Journal of Nannoplankton Research

INA16 abstracts
Athens, Greece

volume 37 | special issue | september 2017

International Nannoplankton Association

16th International *ΝΑΝΝΟΠΛΑΓΚΤΟΝ*
Association Meeting
Athens, Greece
September 24-28, 2017

Diamond level

EYDAP

PALEO DATA

Gold level

International Nannoplankton Association

Silver level

The Micropalaeontological Society

Grzybowski Foundation

Network Stratigraphic Consulting Limited

Micropress.eu

StrataData

BugWare, Inc. Oilfield Paleontology

With the kind support of:

HELLENIC REPUBLIC
National and Kapodistrian University of Athens
Τμήμα Γεωλογίας και Γεωπεριβάλλοντος

Ελληνική Γεωλογική Εταιρία 1951

Επιτροπή Παλαιοντολογίας Στρωματογραφίας

hcmr ΕΛΚΕΘΕ

Ελάα Σαπωνοποιία

Attiki since 1928

ΕΟΤ

INA16 Athens, Greece 2017

Convenors | Organizing Committee & Members

Convenors

MARIA V. TRIANTAPHYLLOU
National and Kapodistrian University of Athens (NKUA)

JEREMY R. YOUNG
University College London (UCL)

Organizing Committee

MARIA TRIANTAPHYLLOU
National and Kapodistrian University of Athens

ATHENA ECONOMOU-AMILLI
Professor Emeritus
National and Kapodistrian University of Athens

MARGARITA DIMIZA
National and Kapodistrian University of Athens

KATERINA KOULI
National and Kapodistrian University of Athens

ELISAVET SKAMPA
National and Kapodistrian University of Athens

ODYSSEAS ARCHONTIKIS
National and Kapodistrian University of Athens

PARASKEVI NOMIKOU
National and Kapodistrian University of Athens

EUGENIA MORAITI
Institute of Geology & Mineral Exploration, (I.G.M.E)

STELLA PSARRA
Hellenic Centre for Marine Research

SPYROS BELLAS
Ministry of Environment, Energy and Climate Change

Special thanks are due to

Dr. LAUREL BYBELL for editing all submitted abstracts for the JNR abstract issue

Assoc. Prof. IOANNIS PAPANIKOLAOU (Agricultural University of Athens) for the geoenvironmental guiding during the pre-Conference fieldtrip to Corinth Canal

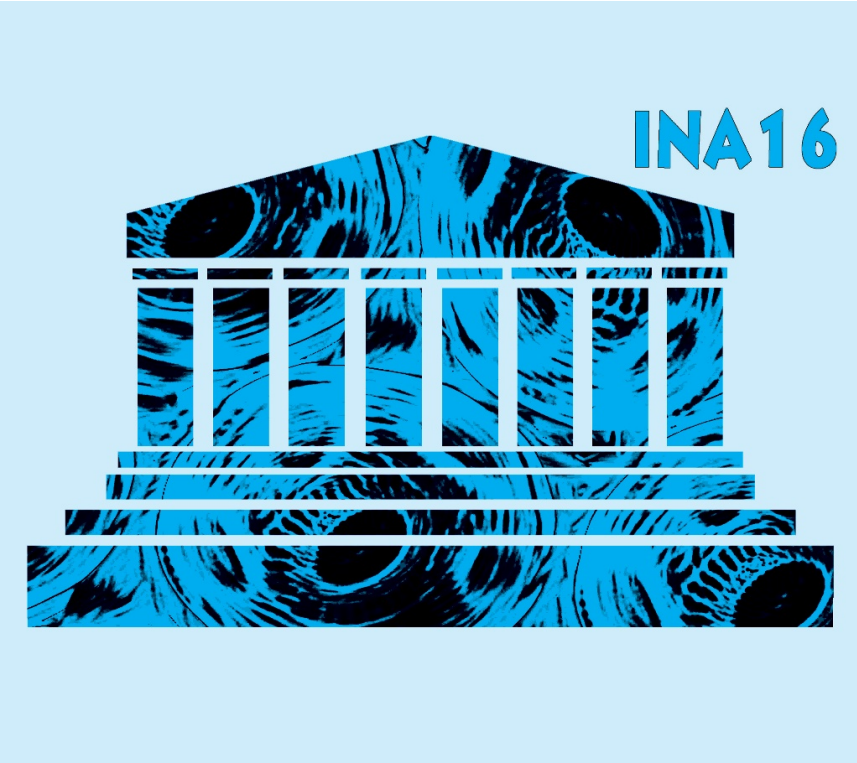
Professor Emeritus DIMITRIOS PAPANIKOLAOU (NKUA) and **Assist. Prof. PARASKEVI NOMIKOU** (NKUA) for the geoenvironmental guiding during the post-Conference fieldtrip to Santorini Island

Student and Staff Volunteers

NKUA (PhDs): Maria Athanasiou
NKUA (MSCs): Boris-Theofanis Karatsolis, Alexandra Ravani, Georgios Vasiliou, Stavroula Giannakopoulou
NKUA (undergraduates): Zois Arnopoulos, Teodora Blagoeva, Maria-Sofia Kapiri, Alexandra Koltiri, Konstantinos Miaritis, Kostas Panagiotaropoulos, Stelios Potamousis, Dimitris Prokos, Angelina Temponera, Kleoniki Theodoridou, Vasilis Tsigenopoulos
Aristotle University of the Thessaloniki (staff): Olga Koukousioura
Aristotle University of the Thessaloniki (undergraduates): Vasiliki Grigoria Dimou, Ioannis Michailidis, Pierros Patoucheas
Harokopion University of Athens: Anna Katsigera

INA16 Athens, Greece 2017

Scientific Committee



24-28 SEPTEMBER 2017

16TH INTERNATIONAL NANNOPLANKTON ASSOCIATION MEETING
ATHENS, GREECE

INA16 will be a perfectly enjoyable experience and a unique opportunity for all nanno-folks to exchange experiences, learn the state-of-the art and develop professional contacts around the globe.

Its main objectives are as follows:

- Nannofossil biostratigraphy - challenges, innovations and developments
- Coccolithophore taxonomy and size variations
- Coccolithophore phylogeny, species-concepts and molecular genetics
- Calcareous nannofossils - indicators of palaeoenvironmental, oceanographic and climatic changes
- Coccolithophore ecology - insights from seasonality and biogeography
- Understanding coccolithophore biocalcification
- Jurassic nannofossil biostratigraphy and paleoecology
- Ecosystem dynamics and applications
- Palaeoceanography of the Indian Ocean and the West Pacific – results from recent IODP cruises

ORGANIZER

National and Kapodistrian University of Athens, Faculty of Geology & Geoenvironment

VENUE / ACCOMODATION

Technical sessions and workshops will take place at the 5* Divani Acropolis Palace on Parthenonos str.117 42, located at the heart of Athens.

FIELD TRIPS

Pre-Conference Field trip will take place in Corinth Canal, Mycenae, Nafplion (23/9/2017; 9:00-19:00). One-day field trip by shuttle bus, including geological-archaeological-touristic tour and wine tasting.

Geoenvironmental guiding: Assoc. Professor Ioannis Papanikolaou

Post-Conference Field trip will take place in Santorini, the famous volcanic Island in the Aegean Sea (29/9-2/10/2017).

