy to quantify the timing and rates of oceanic processes associated with major carbon-cycle perturbations, (3) compile global geochemical proxy data for OAE 1a within a common temporal and sequence-stratigraphical framework, and analyze trends and patterns in these data in sections from the Pacific to Europe to evaluate the roles of sea level and ocean circulation, (4) evaluate the competing volcanic and climatic/orbital hypotheses for initiation of the major carbon-cycle perturbations (OAEs) of the Aptian and Albian, and (5) map and explore the significance of geography in the timing and magnitude of geochemical signals. New 206Pb/238U zircon dates from 13 tuff samples in two parallel sections through the lowermost YG yield ages between 121.28±0.13 and 117.83±0.04 Ma. Using existing C isotope chemostratigraphy and new Os isotope data, these age determinations indicate that the onset of OAE 1a occurred at 119.63 Ma and support an age for the Barremian–Aptian stage boundary of ~121 Ma. Correlation of existing C isotope shifts to the Cismon APTICORE record suggests termination of OAE 1a by 118.84 Ma; however, defining the termination of OAE 1a awaits acquisition of additional Os and C isotope data from the YG. Our 206Pb/238U zircon ages suggest that OAE 1a is slightly younger than in GTS 2020, and that its duration may be 300 kyr shorter than estimated from orbital tuning of the APTICORE record. The emerging chronology and chemostratigraphy of the YG will be exported and correlated to new records from drilled core in the Tethyan VB for which we are also generating new Os – and C-isotope chemostratigraphy and an astrochronological age model focused on the critical onset interval of OAE 1a. Improving the Lower Cretaceous time scale by integrating French and Japanese strata will rectify critical time scale inaccuracies and employ refined time scales and new proxy data to address fundamental questions concerning lithosphere-hydrosphere-biosphere interactions associated with major OAEs.

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HOW DOES THE BONE MICROSTRUCTURE OF *TARBOSAURUS BATAAR* COMPARE TO THAT OF *TYRANNOSAURUS REX* (THEROPODA, TYRANNOSAURIDAE)?

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Tarbosaurus bataar from the Nemegt Formation (Maastrichtian) in Mongolia was an apex predator (Hurum and Sabath 2003) and the second largest representative of the Tyrannosauridae, surpassed only by its North American close relative, *Tyrannosaurus rex.* The growth rates of the latter, estimated on the basis of long bone microstructure, are well documented, showing acceleration during ontogeny (Cullen et al. 2020). In order to check for any differences between the growth ratios of *Ty. rex* and *Ta. bataar*, we thin-sectioned tibiae of six specimens from the collections of the Institute of Paleobiology (ZPAL) of the latter species. The body size of the smallest individual sampled is estimated to have been c. 70% of that of the largest individual sampled, ZPAL MgD-I/188. The cross-sectioned tibiae of all individuals revealed parallel-fibred tissue with mainly laminar vascularization. The arrangement of the mineralized fibers in parallel-fibred tissue is loose in smaller individuals and more organized in larger specimens, especially in the outer cortex. Lines of arrested growth are separated by consistent intervals in all specimens of *Ta. bataar*. Secondary reconstructions are present in all bones sampled, more frequent in the inner cortex and scattered in the middle cortex. The inner cortex of ZPAL MgD-I/188 is strongly remodeled, showing up to three generations of secondary osteons. The general microstructure of the tibia of *Ta. bataar* is similar in overall configuration to that in *Ty. rex* (Horner and Padian 2004; Woodward et al. 2020). However, *Ta. bataar* shows a higher degree of secondary reconstructions than *Ty. rex* of similar size. Moreover, the intervals between the lines of arrested growth are narrower than in *Tyrannosaurus*, indicating a slower growth of *Tarbosaurus.*

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STRATIGRAPHICAL DISTRIBUTION AND IMPORTANCE OF SOME IMPERFORATE BENTHIC FORAMINIFERA FROM THE UPPER CAMPANIAN–MAASTRICHTIAN OF THE TAURIDE CARBONATE PLATFORM, TURKEY

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Many parts of the Tauride Carbonate Platform were exposed to subaerial exposure from the Turonian to Santonian (Farinacci and Köylüoğlu 1982; Solak et al. 2017, 2019). However, the record of Upper Campanian–Maastrichtian in shallow-marine facies is relatively continuous, with the exception of short-term platform emergences (Solak et al. 2017, 2019). The present study focuses on the stratigraphical distribution and importance of some selected benthic foraminifera from the Upper Campanian–Maastrichtian of the Tauride Carbonate Platform. Mainly *Accordiella conica, Moncharmontia apenninica, Fleuryana adriatica, Murciella cuvillieri, Pseudocyclammina sphaeroidea, Rhapydionina liburnica* and *Pachycolumella acuta (= Valvulina aff. V. triangularis)* from different parts of the Tauride Carbonate Platform were studied. On a local and/or regional scale, some of these benthic foraminifera can be regarded as chronostratigraphically significant. *Murciella* *cuvillieri*, whose first occurrence is in the Upper Campanian, and *Rhapydionina liburnica*, which has a narrow stratigraphical range (Upper Maastrichtian), are two examples. Their occurrences and abundance vary throughout the Upper Campanian–Maastrichtian. The presence of *Accordiella conica*, which is represented by a small number of specimens, and *Moncharmontia apenninica*, of which numerous characteristic specimens have been found, characterizes Upper Campanian strata. The Upper Maastrichtian is marked by the occurrence of *Rhapydionina liburnica*, which co-exists with *Pachycolumella acuta,* known from the Upper Maastrichtian–Paleocene interval. Although *Pachycolumella acuta* does not have a narrow stratigraphical range, it is of chronostratigraphical importance since its first occurrence is in the Upper Maastrichtian. *Murciella cuvillieri, Fleuryana adriatica* and *Pseudocyclammina sphaeroidea* occur throughout Upper Campanian–Maastrichtian strata. *Fleuryana adriatica* is represented by larger, typical specimens in the Upper Maastrichtian but by smaller, atypical ones in the older strata. The stratigraphical importance of these species for Campanian–Maastrichtian intervals in the Tauride Carbonate Platform is discussed.

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NEW INSIGHT INTO THE DEPOSITIONAL ARCHITECTURE OF THE UPPER CRETACEOUS IN NORTHERN AND CENTRAL POLAND– SEISMIC EVIDENCE FOR SYNTECTONIC SEDIMENTATION AND BOTTOM CURRENTS

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Unique regional high-resolution 2D seismic reflection data of the PolandSPAN™ survey, obtained in 2012 by ION Geophysical have very precisely depicted the Phanerozoic sedimentary cover of the East European Craton within the Polish borders. One of the significant results of this study is a completely new interpretation of the Upper Cretaceous depositional architecture of the area situated in the northern and central part of the Polish Basin that belonged to a system of the Permo-Mesozoic epicontinental basins of central and western Europe. During the Late Cretaceous–Paleogene, it was completely inverted; as a result, its most strongly subsiding axial part, the Mid-Polish Trough, was transformed into a regional positive structure, the Mid-Polish Swell (MPS). At the same time, synclinoria filled by the syn-inversion Upper Cretaceous succession formed on both sides of the MPS. The study area is located to the north-east of the MPS. Previously, due to significant distances between deep boreholes and sparse seismic data coverage in part of the Polish Basin studied, regional mapping of the Upper Cretaceous succession was based on the stratigraphically continuous ‘layer cake' geological model. PolandSPAN™ data revealed, however, that within the Upper Cretaceous succession there are numerous unconformities, together with thickness changes, incisions and clinoforms. In central Poland, the most striking feature is a hitherto unknown low-angle regional clinoform that pinches out from the north towards the south above the regional unconformity (compare Stachowska and Krzywiec 2021). Such a depositional architecture is fundamentally different from the previously assumed Upper Cretaceous geological model for this part of the basin. The Upper Cretaceous sedimentary cover depicted by regional seismic data comprises depositional sequences associated with: 1) sedimentation in a calm, pelagic environment, 2) significant supply of sediments generally from the north and from the uplifted and eroded MPS, and also (3) bottom current activity that flowed along the uplifted edge of the MPS and

redistributed sediments and locally significantly reshaped sea floor morphology. Interpretation of seismic data also provided ample evidence of the influence of tectonics on sedimentation in northern and central Poland during the Late Cretaceous; the development of low-angle clinoforms overlying the unconformity, could be associated with regional uplift of the area situated in the north, within the Baltic Sea and Scandinavia during the regional Late Cretaceous inversion. The regional Late Cretaceous buckling of the cratonic edge might also have played a significant role in forming the Upper Cretaceous depositional pattern.

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COMPOSITION AND DISTRIBUTION OF SEDIMENTARY ORGANIC MATTER IN THE DISTAL WEALDEN FACIES (KB REHBURG-2) OF THE LOWER SAXONY BASIN, GERMANY

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During the Early Cretaceous (Berriasian; 'German Wealden'), the Lower Saxony Basin (LSB) in northern Germany was characterized by non-marine deposits in a restricted intercontinental setting (Schneider et al. 2017). New insights into these Lower Cretaceous sedimentary rocks can be gained from a recently drilled core (KB Rehburg-2, Lower Saxony, Germany) covering 180 m of Berriasian strata. Stratigraphic assignment is based on ostracods and indicates Wealden 1-4 for the drilled succession. Palynofacies analysis was carried out to reconstruct the depositional environment of the sequence studied. These data were complemented by geochemical measurements (TOC, Stot, $\delta^{13}C_{ORG}$ and RockEval pyrolysis) and sedimentological observations in order to reconstruct the paleoenvironmental conditions during the earliest Cretaceous in the LSB. The particulate organic matter (OM) shows good to very good preservation and is composed of diverse spores, pollen grains, algae and woody debris; marine particles, i.e., dinoflagellate cysts, acritarchs and prasinophytes occur only sporadically. Amorphous OM is common in some intervals of the sequence, presumably representing the decomposed remains of algae. Data evaluation and integration reveals a predominantly lacustrine, freshwater to brackish depositional system with high continental OM input. Phases of subaerial exposure are documented by the repeated occurrence of paleosols and coals rich in plant remains. Two distinct sandstone units are recorded in the Wealden 3 succession and reflect fluvial to deltaic depositional conditions. The relatively high abundance of sporomorphs in relation to phytoplankton can be interpreted to reflect proximity to the terrestrial source (Tyson 1993). Abundance peaks of *Botryococcus* algae (up to 80%) occur throughout the sequence and indicate freshwater to brackish conditions. The rare occurrence of dinoflagellate cysts and acritarchs can be interpreted as indicators of short-term marine ingressions into the LSB. Prasinophytes point to repeated salinity changes. The paucity of dinoflagellate cysts differs significantly from existing studies in the LSB by Schneider et al. (2017), but a correlation with two marine transgressive events is tentatively proposed (TE 1-2). This difference may result from a potentially more terrestrially dominated depositional system represented by the Rehburg-2 core.

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GENERAL CHARACTERISTICS OF CENOMANIAN–TURONIAN OSTRACOD FAUNAS FROM UKRAINE

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During the mid-Cretaceous, the northern margin of the Tethys Ocean, with a coastline stretching from the present-day British Isles to Tajikistan (Eurasia) (Andreev 1986; Slipper 1997; Didenko 2005). The territory of Ukraine occupied a central position along this coastline and Cretaceous strata surround the Ukrainian Shield in nearly identical lithological compositions. Cenomanian deposits were studied in the southern part of the Volyn–Podillya Plate, in the south of the Ukrainian Shield, as well as in northern Donbass. These strata represent different facies: shallow-marine and offshore. In both, ostracods are numerous and of similar overall composition. However, there are differences in species composition, populations condition and species diversity. In western and southern Ukraine, ostracod faunas are in part similar to coeval western European assemblages (Philip 1978; Slipper 1997). In northern Donbass, ostracods are much rarer and a significant portion of Early Cenomanian ostracod relates to endemics. At the Cenomanian–Turonian boundary, no extinction or reorganisation of ostracod faunas is observed. The dominant genera range from the Upper Cenomanian to the Lower Turonian. However, depleted ostracod assemblages are occasionally found in different places. Turonian ostracod faunas are nearly of identical composition, with slight differences in the east. The number and diversity of ostracods in Volyn–Podillya increases and reaches a maximum in the Upper Turonian. At some localities in the southern region, ostracod assemblages are stable with a high diversity of species starting from the Upper Cenomanian. Turonian ostracods are less diverse, occurring in small numbers and marked by a low specific diversity in the Dnieper–Donets rift and northern Donbass. There are also some species that are not found in the west. The different ostracod composition can be explained by a strong influence of Boreal waters in this area. The intersection of the Tethyan and Boreal waters is located in present-day Donbass, which is not accessible for study due to ongoing occupation. A study of this region in Ukraine would make it possible to determine the impact of mixing Boreal and Tethyan waters on the palaeoecology of ostracods, and establish a correlation along the south of Ukraine with access to the Central Asian basin. An important aspect in studies of Cretaceous ostracods in Ukraine is the correlation between epicontinental platform rocks and deep-water deposits of the Crimea. Thus, diversity studies of Ukrainian Cretaceous ostracod assemblages are an important contribution to our understanding of the palaeogeography of the entire northern shelf of the Cretaceous Tethys.

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KILIAN GROUP MEETING

CRITICAL REVISION OF APTIAN–ALBIAN ZONES IN THE STANDARD MEDITERRANEAN AMMONITE ZONAL SCHEME: NEW PROPOSALS AND CORRELATION POSSIBILITIES

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This work is dedicated to the memory of Hugh Gwyn Owen, who passed on 1.03.2022.

During the IGCP Project 262 meeting at Digne, the Lower Cretaceous Cephalopod Team (LCCT) was formed and proposed a preliminary zonation in their first report for the Mediterranean Lower Cretaceous (Hoedemaeker and Bulot 1990). For the Aptian, the LCCT adopted the zonation developed in Georgia which "has been proved to be workable". Related to the Albian, Boreal zonal schemes of Spath and Owen were adopted, however, it was mentioned "only those of *Lyelliceras lyelli* and *Hoplites spathi* [subzones] are usable in the Mediterranean region" (Hoedemaeker and Bulot 1990). This point projected on further challenges towards the applicability of this zonal scheme: many of the indices were taxonomically not revised, their nominal zones had never been established correctly, no type locality had been selected, and in several cases the zone itself was not specified. In 2002, as the successor of the LCCT, the Lower Cretaceous Ammonite Working Group, the 'Kilian Group' (KG) was organized with 18 members (Hoedemaeker et al. 2003). The aims of the KG are clearly established in their meeting reports, including construction and development of the Standard Mediterranean Ammonite Zonation (SMAZ), besides suggesting correlation possibilities towards key areas and making recommendations on stage or substage boundaries (Hoedemaeker et al. 2003). Unfortunately, there was no progress with respect to the zonation of the Aptian and Albian stages, which is willing to be corrected here.

The Mediterranean ammonite zonation for both stages is difficult, for these specific reasons: 1) *paleobiogeographic reasons* behind the periodic endemism of ammonite faunas which resulted in fundamental differences between realms, 2) *debates on taxonomic problems* play a role in ammonite zonal inadequacy, 3) marine deposits of the Western Tethys are characterized by the presence of *hiatuses, condensation, reworked levels, lack of ammonites*, besides several *biotic crise*s that are observed with the occurrence of oxygen-depleted intervals. The definition of the base of the Aptian Stage currently hinges on the base of Chron M0r or the negative value of OAE1a is hardly consistent with ammonite distribution. A discussion on its characterisation by ammonites is here developed. The retention of a twofold Aptian is supported, where the top of the Lower Aptian at the *Dufrenoyia furcata* Zone is marked by a significant faunal turnover recognised almost worldwide. Suggestions on the replacements of the latest Aptian *nolani* and *jacobi* zones are also provided. The definition of the base of the Albian Stage (despite ratification its GSSP) has been highly problematic for decades as the inapplicability of current Boreal zonal schemes towards the Mediterranean settings is clear. A discussion on the *tardefurcata* and mam*millatum* zones is added, and a suggestion for their replacement is made. The adoption of a zonation for the Mediterranean Middle Albian based on hoplitid ammonites is almost impossible and must be abandoned; a new zonation is proposed here. For the Upper Albian, the zonation established on species of *Mortoniceras* is discussed.

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TOWARDS AN AMMONITE ZONATION FOR THE JURASSIC/CRETACEOUS TRANSITION: NEW DATA FROM THE AMMONITICO ROSSO/BIANCONE SECTIONS IN THE TRANSDANUBIAN RANGE (HUNGARY)

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The present work is dedicated to the memory of G. Császár, who passed on 15.12.2021.

This presentation focuses on the heavily debated Late Tithonian–Early Berriasian ammonite taxonomy and stratigraphy of the Mediterranean. As such, it also has implications for the still undefined Jurassic/Cretaceous (J/K) boundary. Reliable recent data on ammonites have also been taken into consideration, thus putting the Hungarian data in a broader context. The sections presented here are located in the Transdanubian Range (TR). During the J/K time interval, this area was part of the western Tethyan oceanic belt and represented a particular unit within the Alpine-Carpathian-Dinaric orogen, because its tectono-sedimentary evolution was related to both Dinaric and Austroalpine domains. The present study is based on a large, typically Mediterranean ammonite fauna that was collected several decades ago, bed-by-bed, from four ammonitico rosso/biancone sections of the TR, namely Hárskút HK-II, HK-12/a, Szilas Ravine and Lókút (LH-I, LH-II and LH-II/I). For the HK-12/a and Lókút LH-II sections magnetostratigraphical and micropalaeontological constraints have already been established (Lodowski et al. 2022). Besides, new collecting campaigns have provided additional ammonite material from the HK-12/a and HK-II sections in order to determine the position of ammonite zones. Sections are partly condensed, but because they are not resedimented, the original stratigraphical order of their succession could be accurately ascertained. Taxon ranges of ammonites were established and these were compared with magneto-, chemo – or micropalaeontological frameworks. Stratigraphically important ammonite taxa are summarized from a critical perspective (Szives and Főzy 2022), but are not presented here. As a result, an updated ammonite zonal scheme for the Upper Tithonian–Lower Berriasian interval in the Mediterranean region is proposed. To achieve a constrained order of zones, the focus here has been solely on those ammonite groups for which a clear taxonomic concept is already available and to those sections where ammonites were recently collected bed-by-bed and calibrated with micropalaeontological and magnetostratigraphical frameworks. After the compilation of data, the positions of the *Volanense* and *Andreaei* zones could be calibrated against magnetostratigraphy. The integrated results presented here are slightly different from previous data as the base of the *Volanense* Zone is in M20r, the base of the *Microcanthum* Zone falling within the M20n2n magnetozone, in the *Chitinoidella* Zone (*Boneti* subzone), while the base of the *Andreaei* Zone falls in the upper M20n1n, its top being in M19n2n.

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CHANGES IN FORAMINIFERAL ASSEMBLAGES DURING THE CRETACEOUS/PALEOGENE BOUNDARY CRISIS: A CASE STUDY FROM THE POLISH OUTER CARPATHIANS

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Foraminifera have been reviewed in order to document environmental and thermal crises at the Cretaceous/Paleogene boundary in the northern Tethys. Changes in their taxonomy and ecological preferences have been mainly observed and their distribution under unstable conditions has also been discussed. These foraminiferal data come from flysch-type deposits of the Polish Outer Carpathians. These Alpine mountains located on the southern margins of the European Platform include mainly siliceous and sometimes calcareous clastic rocks (sandstones, conglomerates, shales) accompanied by calcareous sediments (marls and occasionally limestones) which occur there periodically. In this marginal area the crisis induced by changes in ocean waters and atmosphere was strongly controlled by geotectonic and geodynamic activities. The mainly siliceous deposits were accumulated in tectonically active basins, which were particularly sensitive to changes in sea level and paleogeographical settings, which periodically led to their geomorphological reorganization. The deposits studied belong to external tectonic zones (Subsilesian, Silesian and Skole units) which are located in the northernmost part of the Outer Carpathians. They are siliceous and calcareous turbidites of Campanian to Paleocene (Istebna and Inoceramian formations), as well as Senonian variegated marls of the Frydek-, Weglówka – and Węgierka-type, and the Makówka gravel breccias occurring close to the boundary with the Paleocene. The formation of marls at the boundary of the shelf and slope zone was documented by calcareous and agglutinated benthos belonging to deep and mobile infauna, and sometimes semi-infauna or epifauna, which are derived from slope environments. Part of them are known from shales intercalated with sandstones, which were accumulated by turbidite currents on the slope. Under these conditions, planktic massive forms (globotruncanids), which underwent considerable diversification and became clearly specialised, finally died out. These forms indicate an early and late

Maastrichtian age (*G. havanensis, A. mayaroensis*). In turbidites calcareous foraminifera were usually replaced by agglutinated taxa, which became the dominant elements of the assemblages in the Paleocene (*G. grzybowski*, *Rz. fissistomata*). At that time foraminiferal plankton reactivated. *Globigerina*-like dwarf forms as well as its benthic ancestors (*Guembelitria*) became dominant in acidified surface waters. The plankton occurs in variegated marl complexes (Subsilesian Unit) and episodically in debris and slumped sediments of turbidites (Silesian Unit). In general, the microfauna reacted in different ways to facies changes and environment. On account of life position and wall structure, different preservational styles within the sediment can be differentiated. Their distribution in the flysch-type basins was strictly controlled by regional and local factors. Foraminifera from marl complexes are more representative for the K/Pg crisis than taxa from the shales of the turbidites, in which the biotic record is often poorly readable and obscured by multiple erosion and re-deposition.

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RESPONSES OF FORAMINIFERA TO ENVIRONMENTAL CRISES DURING THE CRETACEOUS IN THE NORTHERN TETHYS (POLISH OUTER CARPATHIANS)

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Foraminifera have been reviewed in order to document environmental changes during the Cretaceous in the Carpathian Basin (northern Tethys). The taxonomy and variability in terms of oxygen and food availability, as well as thermochemical conditions are discussed. The wall structure, arrangement and number of chambers are described in order to indicate life position or food preferences. The mechanism of disintegration and dissolution as well as demineralization of their walls were analyzed in order to document sedimentological processes and environmental factors that led to their accumulation. The data were obtained from flysch deposits exposed in the Polish Outer Carpathians. In this Alpine mountain range located along southern margins of the European Platform, environmental changes linked to oxygen deficiency are documented by dark, organic-rich shales occurring in turbidites dominated by coarse-grained material (sandstones and conglomerates). The strata studied belong to the external tectonic zones which are located in the northernmost part of the Outer Carpathians. These deposits (mainly shales) belong to the Silesian and, in part, to the Subsilesian series and crop out in the Beskidy Mountains and its foothills in the west, while the ones of the Skole series are restricted to the foreland of the Bieszczady Mountains in the east. Part of them constitute independent lithostratigraphic units of the Lower Cretaceous (Cieszyn, Verovice and Spas shale formations), while others occur as shale intercalations in turbidites of Albian–Cenomanian (Lgota Formation) and Campanian–Paleocene (Istebna and Inoceramian formations) age. These formed in tectonically active basins which were particularly sensitive to changes in sea level and paleogeographic settings. The record of OAEs, which usually coincide with thermal changes and ocean acidification, has often been distorted and obscured by erosional and re-depositional processes. Under these conditions impoverished associations including opportunistic and specific forms resistant to environmental stress survived. Monospecific assemblages, as well as those limited to several taxa, include forms that lived at depths in the sediment and fed on anaerobic bacteria (*Pseudoreophax*, *Verneuilinoides*, *Reophax*, *Pseudonodosinella*, *Spiroplectammina* and *Bolivinopsis*), superficial (*Ammodiscus*, *Rzehakina*) and erect epifauna (*Rhizammina*, *Rhabdammina*) or semi – and shallow-infaunal forms among deposit and suspension feeders (*Glomospira*, *Glomospirella*, *Haplophragmoides* and *Recurvoides*). In turn, planktic foraminifera (*Hedbergella*, *Heterohelix*) can be linked to upwelling of acidifying waters. This dysaerobic and eutrophic microfauna occurred in deposits enriched in organic carbon, mineral compounds of Fe, S and P (pyrite, siderite and phosphorite) and also specific clay minerals. Their distribution in flysch-type basins was controlled by regional and local factors. Forms from shale complexes closely relate to periods of oxygen depletion in the late Valanginian, early Aptian (OAE 1a), early Albian (OAE 1b) and Cenomanian/Turonian (OAE 2), while taxa from shales of turbidites indicate periodic impact of unfavorable factors in the Albian, Campanian–Maastrichtian and especially close to the boundary with the Paleocene.

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ORBITALLY-TUNED BIOMETRIC CHANGES IN THE CALCAREOUS NANNOFOSSIL LINEAGE, ARKHANGELSKIELLACEAE, REVEAL A DETAILED EVOLUTIONARY SEQUENCE OF EVENTS ACROSS THE SANTONIAN/ CAMPANIAN BOUNDARY INTERVAL

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Calcareous nannofossils are excellent biostratigraphical markers for the Santonian/Campanian boundary (SCB) due to a sequence of evolutionary events within the family Arkhangelskiellaceae. Besides the long-known use of the first occurrence (FO) of *Aspidolithus parcus parcus* in the earliest Campanian, the recent study of Miniati et al. (2020) has established a useful sequence of events in central Italy spanning the late Santonian to early Campanian, all of which occur within the same family. Interestingly, the classic use of the FO of *Aspidolithus parcus parcus* as a marker for the SCB and its apparent global reliability does not appear to suffer from the subtle taxonomic definition that allows its distinction from the precursor subspecies, *A. parcus expansus*, and/or from the younger subspecies, *A. parcus constrictus*. Moreover, the taxonomic definition of these three subspecies has been accepted for decades in the nannofossil community, despite the absence of any detailed biometric study focused on this lineage across the SCB interval at large. Here we present new biometric results focusing on the total length, rim width and central area width to rim width ratio of all species of *Broinsonia*, *Aspidolithus* and *Arkhangelskiella* encountered in 77 samples spanning over 100 m of sediments across the middle Santonian to lower Campanian at DSDP Site 357 (São Paulo Plateau, western South Atlantic). Based on light microscopy measurements of a total of 5,532 specimens, our results illustrate the progressive shift in dominance of small *Broinsonia* to large *Broinsonia* and *Aspidolithus*, the successive origination of the three aforementioned subspecies of *Aspidolithus parcus* and for the first time, a clear biometric distinction between *Arkhangelskiella cymbiformis* var. NT and *Arkhangelskiella specillata*. Moreover, high-resolution bench XRF data acquired along the ~100-m-long sequence forms the basis of a cyclostratigraphical study and of a subsequent orbital calibration of this deep-sea site to the eccentricity. This biometric study allows for a clarified taxonomic definition of all species of Arkhangelskiellaceae across the SCB interval, provides clear-cut criteria to establish a sequence of biostratigraphical events across that interval, comprising both first occurrences, first common occurrences and distinct shifts in size and abundance of the whole lineage, all of which are calibrated to bulk carbonate carbon isotope variations and orbital eccentricity.