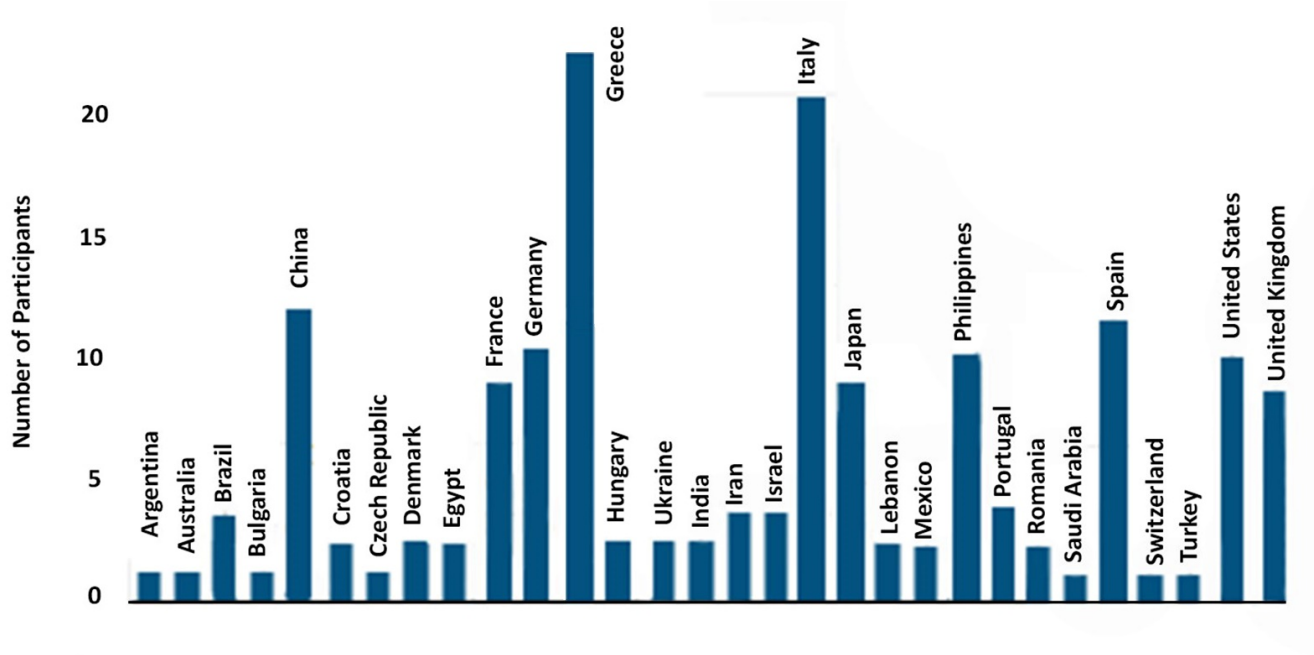
Geoenvironmental guiding:

Professor Emeritus Dimitrios Papanikolaou
Assistant Professor Paraskevi Nomikou

INA16 Meeting

Email: ina16hellas@gmail.com
Website: www.ina16athens.com

We are looking forward to welcoming more than 120 participants (approx. 80 oral and 65 poster presentations).
INA16 will accommodate a nice dispersion of participants all over the globe!



See you all in Athens!

MARIA TRIANTAPHYLLOU, JEREMY YOUNG

INA16 CONVENORS

ATHENS 2017

INA16 Scientific Programme

Saturday 23rd September

9:00 am – 7:00 pm
Pre-Conference Fieldtrip (Corinth Canal, Mycenae, Nafplion).
Geoenvironmental guiding:
Assoc. Prof. Ioannis Papanikolaou (Agricultural University of Athens)
Prof. Maria Triantaphyllou (NKUA)

Sunday 24th September

7:00 pm – 8:30 pm
Ice Breaker Reception/Cocktails. Divani Akropolis lobby

Monday 25th

8:00 am – 9:00 am
Registration Open/Poster Delivery

9:00 am – 9:30 am
Opening Ceremony
Welcome Address
Prof. Fotini Pomoni-Papaioannou Director of Dept. Historical Geology - Paleontology, NKUA
Dr. Dr.Dimitrios Tsagkas, General Director of IGME
Dr. Spyridon Bellas, Ministry of Environment, Energy and Climate Change
Prof. Maria Triantaphyllou - Dr. Jeremy Young, INA16 Convenors

Session 1- Nannofossil biostratigraphy- challenges, innovations & developments

Chairs: Isabella Raffi and Eric de Kaenel

9:30 am
Agnini, Raffi, Westerhold, Röhl
The role of calcareous nannofossils in age model construction: a further step towards high-precision chronologic frameworks

9:45 am
Alqudah, Khoury, Salameh, Mutterlose
An unconventional application of calcareous nannofossils - reconstructing the timing and the course of an Eocene meteorite impact in central Jordan

10:00 am
De Kaenel
Pleistocene calcareous nannofossil biochronology and biozonation

10.15 am
El Fiki, Tawfik, Ahmed, Afifi
Application of high-resolution biostratigraphy to differentiate and correlate reservoir units in Raven Field, Nile Delta, Egypt

10:30 am – 11:00 am
Morning Coffee Break

Session 1- Nannofossil biostratigraphy- challenges, innovations & developments (continued)

Chairs: Isabella Raffi and Eric de Kaenel

11:00 am
Young, Pratiwi, Su
The small *Reticulofenestra* event/*R. pseudoumbilicus* paracme revisited-new data from IODP Expedition 359

11:15 am
Jiang, Kuhanek, Watkins, Jordan, Hoshina
Latest Early Cretaceous calcareous nannofossils from southern Tibet, China

11:30 am
Malinverno, Bosio, Gariboldi, Gioncada, Di Celma, Villa, Urbina, Bianucci
Intergrated biostratigraphy and geochronology of sedimentary successions in the East Pisco Basin that crop out on the western side of the Ica River Valley (Ocucaje, Peru)

11:45 am
Matias, Gallemi
Dating paleontological collections that contain

poorly documented specimens

12:00 pm
Singh
Micula prinsii: latest Maastrichtian marker, record from low latitude northeast India, Meghalaya.

12:15 pm
Hassanein, Giraud, Robert, Jaillard, Masrour, Aly, Hammed
Intergrated stratigraphy of the uppermost Barremian-lower Albian in the Essaouira - Agadir Basin (western Morocco) and correlation with northern Tethyan basins

12:30 pm
Triantaphyllou
A review of Cenozoic calcareous nannofossil biostratigraphic studies in the Hellenic territory (Greece): achievements and limitations

12:45 pm – 2:00 pm
LUNCH

Session 2- Coccolithophore taxonomy and size variations

Chairs: Luc Beaufort and Jeremy Young

2:00 pm
Aubry
A high rank taxonomic classification of the Cenozoic coccolithophores and their Mesozoic roots

2:15 pm
Beaufort, Gally, Barbarin, Mazur, Bolton
Regularity in the quaternary variations of Noelarhabdaceae morphology

2.30 pm
Bottini, Faucher
The effect of mic Cretaceous paleoenvironmental changes on *Biscutum constans* size changes

2:45 pm
Kim, Bown, Gibbs
Recovery of plankton cell and coccolith size after the Cretaceous - Paleogene mass extinction (IODP Expedition 3442 Sites 1403 and 1407, North Atlantic)

3:00 pm
Mattioli, Gollain, Bartolini
Calcareous nannoplankton in a changing paleoworld, a tale of size variations

3:15 pm
Möller, Bornemann, Mütterlose
Size changes of calcareous nannofossils during the Weissert Event (Early Cretaceous)

3:30 pm
Prista, Narciso, Cachão
A new morphometric approach to coccolith morphometry: reassessing *Coccolithus pelagicus* s.l. data from the Holocene

3:45 pm
Zhang, Liu, Jin, Zhou, Bolton
Measuring the sinking characters of coccolith: a refinement of coccolith separation methods

4:00 pm – 4:30 pm
Afternoon Coffee Break

Session 2- Coccolithophore taxonomy and size variations (continued)

Chairs: Luc Beaufort and Jeremy Young

4:30 pm
Varol, Bowman
Taxonomic revision of selected Tithonian species based on the examination from mobile mounting

4:45 pm
Howe
The Ultrastructure of the Family Sphenolithaceae

Session 3- Calcareous nannofossils - indicators of paleoenvironmental, oceanographic and climatic changes

Chairs: Emma Sheldon and Marie-Pierre Aubry

5:00 pm
Denne, Kita
Calcareous nannofossils from the late Campanian

Manson impact structure at the eastern edge of the Western Interior Seaway

5:15 pm
Hassanein, Giraud, Jaillard, Robert, Aly, Hammed, Masrour
Paleoenvironmental conditions during the Aptian-early Albian in the Essaouira - Agadir Basin, western Morocco.

5:30 pm
Püttmann, Linnert, Dölling, Mütterlose
Calcareous nannofossils from Late Cretaceous (Cenomanian - Campanian) shallow-marine deposits in northwest Germany - a record for coastal dynamics

5:45 pm
Sheldon, Dybkjær, Ineson
Timing and paleoceanographic implications of the North Sea 'base Cretaceous Unconformity' event at its correlative conformity: a multi - disciplinary core study, North Jens-1 well, Danish Central Graben

Tuesday 26th September

Session 3- Calcareous nannofossils - indicators of paleoenvironmental, oceanographic and climatic changes (continued)

Chairs: Elisabetta Erba and Mario Cachao

8:45 am
Athanasiou, Bouloubassi, Gogou, Klein, Dimiza, Parinos, Skampa, Triantaphyllou
Paleoclimatic conditions during the "warm Pliocene" interval (~4.1–3.2 Ma) in the eastern Mediterranean (Cyprus): a combined alkenone and calcareous nannofossil study

9:00 am
Lupi, Bordiga, Sacchi, Cobianchi
Middle Pleistocene Transition mechanisms and calcareous nannofossils at ODP Site 1209 (NW Pacific Ocean)

9:15 am
Marquez, Peleo-Alampay, Liu
Late Holocene events in the Sibuyan Sea, Philippines, based on calcareous nannofossils, granulometry, and sediment geochemistry

9:30 am
Martínez-Sánchez, Flores, Sierro, Alonso-García
Productivity and North Atlantic subpolar dynamics at orbital-to-millennial scales during middle Pleistocene Marine Isotope Stages 19–11

9:45 am
Saavedra-Pellitero, Baumann, Lamy, Köhler, Ullermann
Coccolithophore productivity during MIS 11 in the Pacific sector of the Southern Ocean and its impact on the carbon cycle

10:00 am
Sagular, Yavuzlar
Calcareous nannofossils from the Manavgat Sub-basin, SW Turkey, reveal the age of lower Pleistocene paleotsunami deposits that overlie a late Pliocene erosional surface

10:15 am
Kulhanek, Castro, Lakin, Morelos, Prebble, Bostock, Cortese
Early Holocene calcareous nannofossil assemblages as indicators of past sea surface temperature and nutrient conditions in the New Zealand region

10:30 am – 11:00 am
Morning Coffee Break

Session 3- Calcareous nannofossils - indicators of paleoenvironmental, oceanographic and climatic changes (continued)

Chairs: Jose-Abel Flores and Karl-Heinz Baumann

11:00 am
Belhajtahar, Mattioli, Soussi, Chaabane
Calcareous nannofossil assemblages across the Paleocene-Eocene transition in the Kharouba section, northern Tunisia

11:15 am
Chakraborty, Bown, Ghosh, Young
Calcareous nannofossils from the Miocene of the Andaman and Nicobar Islands, India: biostratigraphic and paleoecological perspectives

11:30 am
Chira, Aroldi
Oligocene - lower Miocene calcareous nannofossils and sedimentology of the Transcarpathian Basin in Romania

11:45 am
Galović
Coccolithophores and environmental changes during mid-Miocene major events - responses and records at the marginal Paratethys

12:00 pm
Nyerges, Kocsis, Pálfy
Changes in calcareous nannoplankton assemblages across the Eocene - Oligocene transition in the Hungarian Paleogene Basin (Central Paratethys)

12:15 pm
Raffi, Liebrand, Fraguas, Hilgen, Wilson, Batenburg, Beddow, Crocker, Huck, Lourens, Bohaty, Sabia
Recurrent *Braarudosphaera* acmes in the mid-Oligocene subtropical South Atlantic Ocean linked to astronomical forcing of the hydrological cycle

12:30 pm
Chin, Watkins
Investigating the late Campanian - Maastrichtian cooling trend using clumped isotopes on the coccolith fraction of sediments from the Boreal Chalk Sea and Shatsky Rise

12:45 pm – 2:00 pm
LUNCH

Session 4- Coccolithophore phylogeny, species-concepts and molecular genetics

Chairs: Jeremy Young and Kyoko Hagino

2:00 pm
Aubry
The haploid coccolithophore

2:15 pm
Bendif, Laurent, Probert, von Dassow, Cros, Young, Jeanthon, Garczareck, de Vargas
Microdiversity of cosmopolitan coccolithophores through an oligotrophic gradient in the Mediterranean Sea

2:30 pm
Bendif, Probert, Young, de Vargas
Puzzling speciation and adaptive patterns in the *Gephyrocapsa* complex

2:45 pm
Cappelli, Agnini, Bown, Yamamoto
Middle Eocene evolutionary lineages from the North Atlantic Ocean, IODP Site U1410: biostratigraphic and paleoecological constraints

3:00 pm
Ghosh, Chakraborty, Bown, Young
Early Zanclean nannofossils from Car Nicobar Island, northern Indian Ocean, with remarks on the evolutionary significance of the genus *Ceratolithus*

3:15 pm
Hagino, Bendif, Probert, Young
Molecular phylogenetic position of *Reticulofenestra sessilis*

3:30 pm
Jin, Liu, Zhang
Gephyrocapsa physiology over the past 400 ka

3:45 pm – 5:30 pm
Afternoon Coffee Break | Poster Authors in Attendance

Wednesday 27th September

Session 5- Coccolithophore ecology - insights from seasonality and biogeography

Chairs: Simonetta Monechi and Maria Triantaphyllou

8:45 am
Skampa, Triantaphyllou, Dimiza, Malinverno, Archontikis, Parinos, Stavrakakis, Gogou
Coccolithophore export fluxes in the NE Mediterranean as revealed from different sediment trap records

9:00 am

Archontikis, Dimiza, Malinverno, Triantaphyllou
Coccolithophore biogeography in the eastern Mediterranean: surface sediment evidence

9:15 am
Fonseca, Cachão
The Cretaceous paleobiogeography of *Braarudosphaera bigelowii*

9:30 am
Galović
Coccolithophore ecology - insights from seasonality and biogeography on local and global scales

9:45 am
Karatsolis, Triantaphyllou, Dimiza, Malinverno, Archontikis, Psarra
Tracing NE Aegean water masses using phytoplankton (coccolithophore and silicoflaggelate) assemblages

10:00 am
Meier, Kinkel
Seasonal succession of coccolithophores during a long-term monitoring in the Kiel Fjord (SW Baltic Sea)

10:15 am
Álvarez, Álvarez, Francés, Diz, Grimalt, Casado
Rapid dynamics changes in NE Atlantic transitional surface waters during the last 57 ka

10:30 am – 11:00 am
Morning Coffee Break

Session 5- Coccolithophore ecology – insights from seasonality and biogeography (continued)

Chairs: Simonetta Monechi and Maria Triantaphyllou

11:00 am
Patil, Mohan, Gazi, Shetye, Jafar
Is *Emiliania huxleyi* expanding its presence in polar waters? Evidences from multiyear observations

11:15 am
Rigual-Hernández, Wilks, Trull, Sierro, Fuertes, Bray, Armand, Flores
Coccolithophore and diatom distribution across the main pelagic zonal systems of the Southern Ocean

11:30 am
Tangunan, Baumann, Pätzold, Henrich, Kucera, De Pol-Holz, Groeneveld
Evidence of tropical Pacific forcing in the western Indian Ocean coccolithophore productivity record

Session 6- Understanding coccolithophore biocalcification

Chairs: Gerald Langer and Luc Beaufort

11:45 pm
Balistieri, Ziveri, Mortyn, Fornaciari, Agnini
Coccolith carbonate export dynamics at ODP Site 1089 (Southern Ocean) during the last deglaciation

12:00 pm
Faucher, Erba
A look into coccolith sizes and shapes: the morphological responses of coccolithophore algae calcification to trace metal concentrations

12:15 pm
Gal, Faivre, Scheffel
The roles of coccolith organic components in calcite crystallization

12:30 pm – 2:00 pm
LUNCH

Session 6- Understanding coccolithophore biocalcification (continued)

Chairs: Gerald Langer and Luc Beaufort

2:00 pm
Intxaukspe-Zubiaurre, Flores, Payros
Dissolution and calcification patterns in calcareous nannofossils during the middle Eocene C21r-H6 hyperthermal event (~47.4 Ma) at the Gorrondatxe section (Bay of Biscay, western Pyrenees)

2:15 pm
Langer, Probert, Brownlee, Walker, Wheeler
The silicon requirement of coccolithophore calcification