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ASTROCHRONOLOGY OF THE BARREMIAN BASED ON MULTI-CORING IN THE NORTH SEA: IMPLICATIONS FOR BLACK SHALE DEPOSITION AND GREEN-RED REDOX-ASSOCIATED NUANCES IN EARLY CHALK

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In the Barremian of the Danish Central Graben (North Sea), regular chalk-marl alternations characterize hemipelagic deposits of the Valdemar field (Bo-2 Boje-2C cores) . A cyclostratigraphical study based on high-resolution color variations (based on either luminance, gray level and/or individual RGB channels) of both cores reveal that these alternations were primarily driven by the 100-kyr short eccentricity, while more subtle color variations of lower amplitude characterize precession cycles. This analysis

allows for an astronomical calibration and correlation of the two cores at the level of 100-kyr cycles. Both cores exhibit the Munk marl, a 2–3 m thick interval of laminated black shales that corresponds to the expression of the 'mid-Barremian event', as well as a number of additional pluricentimetric black shales in the upper Barremian that likely represent the equivalent of the "Blätterton" black shales of northwest Germany Our study allows for examination of the peculiar orbital configuration that led to the deposition of these black shales. To the east of the Valdemar area, sediments of the Adda platform exhibit two types of cyclicities: chalk-marl alternations and prominent switches in color from the red to the green channel. These lithological color variations are expressed as green and red redox-associated nuances in all identified distinct facies from slightly marly chalk to marlstone and these red-green color variations are confined to the Adda-2, Adda-3 and SE Adda-1 cores. The red subfacies tend to show higher magnetic susceptibility values and contain more iron than the green subfacies. Moreover, the red subfacies are commonly associated with nodular fabric, in contrast to the green subfacies which are never associated with such features. Both subfacies are completely bioturbated and appear to exhibit similar ichnofossil assemblages. While both red and green chalk subfacies appear to be condensed, the red one might have been deposited at times of more intense condensation. Cores of the Adda platform are typically characterized by condensation and gaps, thus representing a challenge for a cyclostratigraphical study. Calcareous nannofossils allow for a biostratigraphical correlation of orbitally-tuned cores of the Valdemar area to that of the Adda platform, which in turn allows us to examine the nature of these red-green redox changes, their cyclicity and the potential links between sedimentation rate, redox conditions in the sediment and orbital to sub-orbital insolation variations.

A PRELIMINARY NOTE ON THE LOWER CAMPANIAN INOCERAMIDS OF THE MOOREVILLE CHALK, WESTERN ALABAMA

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During the late Cretaceous, the Gulf Coast region sat at the crossroads of three distinct faunal provinces: the Western Interior, the northwest Tethys (Mexico), and Europe. Given the critical significance of the Gulf Coast region as their nexus, careful biostratigraphic studies would represent a significant contribution to our knowledge of inoceramid evolution and paleobiogeography. However, despite the ubiquity of the Inoceramidae in the late Cretaceous Gulf Coast Plain, they have remained little studied, necessitating their collection and re-description. Here, exploratory results are reported from the lower Campanian Mooreville Chalk of western Alabama.

Two basic inoceramid assemblages have been recognized in the Mooreville Chalk. The first, from the lower Mooreville Chalk, contains *Cataceramus ex. gr. balticus*, *Cataceramus pteroides, Cataceramus ellipsoides, Platyceramus cycloides cycloides* and *Cordiceramus sp.*, an assemblage most probably confined to the *Cataceramus beckumensis* Zone. The upper, sampled near the contact of the Mooreville Chalk and the Arcola Limestone, consists of *Cataceramus ex. gr. balticus, Cataceramus subcompressus, Cataceramus marcki*, *"Inoceramus" algensis, and "Inoceramus" bosenbergensis* – in turn indicative of an affinity with the *"Inoceramus" azerbaydjanesis* Zone. In this framework, the base of the Mooreville Chalk in western Alabama was deposited by the middle Lower Campanian and continued to at least the upper Lower Campanian – a result consistent with ammonites, but potentially suggesting a somewhat diachronous base with respect to carbon isotope and microfossil studies.

It is worth noting the essentially cosmopolitan affinity of the Mooreville Chalk inoceramids. All inoceramid species reported here are known from the Campanian of Westphalia, Germany, and several are known from the poorly known Lower Campanian fauna of the Western Interior Seaway. In general, this striking faunal similarity should be understood as reflecting the position of the Gulf Coastal Plain as the faunal ‘gateway’ between Europe and the Western Interior during the late Cretaceous.

HIATAL AND LITHOSTRATIGRAPHIC IMPLICATIONS FOR CONIACIAN CHEMOSTRATIGRAPHY IN THE PUEBLO SUCCESSION (COLORADO, USA)

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The keystone Western Interior chemostratigraphic record ($\delta 13Corg$) is derived from several drill cores, tied to the Western Interior Basin *via* a combination of lithostratigraphy and index fauna. While this archive captures a variety of major and minor perturbations to the global carbon cycle, there are intervals – particularly in the upper Turonian and lower Coniacian – during which the carbon isotopic profile diverges from the global curve, potentially reflecting localized dynamics. Given the presence of substantial hiatuses in the Western Interior during these intervals (Walaszczyk et al. 2014), further investigation of the interplay between physical stratigraphy and stratigraphic geochemistry is warranted.

The Pueblo section (Cenomanian-Campanian) is of considerable importance to Upper Cretaceous stratigraphy, mostly due to its expanded, fossiliferous Cenomanian-Turonian succession. The succession continues through the lower Campanian, capturing – in particular – well-exposed Turonian–Coniacian and Coniacian–Santonian boundary intervals. While Pueblo lacks many stratigraphically important macrofossil and microfossil groups and possesses an endemic ammonite fauna, it remains a worthwhile Western Interior reference section for the Turonian through Campanian. Biostratigraphic constraints on the Turonian-Santonian portions of the Pueblo succession are provided by ammonites and inoceramids, the latter biozonation scheme aligning well with the standard European inoceramid biozonation scheme.

Here, we provide a reference δ13Corg profile for the upper Turonian to lower Santonian of the Pueblo succession. While not all standard Western Interior carbon isotope excursions can be identified, several appear to coincide with major hiatal and lithostratigraphic surfaces:

Event Co1 (*Cremnoceramus deformis erectus* Zone; lower Coniacian), a sharp negative δ13Corg excursion, coincides with a major hiatal surface encompassing the *Cremnoceramus waltersdorfensis hannovrensis* and *Cremnoceramus crassus inconstans* Zones.

Ocean Anoxic Event 3 (*sensu* Joo and Sageman 2014; upper Coniacian), a sustained plateau of elevated δ13Corg values, entirely overlaps with the Lower Limestone of the Niobrara Formation.

Those global carbon isotope events that can be recognized – the upper Coniacian *Kingsdown Event* and the lower Santonian *Michael Dean Event* – are not associated with stratigraphic discontinuities. That being said, global carbon isotopic trends cannot be recognized in the upper Turonian through middle Coniacian, the portion of the Pueblo section most beset by physical unconformities. This work, therefore, highlights the need to carefully consider stratigraphic context, and in particular the influence of stratigraphic surfaces, with regards to observed δ13Corg values in Upper Cretaceous hemipelagic strata.

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DISTRIBUTION AND COMPARISON OF UPPER CRETACEOUS DEPOSITS IN THE GOBI OF TRANS-ALTAI

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The 'Tsagaan-Ovoo-50' project (scale 1:50,000) is being elaborated in Trans-Altai, Gobi, by the Gurvantalst company, for the years 2020-2024, at the localities of Shinejinst and Gurvantes soum of Bayankhongor and Umnugobi aimag. This sector has an extent of 9,680.55 km2. Out of this, 3,420 km2 are covered by Cretaceous sedimentary rocks, such as Upper Cretaceous strata at Nogoontsav, Khermentsav, Ongon and Ekhiin Gol. Currently, the Upper Cretaceous Bayanshiree (Khermentsav) Formation (Albian–Cenomanian; 100.5 Ma), the lower Baruungoyot Formation (Coniacian–Santonian; 86.3±0.5 Ma), the upper Baruungoyot Formation (Santonian–Campanian; 83.6 Ma) and the lower Nemegt (Maastrichtian–Danian; 66.0 Ma) have been identified at the project site. Eberth et al. (2018) worked in the Khermentsav area and observed a full section, named 'Main', below: the upper Bayanshiree Formation (K_2bs): light red, reddish colored siltstone – argillite – sandstone accumulation. We have lately been trying to find some microfossils from this level. The lower Baruungoyot Formation (K_2bg_1), is between 25 and 75 m in thickness and comprises pink colored sandy clay with a conglomerate layer and sandstone – clayey sandstone. Cross-bedded intervals are barely seen at this level. Fossils include the gastropods *Hydrobia rectoides* and *Galba* sp.; the charophytes *Mongolichara paucicostata* and *Mongolianella cuspidigera,* the ostracods *Cypridea cavernosa* and *Cypridea profua*, and Mongolianellinae. The upper Baruungoyot Formation (K_2bg_2) comprises red colored clay with rare gravelly conglomerate layers. Some dinosaur tracks are well preserved and exhibit high-fidelity scale drag marks that were generated when large dinosaurs (sauropods and hadrosaurs?) lifted their feet from a soft substrate (Eberth et al. 2018). The lower Nemegt Formation (K_2nm_1) comprises a green, light-pink colored sandstone with red, gray clay and sand lens-like layers, as well as a conglomerate that contains a rich assemblage of ostracods, tortoises, gastropods and dinosaurs. Four areas in the stratigraphical distribution of paleoenvironmental zones allow the climatic inference to be made that the Late Cretaceous in the Gobi of the Trans-Altai varied from mesonic to seasonally wet-dry to arid, and then back to seasonally wet-dry during deposition of the successions noted above.

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MICROBIAL ACTIVITY AROUND THE K/PG BOUNDARY, NEUQUÉN BASIN, ARGENTINA: A RESPONSE TO THE MASS EXTINCTION EVENT?

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The discovery of carbonates at Pichaihue (Neuquén) is important for the reconstruction of the palaeogeography of the first Atlantic transgression that reached the Andes foothills in Late Cretaceous times. There are three isolated outcrops, composed by pyroclastic flows, ash-fall distal tuffs and calcareous sediments of the Malargüe Group (Aguirre-Urreta et al. 2011). The limestone succession is interpreted as having been deposited in lagoonal to shallow-marine environments with the influence of active volcanism. In the north-eastern outcrop, the stromatolites are disposed in decimetre-thick beds with very thin lamination. The oncolites are isolated subspherical bodies of concentrically arranged laminae up to 10 cm; lamination consists of light-dark couplets, the dark ones being composed of micrite and organic matter, the light ones of quartz, silica and different types of clay minerals. These oncoids have nuclei of silt, probably as a result of disintegration and subsequent infilling of plant stems. These nuclei might be indicators of the existence of former macrophyte meadows, and some oncoids have small gastropods as nuclei as well. In the western outcrop, the stromatolites consist of domes of up to 1 m in height; the large columns (diameter 30 to 100 cm) indicate that the shoreline was exposed to wave action. Some of the nuclei of the domes show masses of serpulid polychaetes. The microbial activity was suspected from outcrops, polished and thin sections, and SEM analysis beyond doubt showed the presence of cyanobacterial filaments, nannobacteria and coccoid microbes that clearly support the microbial origin. There are forms that range from tiny spheres to stubby ellipses and long filaments. Preliminary U-Pb CA-ID-TIMS geochronology from two tuffaceous beds below and above the stromatolites provides constraints on their age. Both data are based on a few small zircon grains recovered: the youngest measured zircons from each yielded maximum depositional ages of 72.62 ± 0.21 Ma and 64.66 ± 0.5 Ma, respectively, for the lower and upper tuffs. In the south-eastern outcrops, the carbonates are represented by massive to peloidal mudstones with intercalated chert levels. SEM analysis of the mudstones showed the presence of filaments and EPS (Extracellular Polymeric Substances) supporting the microbial activity also in this area. This contribution supports the hypothesis that after a major extinction (K/Pg in our case) special environmental characteristics are suitable for the development of microbial communities behaving as 'disaster forms'. Those communities are quickly disrupted when normal marine conditions are re-established.