2:30 pm
Su, Liu, Beaufort
Changes in coccolith weight in the northern South China Sea and their environmental controls

2:45 pm
Suchéras-Marx, Marfil, Beaufort
Pelagic carbonate production across the Cretaceous-Paleogene boundary

3:00 pm
Walker, Taylor, Langer, Tyrrell, Brownlee, Wheeler
Investigating the role of calcification in Coccolithophores

3:15 pm
Perrin, Probert, Langer, Beaufort, Aloisi
Combining physiological modeling at the cellular scale and in situ biogeochemical data to investigate the deep niche of *Emiliania huxleyi* in the South Pacific Gyre

3:30 pm – 5:30 pm
Afternoon Coffee Break | Poster Authors in Attendance

Thursday 28th September

Workshop: Jurassic nannofossil biostratigraphy and paleoecology

Organizer: Emmanuela Mattioli

8:45 am
Ferreira, Mattioli
Numerical tactics to disentangle Lower-Middle Jurassic nannoplankton biogeographic relationships

9:00 am
Fraguas, Comas-Rengifo, Gómez, Goy
Warming-driven nannofossil crisis in the early Toarcian of northern Spain

9:15 am
Menini, Mattioli, Suan, Pittet
The Pliensbachian-Toarcian boundary event (Early Jurassic): New paleoenvironmental interpretations based on calcareous nannofossils data

9:30 am
Stoykova, Grabowski, Lakova
Tithonian - early Berriasian calcareous nannofossil events in Barlya, Bulgaria, and Lókút, Hungary: calibration with magnetostratigraphy and calpionellid biostratigraphy

9:45 am
Thibault, Peti
Abundance and size changes in *Schizosphaerella* – relation to climatic and paleoenvironmental change across the Early Jurassic of the Paris Basin

10:00 am
Visentin, Reolon, Faucher, Erba
Calcareous nannofossil biostratigraphy and paleoceanography across the Toarcian Oceanic Anoxic Event cored at Colle di Sogno (Lombardy Basin, northern Italy)

10:15 am
Discussion

10:30 am – 11:00 am
Morning Coffee Break

Session 7- Ecosystem dynamics and applications

Chairs: Athena Economou-Amilli and Richard Jordan

11:00 pm
Chantzistrountsiou, Lamprinou, Gratsia, Evrigeni, Tzovenis, Economou-Amilli
The microalgae strain bank ATHU-AL at the University of Athens (NKUA)

11:15 pm
Kalaroni, Tsiaras, Petihakis, Economou-Amilli, Triantafyllou
Modeling Mediterranean pelagic phytoplankton

11:30 pm
Jordan, Fujita
Phytoplankton biogeography in the western Pacific and Indian Ocean

11:45 pm
Malinverno

Extant *Stephanocha speculum* from the Ross Sea: abundance, morphologies, and double skeletons

12:00 pm
Kermandji, Kermandji, Touhami
Middle Devonian miospore assemblage biozones in Sahara synclines (Algeria): geological implication and evidence for stages boundaries

12:15 pm
Nomikou
A seafloor observatory for the Kolumbo volcano: an informed modelling system

12:30 pm
Young, Bown
Nannotax: progress and prospects

12:45 pm – 2:00 pm
LUNCH

2:00 pm – 4:00 pm
INA BUSINESS MEETING | CONFERENCE CLOSING

7:00 pm
CONFERENCE DINNER | Limni Vouliagmenis

Friday 29th September – Monday 2nd October

7:30 am
Post-Conference Fieldtrip (Santorini Island, Aegean Sea)
Geoenvironmental guiding:
Prof. Emeritus Dimitrios Papanikolaou (NKUA)
Assist. Prof. Paraskevi Nomikou (NKUA)

POSTER PRESENTATIONS

Abe, Jordan
Late Eocene silicoflagellates from Oamaru, New Zealand

Albasrawi, Watkins
Early Miocene quantitative calcareous nannofossil biostratigraphy from the tropical Atlantic

Alqudah, Hakimi, Abdullah, Hussein, Masri, Mutterlose
Calcareous nannofossil biostratigraphy of the Cenomanian - Turonian interval (Cretaceous) from Jordan

Al Rawahi
Upper Cretaceous calcareous nannofossil biostratigraphy and paleoceanography from Tethyan sediments of Oman

Álvarez, Gutiérrez-Ramírez, Gaviño-Rodríguez, Carbajal-Pérez
Theoretical hydrodynamic efficiency of coccoliths and coccolithophores

Álvarez, Vega-Corza, Bárcena, Quijano-Scheggia
Effect of dense shelf water cascading over planktic fluxes in the Gulf of Lions (NW Mediterranean)

Arapov, Skejić, Bužančić, Bakrač, Ninčević
Seasonal distribution of coccolithophores in the open waters of the central Adriatic Sea

Athanasiou, Triantaphyllou, Dimiza, Gogou, Tsiolakis
Lower-middle Miocene sapropelic layers (Nicosia, Cyprus) and paleoceanographic implications

Ausín, Flores, Zúñiga, Cavaleiro, Granda, Villacieros-Robineau, Alonso-Pérez, Froján, Arbones, Santos, Castro, Abrantes, Eglinton
Spatial and temporal variability in coccolithophore abundance and distribution in the NW Iberian Margin

Baumann, Donner, Köbrich, Fischer
Calcareous plankton fluxes in the upwelling area off NW Africa (Cape Blanc) - dynamics and trends from selected sediment trap series in the past 28 years

Baumann, Vollmar
Coccolithophore response to changes in surface water conditions in the North Atlantic (ODP Site 984) during Marine Isotope Stage 5

Bazzicalupo, Maiorano, Girone, Marino, Nebout-Combourieu, Incarbona
Coccolithophore behavior during short-term climate fluctuations over the last deglaciation: evidence from the Alboran Sea, western Mediterranean

Bottini, Erba, Artoni
Calcareous nannofossils at the Triassic-Jurassic boundary: stratigraphic and paleoceanographic characterizations

Callejo, Fernando
Calcareous nannofossils from the proposed Kapurpurawan National Geological Monument, Ilocos Norte (northwestern Philippines)

Cappelli, Galeotti, Moretti, Lanci, Monechi
The evolution of fasciculiths in the Danian Bottaccione section (Italy): a glance at biotic and geochemical evolution

Castro, Fernando
Calcareous nannofossil biostratigraphy of the late Oligocene to early Miocene Lubuagan Formation (western Cagayan Valley Basin), Kalinga Province, Philippines

Chira, Negru, Balog, Bedelean
Middle Miocene paleoenvironments in the Strei Basin (Romania): calcareous nannofossils, micro- and macrofauna, and sedimentology

Chiyonobu, Sato
Cretaceous calcareous nannofossil biostratigraphy off the coast of northeastern Honshu, Japan

Colmenero-Hidalgo, Ausín, Simón-Baile, Flores, Sierro, Bárcena
Deglacial to Holocene oceanographic changes in the Gulf of Cádiz and the western Mediterranean as revealed by coccolithophores

Cros, Fortuño, Estrada
Coccolithophore seasonality in the NW Mediterranean Sea

Cunha, Motta, Wanderley, Pedrosa
Cretaceous calcareous nannofossils from the São Paulo Plateau (DSDP Leg 39, Site 356): biostratigraphy and paleoecological implications

Doyongan, Fernando, IODP Expedition 363 Scientists
Calcareous nannofossil biostratigraphy of the Oligocene-Miocene interval in IODP Expedition 363 Hole U1490A, northern Eauripik Rise, western Pacific

Ferrnando, Jones, Beaufort, Kulhanek, IODP Expedition 363 Scientists
Stratigraphic distribution of a four-rayed symmetric discoaster in IODP 363 sites in the Indian Ocean and Pacific Ocean

Fernando, Magtoto, Fernandez, Uy
Calcareous nannofossil biostratigraphy of Middle to Late Cretaceous sections in the Philippines

Franceschetti, Martinez-Braceras, Payros, Monechi
The lower Eocene Sopelana section: new insights into environmental effects and biotic response of astronomically driven climate change

González-Lanchas, Remacha, Sierro, Flores
Middle and late Eocene calcareous nannoplankton in the Jaca Basin (south-central Pyrenees Eocene Basin): a biostratigraphic and environmental approach

Granchovski, Stoykova
Nannofossil biostratigraphy of the upper Campanian–Maastrichtian in NW Bulgaria (SE Europe)

Guballa, Peleo-Alampay, IODP Expedition 349 Scientific Party
Calcareous nannofossil biostratigraphy and paleoceanographic clues from the latest Pliocene-Pleistocene from IODP Expedition 349 Site U1431D, South China Sea

Holcová, Hradilová
Calcareous nannoplankton in the chalk grounds of the Romanesque Madonna of Sedes Sapientiae type

Holcová, Michalík
Calcareous nannoplakton from the Triassic/Jurassic boundary interval (section Kardolina, Western Carpathians)

Hoshina, Lei, Wu, Jiang, Jordan
Microfossils from the Precambrian-Early Cambrian, Chengjiang, China

Jalili, Hadavi
Nannostratigraphy of a marly shale flyshoid from Afzalabad in northern Birjand (eastern Iran)

Kallanxhi, Ćorić
Calcareous nannofossils from Oligocene-middle Miocene sediments from the Albanian - Thessalian Basin (Albania): biostratigraphy and paleoecological implications

Kallanxhi, Ćorić, Mandic
Biostratigraphy and paleoenvironment of the Middle Miocene deposits from the southern Pannonian Basin (Bosnia and Herzegovina) based on calcareous nannofossils

Kallanxhi, Koucal, Wagreich
Paleocene - Eocene calcareous nannofossil biostratigraphy from the Gams area (Gosau Group, Northern Calcareous Alps, Austria)

Karatsolis, Dimiza, Nomikou, Polymenakou, Mandalakis, Archontikis, Malinverno, Mertzimekis, Pappa, Triantaphyllou
Possible effects of Kolumbo submarine volcano emissions (Cyclades, Aegean Sea) on coccolithophore assemblages

Kinkel, Baumann, Meier, Young
Biometry of the genus *Gephyrocapsa* during the past 2 million years - implications for taxonomy, stratigraphy, and evolution

Koukousioura, Dimiza, Triantaphyllou, Michailidis, Dimou, Navrozidou, Seferlis
Winter-spring living coccolithophores from Thermaikos Gulf, NW Aegean Sea

Liu, Zhou, Zhang, Liu
Sedimentary mechanisms for the late Miocene deep-sea nannofossil oozes from the South China Sea

Mahanipour, Barmakizadeh
Evidence of Faraoni Oceanic Anoxic Event in Zagros Basin, West of Iran

Mahanipour, Eftekhari
The First record of Mid-Barremian Oceanic Anoxic Event in Zagros Basin: Evidence from calcareous nannofossils

Malinverno, Karatsolis, Triantaphyllou, Cerino
Time series of silicoflagellates and ebridians in the eastern Mediterranean and Black Seas

Martino, Bottini, Erba, Morsalnejad, Parente
Calcareous nannofossils from the Upper Triassic-Lower Jurassic of Lurestan (Iran): preliminary data

Mejía-Molina, Flores, Sierro
Calcareous nannofossil biochronology and paleoecology of onshore and offshore Miocene Colombian sequences

Mikellidou, Triantaphyllou, Patruno, Pomoni-Papaioannou, Karakitsios
Late Cretaceous deposits from Zakynthos Island (Preapulian Zone, Ionian Sea, western Greece): evidence from calcareous nannofossil dating and microfacies analysis

Möller, Ineson, Sheldon
A nannofossil and geochemical investigation into the top Tor hardground, a reservoir barrier/baffle in the Danish Sector of the North Sea

Nogot, Peleo-Alampay, Marquez-Ardiente, Fernando
Distribution of living coccolithophores in the marginal and inland seas in the Philippine Archipelago

Ovechkina
Calcareous nannoplankton and stable oxygen isotopes as proxies for paleoenvironmental reconstructions of the Albian - Cenomanian succession in the Mount Carmel Region (northwestern Israel)

Ovechkina, Avni
Calcareous nannoplankton biostratigraphy of the early–middle Eocene of the central Negev (southern Israel)

Parandavar, Hadavi
Calcareous nannofossil biostratigraphy of the Qom Formation in central Iran

Peleo-Alampay, Marquez-Ardiente, Wiesner, Fernando, de Silva
Calcareous nannofossils and foraminifera from the surface sediments of the Gulf of Tonkin, South China Sea

Pérez Panera, Cuciniello, Agudelo, Olivero
Early Eocene calcareous nannofossils of the Punta Torcida Formation, Austral Basin, Patagonia: biostratigraphy and paleoceanography

Quivelli, Marino, Rodrigues, Girone, Maiorano
Millennial scale climate variability during Marine Isotope Stage 19: calcareous nannofossil, alkenone, and planktonic foraminiferal evidence at ODP Site 975 (Balearic Basin)

Ravani, Karatsolis, Dimiza, Triantaphyllou, Malinverno, Lagaria, Psarra
Coccolithophore distribution in the western Black Sea during early summer 2016

Saavedra-Pellitero, Baumann
Ocean and monsoonal dynamics of the Japan Sea over the last 450,000 years - a coccolithophore perspective

Skejić, Arapov, Bužančić, Ninčević
Winter-spring aspect of coccolithophore species diversity in the open waters of the central Adriatic Sea

Su, Kulhanek
Initial age and deposit environment during onset rifting of the South China Sea and the West Philippine Sea: nannofossil evidences

Tangunan, Baumann, Brentegani, Expedition 361 scientists
The last 1 million years of discoasters: late Pliocene productivity at IODP Site U1476 (Mozambique Channel)

Toledo, Quadros, Camillo, Costa
Paleoceanography for the last 772 ky in the western South Atlantic by means of calcareous nannofossils

Triantaphyllou, Baumann, Karatsolis, Dimiza, Skampa, Vollmar, Archontikis, Nomikou, Koukousioura, Michailidis, Patoucheas, Psarra
Coccolithophore community response along a natural CO_2 gradient off Methana (northeastern Peloponnese peninsula, Aegean Sea)

Tsutsui, Jordan
Semi-automated morphometric system for early Eocene *Naviculopsis* spp. (Silicoflagellata)

Uezato, Jordan
Miocene silicoflagellates from the Paratethys

Utsunomiya, Hagino, Tanaka
Stratigraphic variation in abundance, species composition, and morphology of the genus *Umbilicosphaera* (Calcidiscaceae) in the Pliocene - Pleistocene of ODP Site 709C core (western equatorial Indian Ocean

Uy, Peleo-Alampay, IODP Expedition 349 Scientific Party
Refining Pleistocene-Holocene calcareous nannofossil biostratigraphy of IODP Expedition 349 Site 1433, South China Sea

Vollmar, Strack, Baumann
Modern and past morphology of *Emiliania huxleyi* and its co-occurrence with other Noelaerhabdaceae in the Atlantic Ocean

Late Eocene silicoflagellates from Oamaru, New Zealand

Junya Abe
Yamagata University, Earth Sciences Cluster, Yamagata, Japan; strike_count0@i.softbank.jp

Richard W. Jordan
Yamagata University, Yamagata, Japan; sh081@kdw.kj.yamagata-u.ac.jp

In previous studies, the Oamaru diatomite was dated using diatoms and radiolarians and placed in the late Eocene-early Oligocene. At that time, Oamaru was located about 50km offshore. The excellent preservation of these deposits allowed us to investigate the taxonomy and morphology of the Oamaru silicoflagellates. Silicoflagellates have been under-utilized in biostratigraphic and paleoenvironmental reconstructions due to problems in their classification. Both living and fossil silicoflagellates exhibit a wide range in skeletal morphologies, and skeletal aberrations are quite common. Sometimes, end-member morphologies and aberrants have been described as distinct taxa. In order to improve silicoflagellate taxonomy, it is necessary to document the full range of morphologies exhibited by each taxon. In this study, two outcrop samples from the Schulz Collection were observed and photographed using a light microscope. At Jackson's Siding, the assemblage was dominated by four genera (*Corbisema*, *Naviculopsis*, *Distephanopsis*, and *Dictyocha*), each representing about 20–30% of the total assemblage. At Totara, the assemblage was dominated by *Corbisem*a and *Naviculopsis*, representing 42% and 28%, respectively. Aberrant skeletons provided clues about the order in which skeletal growth occurs, with the basal sides and basal spines being the final steps. Most aberrations occurred in these final steps, rather than at the beginning, as skeletons with aberrant apical structures were much rarer. A morphometric study of the *Naviculopsis* spp. in our Oamaru sample collection revealed that longer specimens tended to have narrow bridges, whilst shorter specimens exhibited a wide range in bridge width. Average spine length and average window length vs. skeleton length showed clear linear trends, but the points in the plots of average spine length and skeleton length vs. skeleton width were more scattered, albeit grouped in a linear trend. This suggests that skeleton width is less constrained than other skeletal dimensions.