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ICHNOLOGICAL ASPECTS OF SOME LATE CRETACEOUS EVENTS

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Cretaceous bio-events had an influence on marine tracemakers and bioturbators. Ichnological investigations contribute to a better understanding of these events. Foremost, changes of oxygenation in pore waters during Oceanic Anoxic Events (OAEs) can be recognized with high confidence. Some short anoxic intervals of the latest Cenomanian Bonarelli Level (OAE 2) can be correlated in some regions, but others disappear or merge laterally (Betic Cordillera, Apennines). In the Pieniny Klippen Belt (Poland), the anoxic intervals are very reduced (Uchman et al. 2013). The Bonarelli Level may be preceded by a few Cenomanian anoxic intervals in thin beds (Silesian Nappe in the Carpathians, Betic Cordillera), but they are absent in the Gubbio area (Apennines, Italy), where the number of anoxic intervals differs from that in the above-mentioned areas, and the density of trace fossils is lower due to lower availability of food caused by palaeogeographical location. At the Betic Cordillera, aerobic subevents are less common in distal sections than in proximal ones (Rodríguez-Tovar et al. 2009). The Cretaceous–Paleogene (K/Pg) boundary is affected by bioturbation to a different degree (Labandeira et al. 2016), less so in the stratotype (El Kef, Tunisia) due to dysoxia. The Bottaccione section (Gubbio, Italy) records the delayed response of tracemakers to the K/Pg crisis and a gradual recovery with initial re-appearance of *Zoophycos*. In the Agost section (Betic Cordillera), the Lilliput effect of *Chondrites* was observed above the boundary (Łaska et al. 2017). Several sections show relocation of the lowest Danian boundary layer in burrows penetrating into the topmost Maastrichtian with all the micropalaeontological and sediment contents. Burrow fillings can be special taphonomic windows, where some Danian microfossils are preserved that are otherwise absent above the boundary. In the Caravaca section (Betic Cordillera), Danian microfossils occur up to 90 cm below the boundary in *Zoophycos* fillings. In the Chicxulub impact crater area (Mexico), the first tracemakers re-appeared within a few years after the impact, but a mature community is not seen until 700 kyr later (Rodríguez-Tovar et al. 2020).

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AN UPDATE ON THE MAASTRICHTIAN GEOHERITAGE PROJECT

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The youngest time interval of the Cretaceous is known as the Maastrichtian Age, a reference to the strata exposed in the area surrounding the city of Maastricht, in the Netherlands-Belgium border region (Jagt 2001). The stratigraphical succession at the original type locality of the Maastrichtian (adjacent to the former ENCI quarry, south of Maastricht) only covers the upper part of the Maastrichtian Stage as defined nowadays. However, a recent integrated bio – and chemostratigraphical revision by Vellekoop et al. (2022) has shown that in combination with similar lithological sequences at other quarries in the region (e.g., Hallembaye [Kreco], former Curfs), a substantial part of the Maastrichtian Stage is represented. Over the past two and a half centuries, the type-Maastrichtian strata have provided a wealth of palaeontological data. Despite its importance to the global geological community, most of the quarries in the region have been closed over the recent decades. Instrumental quarries such as that of Curfs have already been out of commission for more than a decade, while others, such as the ENCI quarry, were recently closed. Because the soft limestone rocks weather easily and become overgrown rapidly, access to and study of the Maastrichtian rock succession in its type area is becoming very limited. To preserve the geological heritage of this original type-locality of the Maastrichtian, in 2018 we initiated the 'Maastrichtian Geoheritage Project'. The goal of this project is to preserve the geological heritage of the Maastrichtian type area by (1) digital imagery, using drone photogrammetry and Differential GPS Base & Rover to generate high-resolution and geo-referenced 3D models of the most important quarries in the Maastrichtian type region; and (2) archiving rock samples of these quarries for future research. Over the past years, we have collected high-resolution (5 cm spacing) reference sample sets from the Hallembaye (2018) and ENCI (2019) quarries, and generated detailed geo-referenced 3D models for both quarries. For the next few years, several other instrumental quarries will be targeted. The acquired sample sets have already spurred a range of stratigraphical, geochemical and palaeontological studies (e.g., Vellekoop et al. 2022), including detailed profiles of carbon isotope data and major and trace element concentrations, and many more to come. Moreover, the Maastrichtian Geoheritage Project sample sets will be made available for collaboration with other researchers in the field.

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PALYNOLOGICAL INVESTIGATION OF SELECTED TAXA FROM CENOMANIAN STRATA AT HLOUBĚTÍN-HUTĚ, PRAHA (CZECH REPUBLIC)

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Sedimentary rocks found at the locality of Hloubětín-Hutě, situated in the eastern suburb of Prague, belong to the Peruc-Korycany Formation of the Bohemian Cretaceous Basin. They comprise sandstones in the basal part that are overlain by coaly mudstones, sandy mudstones, siltstones and sand, being a product of a tidally influenced river and a nearshore swamp influenced by brackish water. The material examined is in part that stored in old permanent slides from the collection of Professor B. Pacltová, and in part from newly processed samples. Both types of material are deposited at the National Museum, Praha. Samples were macerated by standard HCl-HF-HCl treatment and observed with a Light Microscope, Olympus BX 50. Preliminary results have shown rich palynological assemblages characterised mostly by pteridophyte spores of the family Gleicheniaceae. The angiosperm pollen group is also rich and diverse, characterised mostly by monocolpate pollen (*Clavatipollenites* sp.) and tricolpate pollen (*Tricolpites* sp.). Gymnosperm pollen present include *Taxodiaceaepollenites* sp., *Cycadopites* sp., *Alisporites* sp. and *Parvisaccites*. The present study has demonstrated the potential for further palynological analyses of the locality. On the basis of palaeobotanical and palynological studies we can reconstruct the taphocoenosis studied as a tidal river flood plain hosting a vegetation of lauroid angiosperms (*Mauldinia* with leaves *Eucalyptolaurus*, *Lauraceae*) with a nearshore swamp (*Quasisequoia, Elatocladus – Taxodiaceaepollenites, Cycadopites, Gleicheniaceaphyllum*) in the mouth of the estuary. Slopes of hard Ordovician quartz were overgrown by a mesophytic vegetation (*Araliaephyllum, Dicotylophyllum – Clavatipollenites* sp., *Tricolpites* sp.).

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STRONTIUM ISOTOPE STRATIGRAPHY AROUND THE BASE OF THE CAMPANIAN (ITALY AND AUSTRIA)

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Strontium isotope stratigraphy ($^{87}Sr/^{86}Sr$) provides a means of correlation of the Santonian–Campanian boundary. Although no strontium isotope peak is associated with the base of the Campanian, the steady rise in strontium isotope values from the Turonian up to the Paleocene gives a reasonable resolution for correlations. Several recent detailed reports from the Upper Santonian–Lower Campanian interval were published from the Austrian Alps (Wolfgring et al. 2018) and the Western Interior (McArthur et al. 2016). Results from whole rock samples from the (proposed GSSP) Bottaccione section (Italy) show the expected rising trend curve upwards, but with some diagenetic fluctuations. Using the eight nearest samples below and above the base of magnetochron C33r (from 218.5 to 222.45 m; see Maron and Muttoni 2021; Miniati et al. 2020) results in a mean value of 0.707494. This value lies reasonably between the most recent estimates of 0.707455 (McArthur et al. 2016) and 0.707534 (Wolfgring et al. 2018). Based on several records the values of strontium isotopes vs magnetostratigraphy and plankton stratigraphy markers are correlated and discussed.

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PACHYDISCUS NEUBERGICUS (VON HAUER, 1858) – IMPORTANT AS WELL AS PROBLEMATIC

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The assignment of some species in paleontology may be extremely difficult and involve many assumptions. For instance, a limited number of specimens available, incomplete preservation and/or the presence of phenotypic varieties, may all cause complications and generate errors, which in turn lead to incorrect identification, both at the species level and above. It is known that keeping order in the systematics of organisms is very important, but in the case of determining stratigraphically significant species, this importance increases even more. An example of such a situation is an ammonite first described by von Hauer (1858) as *Ammonites neubergicus*. Until recently, it was considered a key species for placing the boundary between the Campanian and Maastrichtian. Unfortunately, many designations over the decades have created a great deal of confusion in the taxonomy of this important taxon. Accordingly, its supposed stratigraphical range also changed, and at some point this species ceased to be considered as index for the Campanian/Maastrichtian boundary. For this reason, the correct identification of specimens of the above-mentioned ammonite is of fundamental importance. *Pachydiscus neubergicus* has a planispiral, semi-evolute, dorso-ventrally flattened shell. Its ornamentation is formed by main and additional ribs. It is relatively small in size compared to other species of the Pachydiscidae. Various descriptions of representatives of this species show too wide a range of taxonomic features. Therefore, it is necessary to revise this species. It seems highly likely that the number of main and additional ribs could play a major role in its taxonomic analysis. Its geographical distribution is potentially global, but the revision may prove otherwise. On the other hand, this species may have had high intra-specific variability related to local environmental conditions. Was it a master of adaptation? Is the species limited to the early Maastrichtian, or does it appear in the late Campanian and disappear in the late Maastrichtian? Can this taxon play a key role in determining the lower boundary of the Maastrichtian? Will an excessively wide stratigraphical range detract from its role as an index species? These are the questions that we ask ourselves. Using a cast of the holotype, as well as illustrations, measurements and other data from the literature, we attempt to verify the variability and biostratigraphical value of *Pachydiscus neubergicus*.

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INOCERAMID INVESTIGATIONS BY KARL ARMIN TRÖGER (1931–2019): METHODOLOGY, SCOPE AND ACHIEVEMENTS

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Karl Armin Tröger (1931–2019) was an eminent researcher of Late Cretaceous inoceramid bivalves, representing the finest trends of the German school, following such leading figures as Rudolf Heinz (1900–1960) and Otto Seitz (1888–1976).

Already in his 1967 benchmark paper on the early Late Cretaceous inoceramids of the North European Province, he outlined his methodology of inoceramid studies, which he subsequently used throughout his entire oeuvre. This was an sophisticated approach, based to a large extent on

Heinz (1928) and Seitz (1961 and references therein), with his own, widely adopted additions and procedures. His morphometric studies were based on: (1) biometric methods, largely bivariate analysis of selected parameters (axial length, width, hinge length), and graphic presentations of length – and height-parallel cross sections; (2) parameterization of ontogenetic variation (such as obliquity and anterior and posterior hinge angles); and (3) careful analysis of inoceramid ornamentation. The character of his earliest material precluded a 'fine-stratigraphic' (stratophenetic) approach.

Tröger began his research with the early Late Cretaceous inoceramids of Germany and adjacent regions (central Poland and Bohemia). During a fellowship at Lomonosov University (Moscow) he was able to extend his studies eastward into the southern margin of the East European Craton (Crimea, the Caucasus). While in Moscow, he furthermore had the opportunity to study an extremely rich collection of Late Cretaceous inoceramids from Sakhalin and Kamchatka (Pacific Russia), brought to Moscow by his longtime friend 'Misha' Pergament, another prominent inoceramid contemporary. While Tröger never published on the topic, this material gave him considerable experience with the Late Cretaceous inoceramids of the Northern Pacific. Another area he studied in detail, although never published upon, was the classic Mangyshlak succession in western Kazakhstan (see Naidin et al. 1984). In the late seventies, he embarked upon a long adventure with north African Late Cretaceous inoceramids. Invited by Pavel Röhlich, his friend and colleague from Prague, he provided a complete record of inoceramid faunas of the Campanian and Maastrichtian of northwestern Libya (Tröger and Röhlich 1991 and references therein). Other areas he expertly documented include the Austrian Alps, Bornholm, and Greenland (the latter never published).

Karl Armin Tröger provided the results of his inoceramid studies across nearly 50 publications. Among his main achievements are: (1) the development of a coherent taxonomic methodology, which he applied rigorously in most of his studies; (2) the compilation of early Late Cretaceous inoceramid taxonomic diversity of the North European Province and adjacent biochores; (3) the recognition of more than 20 inoceramid taxa at the (sub) species level; and, finally, (4) the construction of a comprehensive inoceramid zonation, long regarded as a standard biostratigraphic scheme of the lower Upper Cretaceous in North Europe.

In his final years, Karl-Armin Tröger regularly visited the Museum for Mineralogy and Geology in Dresden, revising the classic inoceramid collection of Bruno Geinitz (1814-1900).

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EVOLUTION AND DIVERSITY OF CONIACIAN INOCERAMIDS

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The Coniacian has long been recognized as an interval of accelerated inoceramid diversification (Pergament 1967; Tröger 1976; Voigt 1995), inferred to be the result of apparently rapid evolution. The rich global record of Coniacian inoceramids provides excellent material for a better understanding of Coniacian biostratigraphy and paleoenvironments, and more broadly for general studies on the nature of evolutionary processes and the structure of diversity trends.

In the interpretation of Coniacian inoceramid evolution, the sequence of taxonomic turnover events is of particular importance: here, four crucial events are treated in detail:

(1) The rapid taxonomic turnover from the late Turonian *Mytiloides*-dominated fauna to the latest Turonian-early Coniacian *Cremnoceramus*-dominated fauna, coinciding with immigration events of the bivalve genus *Didymotis* during the early range of the genus *Cremnoceramus*.

(2) The appearance of the genera *Platyceramus* and *Volviceramus* at the base of the middle Coniacian, following the demise of *Cremnoceramus* and the intermittent emergence of the enigmatic *Inoceramus gibbous* fauna. Due to stratigraphic gaps apparently associated with eustatic changes, the lower–middle Coniacian boundary interval is poorly recorded in both Europe and North America.

(3) The appearance of the *Magadiceramus* fauna in middle latitudes, and *Sphenoceramus* in higher latitudes. This is the most poorly known event among the Coniacian turnovers, although the association of the southward spread of the genus *Sphenoceramus* with a eustatic lowstand has been recently noted.

(4) An almost complete turnover associated with the massive appearance of *Sphenoceramus* ex gr. *pachti* in the higher latitudes, and the corresponding appearance of the genera *Cladoceramus* and *Cordiceramus* in the middle latitudes. This level is taken as the base of the Santonian, and marks the extinction of almost all Coniacian inoceramid lineages.

In general, there seems to exist a good correspondence between inoceramid faunal turnovers and paleoenvironmental instability during the Coniacian. Although further development of geochemical and paleontological datasets are needed to better understand the actual nature of the stratigraphic record, some of the studied sections demonstrate that the appearance of new inoceramid fauna occurs immediately above major flooding surfaces, suggesting a close correspondence between evolutionary and/or migratory appearances and episodes of relative eustatic rise.

Integrated over a global scale, the substage-level inoceramid taxonomic diversity curve shows three distinct peaks. The internal structure of these maxima is variable, however, and is a combination of turnover rate, standing diversity, and biogeographic pattern, requiring individual analysis to be properly understood.

There are still considerable gaps in the knowledge of Coniacian inoceramid paleobiogeographical distribution. Integrated studies on complete, representative sections is needed.

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FORAMINIFERAL RECORD OF THE MID-MAASTRICHTIAN EVENT (MME)

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Pronounced biotic and geochemical changes occur in the middle part of the Maastrichtian, around c. 69 Ma, such as an acme of inoceramids in intermediate waters, eventually followed by their diachronous extinction, the extinction of rudists, and patterns of migration in a number of fossil groups (Johnson and Kaufmann 1990, 1996). Such features have also been related to a discrete, 0.5‰ negative excursion in bulk carbonate carbon isotopes, although this feature is not discernible in our isolated planktonic and benthic foraminiferal carbon isotope data, thus its nature remains puzzling. Other prominent characteristics that have been documented at that time comprise a pronounced peak in benthic foraminifera oxygen isotopes and a positive shift in Nd isotopes. This mid-Maastrichtian Event or MME remains so far poorly documented and understood.

Here, we present a high-resolution record of foraminiferal assemblage changes across the MME in the Polanówka-UW1 borehole located in central Poland and in the Stevns-1 borehole from eastern Sjælland, *Denmark.* Foraminiferal data are integrated with newly conducted $\delta^{13}C$ and $\delta^{18}O$

measured separately in planktonic (*G. prairiehillensis*) and benthic foraminiferal (epifaunal *C. voltzianus* and shallow-infaunal *G. globosus*) species, in addition to Nd isotopic analysis (Nd). Both analyzed profiles are *biostratigraphically* dated and contain a continuous record across the MME without signs of stratigraphic gaps.

We distinguished significant changes in planktonic and benthic foraminiferal communities such as the temporary disappearance of all stensioeinids and appearance of deep-dwelling planktonic species, including keeled species (*Contusotruncana fornicata*, *Globotruncana arca*, *G. bulloides*, *Globotruncanita pettersi*, *G. stuartiformis*) and complex heterohelicids (*Planoglobulina brazoensis*, *P. carseyae*). These deep-dwelling forms are not observed in Poland within the entire Maastrichtian apart from the MME event (Peryt 1980). We also observed an upward decrease of $\delta^{18}O$ values in benthic foraminifera across the event in both examined sections. Interestingly, such a trend has not been recorded in planktonic foraminifera. Furthermore, we detected a distinct decrease of Nd values from – 10.5 to – 12.5 across the MME in the Polanówka-UW1 borehole. The material collected in Polanówka-UW1 is exceptionally well-preserved with no signs of post-depositional alterations. Absence of any significant diagenetic effects was confirmed by micro – and nanostructural observations using a SEM and by elemental composition using electron microprobe.

Integration of these results indicates that this distinctive period of the Late Cretaceous was affected by significant changes in oceanic circulation which acted as a key regulator of climate, nutrient distribution and/or salinity.

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ASTRONOMICALLY CONTROLLED DEEP-SEA LIFE IN THE LATE CRETACEOUS RECONSTRUCTED FROM AN ULTRA HIGH-RESOLUTION BIVALVE SHELL ARCHIVE

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The Earth-Moon-Sun system periodicity carries a key impact on biota functioning ever since life evolved. Biological clock rhythms affect most processes within organisms and can be recorded in skeletal remains. Advances in analytical science, thanks to improved and more precise technologies, now make it possible to reconstruct even the most basic rhythms that occurred in nature in the distant past. The vast majority of these run either by circadian and/or circalunar clock, occurring in obviously periodic light (sun/moon)-dependent environments. Most of the Earth's surface is currently constituted by deep-sea environments where the effects of endogenous stimuli (German *zeitgeber*), such as light, are (and were) strongly reduced or absent. Therefore, for decades, 'blind' deep-sea ecosystems were either considered aperiodic or simply ignored the issue of biological rhythmicity. Nevertheless, the presence of lunar-related periodicity in organism behaviour from deep-marine, light-free conditions has recently been noted (e.g., Mat et al. 2020). Consequently, lunar-related rhythms carry a significant impact on the biosphere, even at great depths, since the setting up of the Earth-Moon (tidal) system. The aim of the present study is to decipher the existence of astronomically controlled biological rhythms, driven by inner clock(s) – circatidal and/or circadian – in fossil material representing a deep-marine aphotic environment, where the main stimuli provided were lunar rhythm frequencies. We examined the Late Cretaceous inoceramid bivalve *Inoceramus (Platyceramus) salisburgensis* found *in situ* in a deep-water flysch facies deposited at the foot of the Skole Basin (north-eastern Tethys Ocean). The presence of very small (~ 1 μm) bioerosion structures on the surface of the shell, diagnosed as *Scolecia serrata* are also indicative of the aphotic zone. Further, diagenetic screening (CL) and internal microstructure (FE-SEM) of the shells demonstrated almost purely primary, unaltered material. The LA-ICP-MS high-resolution elemental ratio scans of Mg/Ca, Sr/Ca and Mn/Ca and time-series analysis revealed explicit rhythmic patterns. We identified the basic dominant cycles with a periodicity of ~0.006 mm. The broader visible light-dark lamination, interpreted as a seasonal signal, yields a rough shell age estimate and growth rate for this large bivalve species supported by a dual feeding strategy. We recognized a biological clock that followed either a semilunar (Model A) or a tidal (Model B) cycle. We interpret that the major control in such an environment was due to barotropic tidal forces, thus changing water pressure. Additionally, our results indicate that a single shell increment (couplet) in *I. (P.) salisburgensis* formed every lunar day specifying an ultra-high-resolution data set record, determining it even up to ~ 2 h accuracy.

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A POSSIBLY NEW ICHNOSPECIES OF *ROGERELLA* (BARNACLE BIOEROSION TRACE) IN A MID-MAASTRICHTIAN INOCERAMID SHELL FROM POLAND

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Barnacles constitute a significant group in sessile marine communities, having marked their presence either in the form of shell remains or bioerosion (etching) traces, ever since the Palaeozoic (e.g., Rodriguez and Gutschick 1977). Distributed from the intertidal zones to abyssal depths and from the tropics to the poles, this diversity represents a highly adaptative strategy to occupy even challenging environments (e.g., Herrera et al. 2015). Even volatile late Mesozoic environmental changes, such as palaeogeographical rearrangement, temperature changes and sea level fluctuations, allow for the first barnacle radiation (e.g., Chan et al. 2021). Therefore, the fossil itself or components associated with other organisms carry meaningful proxies into palaeoenvironmental reconstructions (e.g., Doyle et al. 1996). A new ichnospecies of the ichnogenus *Rogerella* is a small boring or etching trace recognised in large-sized shells of *Inoceramus (Platyceramus) salisburgensis* from Upper Cretaceous flysch deposits of the Ropianka Beds (formerly known as Inoceramus Beds) in the Polish Outer Carpathians. The bioeroded bivalve shells occur within a heterolithic, clay-marlstone and fine-grained sandstone series which comprises the 16th inoceramid-bearing horizon spanning a few metres. The new ichnotaxon was diagnosed in the last horizon (16th) correlating with the highest part of the Inoceramus Beds. This accumulation of *in situ* inoceramids of the last one across the Carpathian flysch deposits and stratigraphically is referred to as the Inoceramid Acme Event (IAE) herein. The detailed architecture of the possibly new ichnospecies of *Rogerella* was examined by cross-cutting shell material, the FE-SEM rubber casting method and precise computer tomographic (CT) analysis. The trace is characterised by semi-circular, pouch-shaped depressions (in case of negative reliefs formed by the boring) with a horizontal ledge ('tabula') in the upper part of the boring. The ledge is wedge-shaped in cross section, with a lower surface parallel to the surface of the bivalve shell and an oblique upper surface. The lower part of the burrow, below the ledge, is always filled with deposits, whereas the upper part is usually empty and only rarely filled with matrix. The aperture is slightly smaller than the size of the actual boring. The distribution of individual borings strongly correlates with shell growth lines, which helped larval stages of the animal that produced *Rogerella* to settle. Moreover, inner-boring microstructure is reflected with the placement of 'laminae pellucida' (organic-rich) and 'laminae obscura' (organic-poor), because of their different physical resistibility. This more likely indicates chemical action, such as lowering the pH on the carbonate substrate and thus local dissolution rather than mechanical drilling. The co-occurrence with *I. (P.) salisburgensis* suggests the ability to inhabit deeper-water (aphotic) environments with at least temporal oxygen deficiency – above sediment-level chemical redox conditions, supported by relatively warm bottom waters (~18°C) and moderate to high OM input. The sudden and numerous occurrence of *Rogerella* isp. nov. in the last inoceramid-bearing horizon might be correlated with an abrupt environmental change responsible for IAE such as deep-water mass circulation creation.

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THE RESPONSE OF TERMINAL MAASTRICHTIAN DEEP-SEA ECHINOIDS TO THE LATEST MAASTRICHTIAN | WARMING EVENT (LMWE) AND THE K/PG BOUNDARY EVENT

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Because onshore deep-sea sediment archives are rare, the fossil record of deep-sea macrofauna is scarce. However, considering not only the entire test but also disarticulated fossil remains, deep-sea drill cores represent a yet unexplored, but powerful source, in particular for echinoderm remains (Thuy et al. 2012). Here, we tested the potential of echinoid spines for reconstructing echinoid dynamics around the K/Pg boundary based on c. 1,000 echinoid fragments from terminal Maastrichtian to Lower Paleocene sediment samples off Newfoundland (U1407C, palaeowater depth c. 1,700 m; U1403B, palaeowater depth c. 3,600 m; IODP Expedition 342). The spine assemblage is dominated by atelostomate spines while cidaroid spines are rare. Some fragments resemble echinothuriid spines. In total, 113 samples (U1403B) across the Deccan volcanism-induced Latest Maastrichtian Warming Event (LMWE), well documented for Site 1403 by Hull et al. (2020), were analysed quantitatively. The LMWE is associated with a decrease of echinoid biomass (spines/g) from a maximum of 1.0 to values close to zero in the main phase of the LMWE and a slight post-event recovery to 0.5. We cannot see any loss of morphological inventory across the LMWE. Maastrichtian to Early Paleocene samples from U1407C show a complete loss of Maastrichtian spine morphologies and a decrease of spine size across the K/Pg boundary. The post-event recovery in the form of increasing spine disparity and size through the Lower Paleocene took more than 1 myr. The observations are in general accordance with the faunal/floral data compilation of Hull et al. (2020) for the K/Pg boundary interval. However, the long duration of the recovery phase is unusual. It needs to be tested, therefore, whether or not this slow

recovery is an expression of extinction and subsequent recovery by *in situ* evolution of deep-sea echinoids.