The role of calcareous nannofossils in age model construction: a further step towards high-precision chronologic frameworks

Claudia Agnini
Università degli Studi di Padova, Dipartimento di Geoscienze, 35131 Padova, Italy; claudia.agnini@unipd.it

Isabella Raffi
Università degli Studi "G. d'Annunzio" di Chieti-Pescara, 66100 Chieti CH, Italy; isabella.raffi@unich.it

Thomas Westerhold
University of Bremen, MARUM – Center for Marine Environmental Sciences, 28334 Bremen, Germany; twesterhold@marum.de

Ursula Röhl
University of Bremen, MARUM – Center for Marine Environmental Sciences, 28334 Bremen, Germany; uroehl@marum.de

Calcareous nannofossils have been a powerful tool for regional and worldwide biostratigraphic correlations and dating of the entire Cenozoic. Biochronologic estimates, which have greatly improved in the last 20 years, are derived from high-resolution calibrations of biohorizons that are based upon other independent chronological scales, such as magnetostratigraphy, stable isotope stratigraphy, and orbitally tuned cyclostratigraphy. Calcareous nannofossils can play different roles in dating and correlation: (1) provide preliminary control points for astronomical tuning of cyclostratigraphic records of deep-sea sediments and (2) improve biochronology through orbitally-tuned time scales. The improvement in precision of bioevent age calibrations is obviously related to the construction of an accurate high-fidelity age model that derives from an integrated approach. This strategy can be developed only if different skills are grouped together, and implies a more difficult effort in term of data gathering, but it guarantees the quality of the final results and permits the construction of highly resolved, integrated time scales.

In a recent example of this approach for the early Eocene (ca. 56–47Ma) (Westerhold *et al*., 2017), multi-site, high-resolution proxy records (XRF core scanning iron intensity, bulk stable isotope, magnetostratigraphic, and nannofossil data) were combined. Calcareous nannofossil biostratigraphy was first used for a correct interpretation of the magnetostratigraphic reversals. Once a consistent bio-magnetostratigraphic framework was achieved, geochemical/mineralogical parameters were used to tune the entire dataset and establish a 405-kyr eccentricity cyclostratigraphic framework. The use of this multi-site timescale allows for precise calibration of calcareous nannofossil biohorizons in different geographical areas. This then makes it possible to discuss the isochrony/diachrony of individual biohorizons and to evaluate their reliability. The opportunity to have an increasingly precise calcareous nannofossil biochronology is surely a bonus, but we would stress that the quality of the final biochronology depends not only on the precision of the age model but also, and more importantly, on the quantitative, highly resolved data that must be gathered through the use of rigorous analytical techniques to recognize the biohorizons.

References

Westerhold, T., Röhl, U., Frederichs, T., Agnini, C., Raffi, I., Zachos, J.C. &, Wilkens, R.H. 2017. Astronomical calibration of the Ypresian time scale: implications for seafloor spreading Rates and the chaotic behaviour of the solar system? Climate of the Past Discussion. doi:10.5194/cp-2017-15.

Upper Cretaceous calcareous nannofossil biostratigraphy and paleoceanography from Tethyan sediments of Oman

Zainab Al Rawahi

University of Birmingham, School of Geography, Earth and Environmental Sciences, Birmingham B15 2TT, UK; ZAA445@student.bham.ac.uk

The Late Cretaceous Fiqa Formation in northern Oman yields a rich and diverse calcareous nannoplankton assemblage, and seven nannofossil biozones can be identified using the Burnett (1998) UC scheme for the Tethyan realm that spans the early Coniacian to late Campanian (UC9 to UC15). The current biostratigraphic study includes core samples, sidewall core samples, and ditch cuttings from five hydrocarbon exploration wells from northern to southern Oman. This provided a more accurate date for the Fiqa Formation and improved understanding of the history of the Aruma foreland basin and its sequence stratigraphy. Integration of nannofossil and microfossil data from one well indicated that there were systematic fluctuations of climate, sea level, and nutrient supply. The planktonic/benthic ratio of foraminifera and the overall microfossil assemblages indicate open-marine conditions with intervals of shoaling while the submarine fan system of the lower Fiqa Formation was deposited. The nannofossil assemblages indicate a long-term shift from more oligotrophic, warm water to more eutrophic, shallower and colder ocean waters. This may coincide with an overall cooling trend and general shallowing of the Aruma basin approaching the Maastrichtian. In the future, additional wells will be examined across Oman that will be followed by an analysis of the evolutionary trends of some Late Cretaceous taxa and isotopic and foraminiferal analyses.

References

Burnett, J.A. 1998. Upper Cretaceous. *In:* P.R. Bown (Ed.). *Calcareous Nannofossil Biostratigraphy.* British Micropalaeontolical Society Publication Series. Chapman and Hall/Kluwer Academic Publishers, London: 132–199.

Early Miocene quantitative calcareous nannofossil biostratigraphy from the tropical Atlantic

Waheed A. Albasrawi

Saudi Aramco–Dhahran 31311, Saudi Arabia; Waheed.basrawi@aramco.com

David K. Watkins

University of Nebraska - Lincoln, Department of Earth and Atmospheric Sciences, Lincoln, NE, USA; dwatkins1@unl.edu

A quantitative analysis of calcareous nannofossils was conducted on lower Miocene sediments from Ocean Drilling Program Hole 959A on the West African margin. Combined with data from previous investigations of the lower Miocene from the tropical Atlantic, this research identifies and tests the viability of markers used in current zonation schemes, identifies alternative markers for age boundaries, and examines statistically the most probable order of events in the lower Miocene with the use of the ranking and scaling method (RASC).

In Hole 959A, all major calcareous nannofossil zones and subzonal boundaries from CN1 to CN4 were identified, except for the boundary between Subzones CN1a and CN1b, using primary and secondary markers from the Okada and Bukry zonation (1980). All age boundaries were identified or closely estimated using the established calcareous nannoplankton markers from the Chattian to Langhian Stages.

The resulting list of events that was obtained from Hole 959A, along with events from seven other sites, was biostratigraphically examined using RASC. A well threshold of 4 was selected as an appropriate control parameter, which resulted in 22 events in the optimum sequence, 13 of which had a low standard deviation. Furthermore, interpolation of ages of events with the use of an age-depth model for Hole 959A was examined. The extracted ages provided a reasonable preliminary age estimate of secondary events.

References

Okada, H. & Bukry, D. 1980. Supplementary modification and introduction of code numbers to the low-latitude coccolith biostratigraphic zonation (Bukry, 1973; 1975). *Marine Micropaleontology*, **5**(3): 321–325.