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BIOSTRATIGRAPHICAL REASSESSMENT OF THE CUCHIA WEALDEN SECTION (NORTH CANTABRIAN BASIN, NORTHERN SPAIN) BASED ON A HIGH-DIVERSE CHAROPHYTE FLORA: IMPLICATIONS FOR PALAEOBIOGEOGRAPHY AND REGIONAL TECTONO-SEDIMENTARY EVOLUTION

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The 55-m-thick Wealden section of Cuchia, west of Santander (Lower Cretaceous, North Cantabrian Basin, Cantabria, northern Spain), rests in a small graben structure unconformably on tilted Jurassic sediments. It provided a rich and diverse charophyte assemblage, consisting of 22 taxa. Two distinct charophyte assemblages can be recognised. The lower assemblage from the base of the section yielded *Echinochara lazarii, Atopochara trivolvis* var. *triquetra, Globator mallardii* var. *trochiliscoides, Clavator grovesii* var. *gautieri, Clavator harrisii* var. *dongjingensis, C. harrisii* var. *harrisii, C. calcitrapus* var. *jiangluoensis, C. calcitrapus* var. *calcitrapus, Ascidiella stellata* var. *stellata, A. triquetra, Hemiclavator neimongolensis* var. *neimongolensis, H. neimongolensis* var. *posticecaptus, Mesocharavoluta* gr. *voluta* and *Favargella* sp. The assemblage can be related to the Eurasian '*Hemiclavator neimongolensis* var. *neimongolensis*; biozone of Pérez-Cano et al. (2022) (late Early Barremian–early Late Barremian). The higher charophyte assemblage consists of *E. lazarii, A. trivolvis* var. *triquetra, A. trivolvis* var. *trivolvis, C. grovesii* var. *jiuquanensis, C. harrisii* var. *dongjingensis, C. harrisii* var. *harrisii, C. harrisii* var. *reyi, Ascidiella cruciata, H. neimongolensis* var. *neimongolensis, H. neimongolensis* var. *posticecaptus, Mesocharavoluta* gr. *voluta, Munieria grambastii, Clavatoraxis* sp., *Charaxis* sp. and *Tolypella* sp. vel *Mesochara* sp. This assemblage represents the Eurasian '*Clavator grovesii* var. *jiuquanensis*' biozone (Late Barremian–Early Aptian). Because the overlying marine *Orbitolina*-bearing limestones are Early Aptian in age, the Wealden of the Cuchia section can be dated as late Early Barremian to Late Barremian. This contradicts earlier dating (e.g., Najarro et al. 2011: Hauterivian to Barremian). The new stratigraphical model shows that only the upper part of the Cantabrian Wealden is developed at Cuchia. The Cuchia charophyte assemblages provide a tool for a correlation with those of the Iberian Chain and the Pyrenees, and enable a detailed palaeobiogeographical comparison. In addition, the fine-tuned stratigraphical framework contributes to a better dating of tectono-sedimentary events at the northern margin of the Iberian microcontinent.

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THE UPPER CENOMANIAN TAKHTE-SHEITAN MEMBER (KOLAH-QAZI FORMATION, ESFAHAN, CENTRAL IRAN): TAPHONOMIC PROCESSES AND AMMONITES OF A CLASSIC 'KONZENTRAT-LAGERSTÄTTE'

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In the Esfahan area (central Iran), the 'Glauconitic Limestone' formed a thin (<4 m) lithological unit that is well known for its Late Albian–Middle Cenomanian ammonite faunas (Kennedy et al. 1979). However, a detailed stratigraphical reinvestigation has demonstrated that it consists of two genetically unrelated units (Hairapetian et al. 2018): the lower part, mid-Late Albian in age, sharply rests on basinal marls (lower to mid-upper Albian Bazyab Formation) and consists of fossil-poor limestones, forming an erosional remnant of the lower Debarsu Formation. The upper part has a major erosional unconformity at its base and consists of a fossiliferous glauconitic pebble-to-boulder conglomerate with phosphatised bio-/lithoclasts, yielding the famous ammonite faunas. It fines upwards into an overlying marl and argillaceous limestone unit. The matrix of the glauconitic conglomerate was dated as mid-Late Cenomanian (upper *Rotalipora cushmani* Zone) and the overlying offshore deposits as latest Cenomanian–Early Turonian by means of foraminifera, ammonites, inoceramid bivalves and stable carbon isotopes (Hairapetian et al. 2018). Consequently, the succession was lithostratigraphically completely revised, the upper part of the former 'Glauconitic Limestone' defined as the basal Takhte-Sheitan Member of the new Upper Cenomanian–Lower Turonian Kolah-Qazi Formation. Thus, the Late Albian to Middle Cenomanian phosphatised ammonites from the Takhte-Sheitan Member are derived from the regional erosion of older strata (Debarsu and upper Bazyab formations) during a late Middle to early Late Cenomanian uplift phase, i.e., represent classic remanié faunas of a Konzentrat-Lagerstätte (complex transgressive lag).

More than 70 ammonite taxa have been recorded from the Takhte-Sheitan Member. The oldest species recorded is the late Middle Albian

Semenoviceras solidum. Typical Late Albian species include *Mortoniceras (Subschloenbachia) rostratum* and *M. (S.) perinflatum*. The Lower Cenomanian Substage is extensively documented by numerous species of the genera *Mantelliceras, Sharpeiceras, Mariella* and *Hypoturrilites*, as well as by common *Schloenbachia varians*. The lower Middle Cenomanian is proved by *Acanthoceras* sp., *Turrilites costatus* and *Calycoceras (Gentoniceras) gentoni*. Taphonomic studies show that the ammonites occur almost exclusively in black phosphatised internal mould preservation, often with polished surfaces, and are in part fragmented, thus indicating their reworked character. Indigenous faunas from the marl and argillaceous limestones above comprise *Pseudocalycoceras* cf. *angolaense* and *Thomelites* sp., documenting a latest Cenomanian age for the fine-grained strata overlying the Takhte-Sheitan Member.

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THE EARLY CENOMANIAN *CRIPPSI* EVENT: PALAEONTOLOGICAL AND STRATIGRAPHICAL SIGNIFICANCE OF A WIDESPREAD EARLY LATE CRETACEOUS BIOEVENT

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The early Cenomanian *crippsi* Event comprises a commonly 1–3-m-thick interval of strata characterized by a flood occurrence of the inoceramid bivalve *Gnesioceramus crippsi*. Its stratigraphic position is located in the lower lower Cenomanian *Mantelliceras mantelli* Zone (upper part of the *Sharpeiceras schlueteri* Subzone), just below the interregional sequence boundary SB Ce 1. Based on a new fauna from Lüneburg (northern Germany; Wilmsen et al. 2021) and the evaluation of other records, the event can characterized as a densely packed shell accumulation consisting of in part very large, flat and disc-like valves of *G. crippsi*. Taphonomic as well as bio – and microfacies analyses suggest that the event at Lüneburg formed as a primary biogenic concentration in a deeper shelf setting below the normal storm-wave base. The inoceramids are interpreted as recumbent forms that lived in dense populations on a soft substrate. Towards the basin margins (e.g., Subhercynian and Münsterland sub-basins), the event grades into storm wave-reworked bioclastic concentrations, consisting of shell-detrital chalks rich in inoceramid debris. When tracked inter-regionally, the cyclic stratigraphic patterns of the *crippsi* Event, consisting of several chalk-marl couplets, suggest a moderately prolonged period (≤100 kyr) of increased shell production and preservation in the late phase of depositional sequence DS Ce 1, caused by an interregional population bloom of *G. crippsi*. Thus, the *crippsi* Event forms a late highstand bioevent (proliferation epibole) and it is an important marker for intra – and interbasinal correlation (cf. Amédro et al. 2012; Wilmsen 2012).

The first record of *G. mowriensis*, hitherto only known from the U.S. Western Interior Seaway, from the level of the *crippsi* Event at Lüneburg (Wilmsen et al. 2021), and the contemporaneous occurrence of the ammonite *Metengonoceras teigenense*, similarly a faunal element endemic to North America, from the *crippsi* Event in northern France (Amédro et al. 2022), suggest faunal exchange between the New and Old worlds during early Cenomanian times. The conspicuous faunal dispersal of Western Interior-derived faunas and the coeval existence of warm-water biofacies in western Europe (e.g., coralgal reefs in northern Spain, northward dispersal of orbitolinid foraminifers) during the early Cenomanian may be explained by the establishment of a continuous NE-directed surface current conveying warm waters from the Gulf of Mexico towards Europe (proto-Gulf Stream). Furthermore, the appearance of the short-lived ammonite species *M. teigenense* in France allows to calibrate the uppermost *schlueteri* Subzone of the mid-*mantelli* Zone of the European biozonation to the lowermost part of the North American *Neogastroplites muelleri* Zone, assigning an approximate age range of ~98.6–98.7 Ma to the *crippsi* Event.

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INTENSE CHEMICAL WEATHERING OF THE CONTINENTS: A KEY FOR WIDESPREAD SHALLOW-MARINE GLAUCONY FORMATION DURING THE LATE CRETACEOUS

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Massive and geologically fast shallow-marine glaucony formation was a widespread phenomenon during the Cretaceous greenhouse world that has no recent counterpart. Recently, it was repeatedly speculated that intense continental weathering played an important role in that process, supplying essential elements for glauconitisation to the marine basins. However, supportive evidence was sparse up to now. In order to test the weathering hypothesis, we conducted a detailed integrated investigation of a stratigraphical transect from the Upper Turonian of the Danubian Cretaceous Group (southern Germany), which allows to link the deep chemical weathering in the catchment of a river system (Seugast Member of the Roding Formation), discharging southwards into the sea, to contemporaneous shallow-marine authigenic glaucony precipitation (Großberg Formation). Nine glauconitic facies types have been identified within the Großberg Formation that reflect a shallow-marine depositional environment with mixed sediments predominantly consisting of land-derived siliciclastics, marine carbonates and authigenic glaucony. The green authigenic

clays of the Großberg Formation have unequivocally been identified as glauconitic minerals by means of XRD analyses, comprising grainy and matrix glaucony. Geochemical proxies, especially the very high values of the chemical index of alteration, CIX, demonstrate that the catchment area of the River Seugast was deeply chemically weathered and leached. Comparisons to modern tropical streams draining areas with high precipitation rates and deep chemical weathering suggest that elemental concentrations of the fluvial waters of the River Seugast must have been considerably elevated with respect to particular element species needed for glaucony formation, such as Fe, Si and Al. We thus propose that the widespread nearshore glaucony formation during Late Cretaceous times was in fact basically related to the physico-chemical properties of the riverine flux from the low-lying, soggy and deeply chemically weathered continents.
The deposition of the Großberg Formation corresponds to the Late Turonian depositional sequence DS Tu 5 that commenced, after a major Mid-Late Turonian sea level fall, with strongly siliciclastic lowstand deposits and fluvial incision at the base of the Seugast Member of the Roding Formation. During the following transgressive and highstand systems tracts, strongly glauconitic, mixed calcareous and siliciclastic sediments of the middle and upper Großberg Formation accumulated and the incised valleys to the north were backfilled with fluvial siliciclastics of the Seugast Member (contemporaneous non-marine onlap). The sequence stratigraphical patterns observed in the Upper Turonian of the Danubian Cretaceous Basin can be correlated on regional and inter-regional scales, suggesting a eustatic control of deposition. Thus, temporal constraints derived from the bio – and sequence stratigraphical calibration of the Großberg Formation also demonstrate that Late Cretaceous glaucony formation was a geologically rather fast process, coming to completion in much less than 500 kyr.

THE CRETACEOUS SUCCESSION AT THE EASTERN RIM OF THE ANARAK METAMORPHIC COMPLEX (CENTRAL IRAN): INTEGRATED STRATIGRAPHY AND FACIES DEVELOPMENT AT THE MARGIN OF THE KHUR BASIN

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Cretaceous strata of the Khur area (northern part of the Yazd Block, central Iran) attain a huge thickness of several kilometres, but the stratigraphical record is substantially reduced westwards, towards the Anarak Metamorphic Complex (AMC), a basement uplift consisting of Palaeozoic to Triassic rocks. The scope of the present study is to understand the complex litho-/sequence stratigraphical patterns, to reconstruct depositional environments, to trace tectonic unconformities and to elucidate the tectono-stratigraphical significance of the succession for the Cretaceous geodynamic evolution of central Iran. To obtain these goals, several sections have been logged, sampled and biostratigraphically dated using macro – and microfossils (Wilmsen et al. 2020). The c. 800-m-thick Cretaceous succession rests on a pronounced palaeo-relief formed by basement rocks of the AMC. It starts with patchily developed continental red beds (Noqreh Formation) that can only be dated by stratigraphical superposition as pre-late Early Aptian. The overlying shallow-marine, rudist-bearing platform carbonates of the Shah-Kuh Formation accumulated in the latest Early Aptian, as indicated by orbitolinids. The lower member of the overlying

Bazyab Formation documents a considerable deepening in the early Late Aptian. The boundary to the middle member is a conspicuous mid-Late Aptian sedimentary unconformity, separating marly offshore strata below from shallow-marine, bioclastic sandstone above. Renewed deepening in the Early Albian resulted in the deposition of the deeper-marine upper marl member of the Bazyab Formation. In the earliest Cenomanian, another rudist platform formed, documented by the shallow-water carbonates of the Debarsu Formation. Above an intra-formational, Middle–Late Cenomanian tectonic unconformity, the carbonates of the lower Debarsu Formation were replaced by an upper marl member, reflecting a regionally widespread deep-water setting during the Turonian. The Debarsu Formation is truncated along another major regional unconformity correlated to an inter-regional Coniacian tectoevent, indicated by an extremely coarse, thick conglomerate at the base of the Haftoman Formation. The Cretaceous succession at the margin of the AMC is strongly reduced in thickness compared to the Khurarea, displaying a more proximal character. Nevertheless, the area was characterised by a similar succession of depositional environments and punctuated by the same tectonic events that may have their causes in far-field effects of large-scale ophiolite emplacements in the Neotethys Ocean to the southwest.