Calcareous nannofossil biostratigraphy of the Cenomanian-Turonian interval (Cretaceous) from Jordan

Mohammad Alqudah
American University of Beirut, Department of Geology, Beirut, Lebanon; ma404@aub.edu

Mohammed Hail Hakimi
Taiz University, Geology Department, Faculty of Applied Science, 6803 Taiz, Yemen; ibnalhakimi@yahoo.com

Wan Hasiah Abdullah
University of Malaya, Department of Geology, 50603 Kuala Lumpur, Malaysia; wanhasia@um.edu

Mohammad Ali Hussein
Ministry of Energy and Mineral Resources, Geological Mapping Division, Amman, Jordan; Mohammad.AliHussein@rub.de

Ahmad Masri
Ministry of Energy and Mineral Resources, Geological Mapping Division, Amman, Jordan; aiamasri@yahoo.com

Jörg Mutterlose
Ruhr-Universität Bochum, 44801 Bochum, Germany; joerg.mutterlose@rub.de

During the Cenomanian, major shifts in the depositional environment of Jordan were associated with changes in the tectonic setting of the northwestern margin of the Arabian Plate. A detailed investigation of calcareous nannofossils was conducted on a carbonate section from Wadi Mujib (central Jordan). This section contains Cenomanian–Turonian deposits of the inner/mid shelf that overlie shallow subtidal to supratidal platform deposits of Cenomanian age (Abed, 1984; Alsharhan & Nairn, 1997; Schulze *et al*., 2003). Twenty samples were analyzed for calcareous nannofossils, and the presence of *Microrhabdulus decoratus*, *Helena chiastia*, *Quadrum gartneri*, and *Lucianorhabdus maleformis* assigns the Wadi Mujib section an age of late Cenomanian to early Turonian.

The occurrence of *M. decoratus* and *Eiffellithus turriseiffelii* at the base of the section suggests a late Cenomanian age. The first occurrence (FO) of *Q. gartneri* marks the top of biozone CC 10 in sample 12 following Sissingh (1977) and Perch-Nielsen (1985). The top of biozone CC 11 is defined in sample 17 based on the FO of *L. maleformis*. Following the scheme of Burnett (1998), the last occurrence (LO) of *H. chiastia*, which was observed in sample 6, can be used to define the top of biozone UC 5.

References

Abed, A. 1984. Emergence of Wadi Mujib (Central Jordan) during Lower Cenomanian time and its regional tectonic implications. *Geological Society, London, Special Publications 1984*, **17**: 213–216.

Alsharhan, A.S. & Nairn, A.E.M. 1997. *Sedimentary basins and petroleum geology of the Middle East*. Elsevier, Amsterdam: 843pp.

Burnett, J.A. 1998. Upper Cretaceous. *In:* P.R. Bown (Ed). *Calcareous Nannofossil Biostratigraphy*. British Micropalaeontolical Society Publication Series. Chapman and Hall/Kluwer Academic Publishers, London: 132–199.

Perch-Nielsen, K. 1985. Cenozoic calcareous nannofossils *In:* H.M. Bolli, J.B. Saunders & K. Perch-Nielsen (Eds). *Plankton Stratigraphy*. Cambridge University Press, New York: 427–545.

Schulze, F., Lewy, Z., Kuss, J. & Gharaibeh, A. 2003. Cenomanian-Turonian carbonate platform deposits in west central Jordan. *International Journal of Earth Sciences*, **92**(4): 641–660.

Sissingh, W. 1977. Biostratigraphy of Cretaceous calcareous nannoplankton. *Geologie en Mijnbouw*, **56**: 37–65.

An unconventional application of calcareous nannofossils – reconstructing the timing and the course of an Eocene meteorite impact in central Jordan

Mohammad Alqudah
American University of Beirut, Department of Geology, Beirut, Lebanon; ma404@aub.edu.lb

Hani Khoury
University of Jordan, Department of Geology, 11942 Amman, Jordan: khouryhn@ju.edu.jo

Elias Salameh
University of Jordan, Department of Geology, 11942 Amman, Jordan; salameli@ju.edu.jo

Jörg Mutterlose
Ruhr-Universität Bochum, 44801 Bochum, Germany; joerg.mutterlose@rub.de

A meteorite impact structure has been recognized in the central part of eastern Jordan. Although geologists do have some evidence for this meteorite impact, the age of the Waqf as Suwwan impact is still poorly constrained. By examining calcareous nannofossils from sediments exposed in this structure, an age model for the timing of the event has been obtained. A total of 81 smear slides from two cores (BH-1 and BH-2), which penetrated the sediments of the central structure, were studied in order to obtain biostratigraphic ages for the post-impact sediments.

The calcareous nannofossils assigned the sediments of core BH-1 a late Campanian to early Eocene age and to core BH-2 a late Campanian to late Maastrichtian age. The upper part of the sedimentary sequence in the impact structure, which was removed from the adjacent area, consists of breccia components. The biostratigraphic study of the sedimentary breccias provides an important data set for interpreting the history and the course of the impact event. The calcareous nannofossils suggest that the components came from two different sources: Cretaceous and Paleocene-early Eocene. The deposition of the breccias resulted from a gravitational collapse of water-saturated sediments in two stages. The earlier of these was more intensive than the latter. The stratigraphic framework and the presence of reworked Cretaceous and Paleocene calcareous nannofossils within Paleogene nannofossil Zone NP13 suggest an early Eocene age for the impact. The upper part of the Cretaceous sediments was thermally altered by the impact, causing partial or complete dissolution of the calcareous nannofossils. This caused overgrowth for the more resistant species, while others were dissolved.

Rapid dynamics changes in NE Atlantic transitional surface waters during the last 57ka

Javier Álvarez
Universidad de Colima, CEUNIVO, Campus El Naranjo, Manzanillo, Colima, México C.P. 28860; jvalvarez3@gmail.com

Maria C. Álvarez
Universidad de Colima, CEUNIVO, Campus El Naranjo, Manzanillo, Colima, México C.P. 28860; malvarez1@ucol.mx

Guillermo Francés
University of Vigo, Department of Marine Geosciences and Territory, 36200 Vigo, Spain; gfrances@uvigo.es

Paula Diz
University of Vigo, Department of Marine Geosciences and Territory, 36200 Vigo, Spain; pauladiz@uvigo.es

Joan Grimalt
Institute eecof Environmental Assessment and Water Research (CSIC), Barcelona, Spain; joan.grimalt@idaea.csic.es

Marta Casado
Institute of Environmental Assessment and Water Research (CSIC), Barcelona, Spain; marta.nunez@idaea.csic.es

Northeast Atlantic transitional surface water dynamics was reconstructed from calcareous nannofossil assemblages and molecular biomarkers for the last 57ka (MIS3-MIS1). Gravity core KTA-05 (46.18595º N, -18.31385º W; 3939mbsl; 337cm long) contained placoliths, especially small *Gephyrocapsa* taxa, although colder stadials also had high abundances of *Gephyrocapsa muellerae* and *Emiliania huxleyi*. Several drastic changes in nannofossil accumulation rates (NAR) occurred during the studied period. In early MIS3, the total NAR was markedly higher than in MIS2 and MIS1. We hypothesize that there was a combined effect of a southernmost position of the current location of high coccolithophores abundances in the North Atlantic and a narrowing of the transitional water zone due to the expansion of the subpolar front that constricted the North Atlantic Current. An abrupt decrease in NAR, including some barren intervals, occurred during Heinrich Events when an increase in colder and less saline arctic water masses would have hampered coccolithophore development. Nevertheless, an exception occurred during H5 when, in spite of a NAR depletion, *Florisphaera profunda* increased, probably due to a shallow effect of this event. During the coldest stages and substages, as well as during Heinrich Events, N ratio and $\%C_{37:4}$ suggest that there was major stratification of ocean waters, which was triggered by a desalinization effect that slowed down the Atlantic Meridional Overturning Circulation (AMOC), at least in the upper meters of the water column. This decreased the productivity due to the colder temperatures and a reduction in nutrient input. Results from the KTA-05 core revealed that there were important submillennial changes in North Atlantic transitional waters during the last glaciation.

Theoretical hydrodynamic efficiency of coccoliths and coccolithophores

Maria C. Álvarez
Universidad de Colima, CEUNIVO, Campus El Naranjo, Manzanillo, Colima, México C.P. 28860; malvarez1@ucol.mx

Aranza Gutiérrez-Ramírez
Universidad de Colima, CEUNIVO, Campus El Naranjo, Manzanillo, Colima, México C.P. 28860; agutierrez14@ucol.mx

Juan H. Gaviño-Rodríguez
Universidad de Colima, CEUNIVO, Campus El Naranjo, Manzanillo, Colima, México C.P. 28860; gavinho@ucol.mx

José N. Carbajal-Pérez
IPICYT Instituto Potosino de Investigación Científica y Tecnológica. Col. Lomas 4 sección, San Luis Potosí S.L.P., CP. 78216, México; noelc@ipicyt.edu.mx

Several factors can influence the sinking of a particle: for example, the medium in which it is found and the specific characteristics of the particle. Coccolithophores and coccoliths have various shapes and sizes, and their sinking velocities and sinking trajectories are closely dependent upon the above factors.