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MIDDLE CENOMANIAN AMMONITES FROM THE OBERHÄSLICH FORMATION (ELBTAL GROUP, GERMANY): THEIR IMPACT ON THE STRATIGRAPHY AND PALAEOGEOGRAPHY OF THE SAXONIAN CRETACEOUS

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A systematic reappraisal of ammonite faunas from the supposed exclusively lower Upper Cenomanian Oberhäslich Formation (Elbtal Group, Saxony) has documented that, in its lowerpart, several Middle Cenomanian taxa such as *Acanthoceras rhotomagense, Acanthoceras jukesbrownei,* early forms of *Calycoceras (Proeucalycoceras) picteti* and *Calycoceras (Newboldiceras) asiaticum asiaticum* occur (Wilmsen et al. 2022). Thus, ammonite biostratigraphy clearly shows that the Oberhäslich Formation ranges down into the Middle Cenomanian, comprising the *A. rhotomagense* and *A. jukesbrownei* zones, proved by their index taxa, while the lowermost Middle Cenomanian *Cunningtoniceras inerme* Zone is absent. Seemingly, the unequivocal early Late Cenomanian index fossils the Oberhäslich Formation is well-known for predominantly originate from its lithologically homogenous, fine-grained upper part that was widely quarried as a freestone (the former Unterquader) in historical times (Niebuhr et al. 2021). These new data evidently prove that the Oberhäslich Formation consists of two distinct members, Middle and early Late Cenomanian in age, respectively (the proposed Merbitz and Werksandstein members). The two members are separated by a sedimentary unconformity corresponding (in sequence stratigraphical terms to sequence boundary SB Ce 4 in the Middle–Upper Cenomanian boundary interval. The onlap of marine Middle Cenomanian strata of the Merbitz Member far onto the Osterzgebirge indicates that the Cenomanian transgression progressed much further southwards far earlier than hitherto thought. In addition, the stratigraphical superposition of the marine Middle Cenomanian Merbitz Member onto the fluvial Niederschöna Formation, also in the type region of the unit, clearly demonstrates that the latter strata are evidently Early Cenomanian in age, in contrast to some published stratigraphical assignments suggesting a Middle or even Late Cenomanian age. Previous palynological data from the Niederschöna Formation that supported the older age, largely ignored by subsequent workers, are thus confirmed. Palaeobiogeographically, the Saxonian ammonite assemblage from the Merbitz Member shows considerable resemblance to Middle Cenomanian acanthoceratine faunas from the historical type area of the Cenomanian Stage in Sarthe (France), that likewise occur in shallow-marine siliciclastic facies. In short, the occurrence of moderately diverse Middle Cenomanian ammonite faunas from the lower part of the Oberhäslich Formation shows that the transgression history of the Cretaceous in Saxony is much more complex than previously thought.

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AN EFFECTIVE AND REALISTIC DEFINITION OF THE BASE OF THE BERRIASIAN STAGE (J/K BOUNDARY)

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Any selected GSSP boundary should preferably conform to traditional/historical usage. The Jurassic/Cretaceous boundary was first placed at d'Orbigny's "Portlandian/Purbeckian" junction, near the subsequently used *Berriasella jacobi* ammonite Zone in Tethys (Wimbledon et al. 2020a) . Latterly, in the classical regions (Berrias, Le Chouet, Puerto Escaño, Crimea etc) the Tithonian/Berriasian boundary has been accepted as best defined within magnetosubzone M19n.2n, using the *Calpionella alpina* subzone (and its proxies) as the most widely distributed boundary level: just below the "fingerprint" M19n.1r (only 30,000 year "Brodno") Former Berriasian Working Group (ISCS) members studied all J/K marine and non-marine regions and useful sections in them: key microfossil marker species allowed correlation from Tethys to Mexico, the Andes and California. Using magnetostratigraphy, isolated marine (Arctic Russia) and non-marine basins (Purbeck facies) have been correlated. Inconsistent or uncalibrated suggested primary markers were rejected, some dismissed as thoroughly unsuitable (below). We examined these (calpionellid, ammonite and magnetozone) datums (in ascending order):

Subzone bases of *Praetintinopsella* (not always identified) and *Remanei* (not always easily found).

Mid-Tithonian, in M20, 1 myr+ earlier than accepted Berriasian base.

M19n base: no coincidence with widespread/consistent biomarkers

Jacobi Zone base: +/ – base M19n.2n, but *Strambergella jacobi* FO occurs considerably higher: limited to Mediterranean Tethys.

Alpina Subzone base, mid M19n.2n: closest definable level to *Jacobi* Zone base – widespread, consistent, associated with nannofossil FOs, and ammonite *Delphinella* FO. Just below M19n.1r, and close to the "Portlandian/ Purbeckian" boundary (sub-boreal)(Wimbledon et al. 2020b)

M19n.1r: not always detected, but a key secondary marker

M18r base: already 1 myr+ later than traditional stage base. No biomarkers fixed.

Ferasini Subzone base: not always clearly identified, position variable M19n/M18r *Elliptica* base: lower M17r (longest reversal)/M18n.

Occitanica base: varying levels in mid M17r. No nannofossil FO coincides. Index ammonites are taxonomically problematic, sometimes absent (*T. subalpina, T. occitanica*) and geographically limited. In the boreal, this is an impossible correlative level: M17r (doubtfully identified?) is the shortest magnetozone present.

Globally, the *Calpionella alpina* subzone base (with supporting, independently correlatable secondary markers and proxies) is the most consistent bioevent identified. We use a plexus of secondary markers: avoiding using only one defining taxon, as has happened with some other stages/ GSSPs. The boundary is marked by a turnover: dominant small *C. alpina*, rarer *Crassicollaria parvula* and *Tintinopsella carpathica*, replace a *Crassicollaria* assemblage.

Nannofossils act as proxies: *Nannoconus wintereri* FO (just below the boundary) and *Nannoconus steinmannii minor* FO (at/just above). In 2016, a formal vote of the 70-strong former Berriasian Working Group (ISCS) fixed this usage: Tré Maroua (Hautes-Alpes) was subsequently proposed as the GSSP. Notable additional proxies: boreal-sub-boreal belemnite *Tehamaensis* Zone (mid M19n.2n), in Siberia and Panthallasa (Japan and California); 140.22 ±0.14 Ma date on *Alpina* Subzone base (Argentina), a precise (?untested) system boundary age; base radiolarian “unitary zone” 14, just above the *Alpina* Subzone; the base of the *Substeueroceras koeneni* Zone in the Andes. Insurmountable problems remain: condensed Russian Platform marine sequences are unsuitable for magneto – or chemostratigraphy. And, in Siberia, Nordvik alone has so far yielded an acceptable magnetostratigraphy, but with uncertain ammonite and magnetozone assignments (Schnabl et al. 2015).

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NEW RECORDS OF FOSSIL SILICEOUS PHYTOPLANKTON FROM THE CRETACEOUS ARCTIC: WORK IN PROGRESS

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Siliceous phytoplankton, in today's oceans represented mostly by diatoms and silicoflagellates, is crucially important in carbon and silicon cycling, but its early fossil record is notoriously patchy and incomplete. There are spotty occurrences of diatoms in Lower Cretaceous (Barremian–Aptian) and possibly also Lower Jurassic rocks (e.g., Sims et al. 2006). The oldest diverse and well-preserved siliceous phytoplankton assemblages come from the Albian, but are known from only few deposits. By the Campanian, on the other hand, diatoms are widespread and diverse in marine environments (Harwood et al. 2007). These occurrences are separated by a ~30 my gap, spanning the Cenomanian through Santonian. Until recently, no well-preserved siliceous phytoplankton occurrences were known from this stratigraphic interval. Recently, important new diatom and silicoflagellate-bearing deposits of the Turonian to Campanian Kanguk Formation were discovered from sites located on Devon Island (Eisdbotn Graben), Ellesmere Island (Slidre Fiord and Sawtooth Range), Ellef Ringnes Island (Hoodoo Dome) and Bylot Island in Nunavut, and from correlative outcrops along Horton River and on Eglinton Island (Cape Nares) in the Northwest Territories (Tapia and Harwood 2002; McCartney et al. 2011). Some of these occurrences, characterized by excellent preservation and high taxonomic richness, were initially thought to straddle the Santonian/Campanian boundary based on diatom biostratigraphic correlation to Eurasian Platform and Southern Ocean sites (Witkowski et al. 2011). These are now known to extend back to the early Turonian and into OAE2. New age control from bentonite dating and carbon isotope stratigraphy provides a robust chronostratigraphy to date a mature silicoflagellate biostratigraphic framework, and to anchor the developing diatom biostratigraphy. Although each deposit contributes new information, the most continuous records of well-preserved assemblages are from the Kanguk Formation on Devon Island (~94 to 84 Ma; early Turonian to late Santonian) and from Mason River Formation outcrops along the Horton River (Campanian). Recent metre-scale sampling of a continuous (~150 m-thick) siliceous microfossil-bearing sequence on Devon Island provides a wealth of new information on the evolution and biostratigraphical utility of diatoms and silicoflagellates, which is presently being documented to help shed light on this poorly known interval, and to assess the contribution of fossil siliceous phytoplankton on global carbon and silica budgets in the Cretaceous realm.

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CHANGES IN BENTHIC FORAMINIFERAL ASSEMBLAGES DURING THE ONSET OF LATE CRETACEOUS COOLING IN THE SANTONIAN, IODP SITE U1513 (INDIAN OCEAN)

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The International Ocean Discovery Program (IODP) Expedition 369 "Australia Cretaceous Climate and Tectonics" recovered a nearly complete pelagic Santonian succession at Site U1513 on Naturaliste Plateau, ~400 km offshore Western Australia (Holes 1513A and 1513B). The data recorded at Site U1513 provide an exceptional insight into the biostratigraphy and palaeoecology of Late Cretaceous microfossil communities (Petrizzo et al. 2022 and references therein). Upon compiling benthic and planktic stable isotopic data, we see evidence that the drop in water temperatures was expressed in different magnitudes at different depth habitats. Sixty samples taken every 1.5 m throughout the Santonian succession were analysed. The deep-water benthic foraminiferal assemblage includes more than 140 taxa. Gavelinellids (*Notoplanulina*, *Gavelinella*, *Anomalinoides* and *Gyroidinoides*) are most abundant and, together with other epifaunal taxa, dominate most of the Santonian, while agglutinated benthic foraminifera are nearly absent. The benthic foraminiferal assemblage at Site 1513 shows a decline in diversity towards the Upper Santonian. We record a relative increase in opportunist taxa together with foraminifera with an infaunal mode of life as well as taxa tolerant of lower organic flux. Epifaunal taxa with a preference of oxic habitats decline in abundance and some groups (*Notoplanulina*, *Gavelinella* and *Anomalinodes*) are virtually absent by the Upper Santonian. Foraminifera exhibiting different habitat preferences show to have responded differently to the cooling ocean. Epifaunal and infaunal benthic foraminifera as well as different ecological groups of planktic foraminifera document a different pace in their reactions to changing palaeoenvironments (like changes in abundance and habitat preference). Surface-dwelling planktic foraminiferal oxygen isotope values show a prominent increase in 18O through the section, while epifaunal benthic foraminifera illustrate only a slight increase in 18O values. The Santonian cooling is primarily a surface water signal; however, the cooling trend recorded in benthic foraminifera follows the trend recorded in planktic foraminifera. According to the isotopic data, the surface waters cooled by 5°C, while the sea floor temperature declined by an average of 2°C.

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FORAMINIFERAL STRATIGRAPHY AND PALEOENVIRONMENTS OF A HIGH LATITUDE MARGINAL MARINE BASIN – A LATE CRETACEOUS RECORD FROM IODP SITE U1512 (GREAT AUSTRALIAN BIGHT)

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A new high-resolution micropaleontological record (deep water agglutinated foraminifera, DWAF) combined with additional geochemical data was produced from IODP Site U1512, with the goal of recognizing benthic foraminiferal biozones, their relationship to the Tethyan realm and associated paleoenvironmental changes. We document a diverse benthic foraminiferal assemblage consisting of 162 taxa (110 agglutinated and 52 calcareous). The most common elements of the DWAF assemblage are tubular (i.e., *Kalamopsis grzybowskii, Bathysiphon* spp.) and planispiral forms (i.e., *Ammodiscus* spp., *Haplophragmoides* spp., *Buzasina* sp., *Labrospira* spp.). The Turonian strata yield abundant *Bulbobaculites problematicus* and *Spiroplectammina navarroana*. The presence of *Uvigerinammina jankoi* provides a tie point to the Tethyan DWAF biozonation of Geroch and Nowak (1984).

The calcareous foraminiferal assemblage is composed of cosmopolitan deep-water forms including *Lenticulina*, *Dentalina, Gavelinella/Anomalinoides, Praebulimina* and *Pseudobolivina*. Organic geochemical data (notably steranes/hopanes ratios), foraminiferal assemblages, together with an increasing abundance of radiolaria reveal a complex and constantly changing marginal marine paleoenvironment. The prevailing regime (oxic or dysoxic, marine, or terrestrially influenced) was strongly influenced by paleobathymetry, unstable oceanic circulation and terrestrial runoff. These factors caused the paleoenvironment to change five times over 10 million years, each lasting <2 Ma. A major increase in the abundance of radiolaria (>50%) after the mid-Turonian followed a peak in the abundance of tubular epifaunal foraminifera during the lower to mid-Turonian. This is possibly related to an increase in bathymetry that could correspond to a preceding sea level lowstand, and associated changes in ocean chemistry, such as changes in organic flux or salinity. Foraminiferal and geochemical evidence from Site U1512 allow for far-reaching interpretations of the paleoenvironments of the Great Australian Bight during the Late Cretaceous.

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BENTHIC FORAMINIFERAL ASSEMBLAGE CHANGES DURING OCEANIC ANOXIC EVENT 2 IN THE SOUTHERN HIGH LATITUDES – IODP SITE U1516

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The International Ocean Discovery Program (IODP) Expedition 369 Australia Cretaceous Climate and Tectonics recovered an almost complete pelagic record of the Upper Cretaceous, including the Oceanic Anoxic Event 2 (OAE 2) at Site U1516 (Mentelle Basin, southeast Indian Ocean, offshore western Australia). The present study documents one of the few benthic foraminiferal records spanning the OAE 2 in the southern high latitudes. Coinciding with severe perturbances of the ocean-climate system and the extensive burial of organic matter, benthic communities experienced severe restrictions. The OAE 2 interval is characterized by a prominent positive carbon isotope excursion (CIE) and an associated low carbonate interval, visible in the sedimentary record. The microfossil assemblage documented at IODP Site U1516 illustrates an extreme decline in benthic foraminifera during OAE 2, that is followed by a profound repopulation event. Within a 30 m thick interval, 33 samples were analyzed for benthic foraminiferal taxonomy and palaeoenvironmental interpretations. According to the benthic foraminiferal taxa identified, a distal, bathyal depositional environment is inferred. Predominantly calcareous deep-water species were recovered, whereas agglutinated benthic taxa occu rarely. During the OAE 2 interval, gavelinellids, lingulogavelinellids and gyroidinoids dominate the assemblage. Agglutinated taxa are present throughout and show an increased abundance above the CIE and the low-carbon interval associated to the OAE 2. Upon comparing the pre – and post-CIE benthic foraminiferal assemblage, a higher relative abundance of gavelinellids (e.g., the genera *Gavelinella*, *Lingulogavelinella*, *Stensioeina*) after the main CIE is recorded, while the relative number of gyroidinids and other opportunistic taxa (e.g., *Dentalina*, *Lenticulina*) is highest below this interval. During the CIE and the low-carbonate interval, the microfossil record documents a substantial increase in Radiolaria, that completely replace calcareous fossils in most

samples. Foraminifera are almost absent in this interval, only one sample records benthic foraminifera. The absolute abundance of benthic foraminifera per gram is on average lower in the peak phase, right below the low carbonate interval, than in the fading phase of OAE 2 (~6 compared to ~50 foraminifera/g). The benthic foraminiferal dataset collected the Site U1516 represents one of the most complete records of the last global Oceanic Anoxic Event in the southern high latitudes and is an important record of environmental change recorded in benthic foraminifera in the Late Cretaceous in the Southern Hemisphere (Petrizzo et al. 2021).

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THE TIME OF RELOCATION OF EXOTIC ROCKS INTO FLYSCH DEPOSITS OF THE SKOLE NAPPE IN THE AREA OF PRZEMYŚL, POLISH OUTER CARPATHIANS

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Exotic rocks, represented by olistoliths and olistostromes, are a well-known component within deposits of the Polish Outer Carpathians. In this respect the Przemyśl area constitutes a classical region for their studies. One of the best-known sites, containing exotics, is the Kruhel Wielki Klippen located in the Skole Nappe, in the upper part of the Ropianka Formation (Leszczyny Member). However, the age of relocation of the exotics into the matrix of particular nappes remains unclear and still controversial. Niedźwiedzki (1876) dated it as Neocomian. Wójcik (1907) interpreted exotics from the Przemyśl area as olistoliths suspended in Oligocene beds, while Bukowy and Geroch (1956) dated marls adjacent to olistostromes near Kruhel Wielki as latest early Maastrichtian. According to Gucik (1986), the formation of horizons with exotics was a single event in the Paleocene, whereas Kotlarczyk (1988) argued for their presence both within Maastrichtian and Paleocene beds. Further studies by Geroch et al. (1988) based on foraminifera again yielded ambiguous results. Jankowski (1997, 2007) interpreted the Kruhel Wielki Klippen as part of the Miocene chaotic complex. Olszewska (2011) dated the matrix for exotics as Turonian and Maastrichtian-Oligocene in age. In the cartographic reports (Gucik et al. 2005, 2017) sites with exotics were assigned to the Upper Cretaceous and Paleocene interval. In light of the above discrepancies concerning the age of relocation of exotics into the Skole Basin, four study sites were chosen. The most promising data were obtained from the Zielonka section, located 1.5 km east of the Kruhel Wielki Klippen. The structural position of this site indicates that the beds located at Zielonka should either be below or host the exotic rocks. Four samples studied from Zielonka, containing mainly planktic foraminifera, have stratigraphical significance. Foraminiferal tests were in a satisfactory state of preservation, although commonly the apertural parts were filled and partly covered with sediment. Part of the specimens were broken or corroded by dissolution. No traces of redeposition were found. Over 20 species, characteristic mostly of the Campanian-Maastrichtian interval, were recognized representing the following families: Heterohelicidae, Globigerinelloidiidae, Hedbergellidae and Globotruncanidae. The planktic foraminifera from Zielonka (deposits either underlying or hosting the exotic blocks) can be safely dated as Middle to Late Maastrichtian. Among the recognized foraminifera, the narrow total stratigraphical range, i.e., Middle to Late Maastrichtian, have *Racemiguembelina fructicosa (R. fructicosa-P. hariaensis* Zone) and *Contusotruncana walfischensis (R. fructicosa-P. hantkeninoides* Zone). They co-occur with *Globotruncanita pettersi* and *Globotruncana aegyptiaca,* known from Campanian up to the Middle/Upper Maastrichtian *A. mayaroensis* Zone. Another confirmation of this age, albeit with a question mark, is the possible presence of *Contusotruncana plicata.* This form is represented by a single, poorly preserved specimen, therefore its presence needs confirmation. Benthic foraminifera are represented mostly by calcareous forms. A few specimens of *Bolivinoides draco* were identified. The presence of this form coincides with the biostratigraphical data resulting from plankton analysis. All of the above foraminifera data and structural position of the Zielonka section indicate that the exotic Kruhel Limestone blocks were relocated into the Skole Basin not earlier than middle to late Maastrichtian *(R. fructicosa-A. mayaroensis* zones). This is the lower limit, meaning that any younger relocation cannot be excluded.

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CRETACEOUS STRATIGRAPHY AND BIOTA IN THE SONGLIAO BASIN, NORTH-EAST CHINA

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In China, Cretaceous non-marine deposits are extremely widely distributed; they have been comprehensively studied recently (Xi et al. 2019). The Songliao Basin in north-east China is one of the largest Cretaceous non-marine basin worldwide, with the giant Daqing Oilfield situated in it. Well-preserved, continuous Cretaceous terrestrial deposits here provide unique material for studying the stratigraphy, biota, palaeoenvironment and palaeoclimate of the non-marine Cretaceous. The Cretaceous International Continental Scientific Drilling Project cores SK1, SK2 and SK3 from the Songliao Basin offer the rare opportunity to document Late Cretaceous non-marine stratigraphy, biota and palaeoenvironment over a long, continuously documented time interval (Wan et al. 2013; Wang et al. 2013; Gao et al. 2019). Based on cores SK1, SK2 and SK3, as well as on other borehole cores and outcrops, the stratigraphy and biota in the Songliao Basin are now well studied. The Lower Cretaceous Huoshiling, Shahezi, Yingcheng and Denglouku formations in the Songliao Basin comprise volcanic-volcanoclastic rocks and alluvial-lacustrine sedimentary rocks, while the Upper Cretaceous Quantou, Qingshankou, Yaojia, Nenjiang, Sifangtai and Mingshui formations are composed of lacustrine, deltaic and alluvial sedimentary rocks. The Huoshiling Formation is dated as Late Hautevian to Barremian, representing the onset of the Songliao Basin development. The boundaries between the Lower and Upper Cretaceous and between the Cretaceous and Paleogene are located within the lower Quantou Formation and upper Mingshui Formation, respectively. The biota of the Songliao Basin includes ostracods, plants, spores and pollen, dinoflagellates, charophytes, conchostracans, gastropods, bivalves, fishes and dinosaurs. Three key biota were identified from the Songliao Basin, namely the Jehol Biota (Huoshiling and Shahezi formations, ~130–115 Ma), Songhuajiang Biota (Denglouku to Nenjiang formations, ~110–79 Ma) and Mingshui Biota (Sifangtai and Mingshui formations, 76–65 Ma). A major biotic change occurred between the Nenjiang Formation and Sifangtai Formation, that is, between the Songhuajiang Biota and Mingshui Biota. However, there is no obvious expression of a mass extinction at the Cretaceous/Paleogene boundary in the Songliao Basin. In addition, due to sea water influx events, a few foraminifera, calcareous nannofossils and marine fish have been recovered from the Qingshankou and Nenjiang formations.

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EVOLUTION OF THE ARABIAN CARBONATE PLATFORM (APTIAN– CAMPANIAN) IN SOUTH-EAST TURKEY: RESPONSES TO PALAEOCLIMATE, TECTONICS AND PALAEOCEANOGRAPHICAL CHANGES

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Measured stratigraphical sections (İnişdere-Adıyaman, Türkoğlu-Kahramanmaraş and Sabunsuyu-Kilis) have enabled us to determine the carbonate platform evolution during the Aptian–Campanian interval in south-east Turkey. It starts with thin clastics and an overlying alternation of carbonates and clastics (3–50 m thick Areban Formation; Barremian–Albian) unconformably overlying basement rocks (Mülayim et al. 2019). A thicker carbonate sequence follows; the 40–410 m thick Sabunsuyu Formation (Albian–Cenomanian) is characterized by shallow subtidal carbonate facies and thicker dolostones. The Derdere Formation (Cenomanian) with an average thickness of 50-250 m overlies conformably the Sabunsuyu Formation and is characterized by cyclic shallow-water facies, while the platform evolved as a ramp type (Simmons et al. 2020). The 10–180 m thick Karababa Formation (Turonian–Santonian) is represented by organic-rich, hemi-pelagic to pelagic facies below becoming shallower upwards (bioclastic facies). Hardgrounds at the top of Derdere Formation were recognized by the presence of glauconite and phosphate at the base of the Karababa Formation. The latter is among the main source rocks in the region and is overlain by the 10–60 m thick Karaboğaz Formation, the second main source rock in the region (Santonian–Campanian) with a 'drowning' unconformity (Mülayim et al. 2019). The latter comprises organic-rich clayey limestones with chert nodules, being conformably overlain by shallow-water platform carbonates with rudists, calcareous algae, *Actaeonella*, sponges and bryozoans in the south or its pelagic equivalents (Saytepe Member, Campanian) in the north and by an alternation of pelagic limestone, marl, black shale, clayey limestone and cherty limestone facies (Sayındere Formation, Campanian–Maastrichtian, around 30–250 m thick). Abundant macrofossil occurrences in Saytepe and lateral equivalents and the Sayındere Formation can also be considered as bioevents related to changes in sea level/depth/nutrients in carbonate platform evolution. The contact between the Saytepe Member and Sayındere Formation is a drowning unconformity. A hardground surface is reflected by iron and manganese oxide crusts and a thin layer of sandy carbonate with abundant glauconite. Aptian–Campanian successions are characterized by rudists, actaeonellids, benthic and planktic foraminifera and calcareous algae of biostratigraphical importance (Mülayim et al. 2019). In the intervals studied, multiple hardgrounds were seen at three levels (Cenomanian, Turonian/Coniacian–Santonian and Campanian). The sudden changes triggered breaks in platform development, accompanied by regeneration after sudden deepening. Thus, the platform could not regenerate or partially developed as a small platform on tectonically elevated areas. However, earlier carbonate generations are well developed and can be correlated over long distances. Therefore it can be concluded that Cenomanian, Turonian/Coniacian–Santonian and Campanian platform regenerations can also be associated with the interplay of sea level, palaeoceanographical changes and tectonics (Yılmaz et al. 2018). Settlement of phosphate and the main source rocks directly above the hardgrouds can be associated with global oceanographical events and sea level changes during these time intervals. However, the last drowning event might have been mostly controlled by tectonics.

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