In order to describe the sinking efficiency of coccoliths, sinking velocities (Vh) and sinking trajectories were estimated from experiments in a graduated fish tank with PLA (polylactic acid) scaled figures. Videos were used to record the sinking of the figures, which then were analyzed, and a model was generated with bilinear interpolation to estimate the sinking time in the mixing layer (CM) and below the CM.

The trajectories exhibited by the scaled figures had heterogeneous displacements. *Discoaster pentaradiatus* had the most uniform pattern, and *Florisphaera profunda* had the most variable. The Vh results from the model showed that an increase in diameter of spherical particles (PE) generated an increase in Vh. Sizes with a range of 0–20μm had a Vh of less than 200μm/second, whereas for sizes larger than 20μm, the increase in Vh was relatively constant or 200μm/second for every 10μm of increase in size.

For particles inside of the CM, size does not influence the sinking because its behavior in the CM depends primarily on the dynamics of the CM. Below the CM, the Vh of large PE is 1000 times greater. If shape is compared, the Vh of large PE is markedly higher than the non-spherical ones. For small particles, Vh is similar between PE and non-spherical.

Effect of dense shelf water cascading over planktic fluxes in the Gulf of Lions (NW Mediterranean)

Maria C. Álvarez
Universidad de Colima, CEUNIVO, Campus El Naranjo, Manzanillo, Colima, México C.P. 28860; malvarez1@ucol.mx

Karla A. Vega-Corza
Universidad de Colima, CEUNIVO, Campus El Naranjo, Manzanillo, Colima, México C.P. 28860; vega_karla@ucol.mx

Maria Á Bárcena
Universidad de Salamanca, Departamento de Geología, 37008 Salamanca, Spain; mbarcena@usal.es

Sonia Quijano-Scheggia
Universidad de Colima, CEUNIVO, Campus El Naranjo, Manzanillo, Colima, México C.P. 28860; quijano@ucol.mx

Cascading was defined by Canals *et al*. (2006) in the Gulf of Lions as a dense current that results from the formation of dense water due to cooling or evaporation. Sediment gravity flows can be triggered by dense shelf water cascading (DSWC) and transporting large amounts of sediment and organic matter to the deep ocean.

Particle flux was recorded in two sediment traps located over the center of Creus Cap Canyon (42°20'40.43''N, 3°35'56.99''E) and over the end of the Canyon (42°8'57.44''N, 4°10'39.45''E) from November 2005 to October 2006.

Results from coccoliths, diatoms, and silicoflagellates revealed that coccoliths were the dominant group throughout the period of study. Winter was the season with highest fluxes in every group due to the mixed water column that was the result of local wind dynamics (the Mistral and Tramontana).

Between January and March of 2006 with a duration of 80 days, a cascading event was reported by Pasqual *et al*. (2010). During the cascading, there was a sharp decrease in fluxes in most species that was related to intense mixing and low light intensity in the water column. Subsequent to the event, fluxes increased again, but not to the original magnitude. In summer, water stratification is the main characteristic of the water column, and generally low fluxes were recorded. The only calcareous nannoplankton species to show positive peaks were *Helicosphaera carteri* and *Calcidiscus leptoporus leptoporus,* although the planktonic group of diatoms also had a peak. These species reveal that there were mesotrophic conditions and an increase in water temperatures at this time. *Dictyocha fibula* and *Distephanus speculum* also showed positive peaks in summer, but they are typical of lower photic zone habitats.

In addition, spatial variability was considered in the study area because the sediment trap at the end of the canyon recorded higher fluxes than the one at the center of the canyon during the entire study period and for every studied group.

References

Canals, M., Puig, P., de Madron, X.D., Heussner, S., Palanques, A. & Fabres, J. 2006. Flushing submarine canyons. *Nature*, **444**(7117): 354–357.

Pasqual, C., Sànchez Vidal, A., Zúñiga, D., Calafat Frau, A., Canals Artigas, M., Durrieu de Madron, X., Puig, P., Heussner, S., Palanques Monteys, A. & Delsaut, N. 2010. Flux and composition of settling particles across the continental margin of the Gulf of Lion: the role of dense shelf water cascading. *Biogeosciences*, **7**(1): 217–231.

Seasonal distribution of coccolithophores in the open waters of the central Adriatic Sea

Jasna Arapov
Institute of Oceanography and Fisheries, 21000 Split, Croatia; arapov@izor.hr

Sanda Skejić
Institute of Oceanography and Fisheries, 21000 Split, Croatia; sanda@izor.hr

Mia Bužančić
Institute of Oceanography and Fisheries, 21000 Split, Croatia; buzancic@izor.hr

Ana Bakrač
Institute of Oceanography and Fisheries, 21000 Split, Croatia; jelacic@izor.hr

Gladan Živana Ninčević
Institute of Oceanography and Fisheries, 21000 Split, Croatia; nincevic@izor.hr

Seasonality of coccolithophore assemblages from the open waters of the Adriatic Sea was studied using both a light microscope (LM) and a scanning electron microscope (SEM). Sampling was conducted at four stations during winter (December 2015) and spring (April 2016) cruises.

The total number of coccolithophores counted with the LM and SEM were in agreement, although somewhat higher values were obtained with the SEM. In winter, coccolithophores were a major component of the phytoplankton community in deeper water layers (below 50m). In spring, their proportion exceeded 80% of total phytoplankton abundance in almost every sampled layer. A positive correlation was confirmed between the chlorophyll-*a* concentration and coccolithophore abundances obtained by LM ($r=0.68$; $p<0.01$) and SEM ($r=0.83$; $p<0.01$).

SEM abundances ranged from 3×10^3–5×10^4 cells L^{-1} in winter and 1.7×10^4–1×10^5 cells L^{-1} in spring. In spring, the highest abundances were recorded in subsurface layers, whereas in winter, high abundances were recorded also in the surface layer.

A total of 84 coccolithophore morphotypes were observed, including 58 species. *Emiliania huxleyi*, which was found in all analyzed samples, prevailed mainly in the winter, except in the deepest layer when *Algirosphaera robusta* occurred in similar abundances. In spring, however, *E. huxleyi* dominated only in depths below 50m, while a higher diversity was noticed in euphotic layers, where *Rhabdosphaera clavigera* and *Syracosphaera protrudens* were observed in similar abundances as *E. huxleyi*.

Coccolithophore biogeography in the eastern Mediterranean: surface sediment evidence

Odysseas A. Archontikis

National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis 157 84, Athens, Greece; odysseas67@windowslive.com

Elisa Malinverno

Università degli Studi di Milano-Bicocca, Dipartimento di Scienze dell'Ambiente e della Terra, 20126 Milano, Italy; elisa.malinverno@unimib.it

Margarita D. Dimiza

National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis 157 84, Athens, Greece; mdimiza@geol.uoa.gr

Maria V. Triantaphyllou

National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis 157 84 Athens, Greece; mtriant@geol.uoa.gr

We present coccolithophore abundance (coccoliths/gram, LM counts) and biogeographical distribution patterns that were obtained from eastern Mediterranean Sea surface sediments. *Emiliania huxleyi* was dominant in the coccolithophore assemblages of the entire basin. Dominance of this species has been documented at 70% in the North Aegean and Marmara Seas and about 60% in the Ionian and Levantine Seas. The next most frequently observed species, *Rhabdosphaera clavigera* and *Syracosphaera pulchra*, were present in low percentages (<10%). *Florisphaera profunda* also displayed low values, particularly in the Levantine Sea, whereas *Helicosphaera carteri* had low abundances in the open Aegean Sea. Morphometric evaluation of the dominant species, *E. huxleyi,* using the scanning electron microscope, indicated variability in the degree of calcification. A total of 2,560 coccoliths were analyzed with the use of ImageJ software following the biometric approaches of Young *et al*. (2014). In the Marmara Sea and the relatively deep North Aegean Sea, numerous *E. huxleyi* specimens had characteristically low relative tube width values, whereas typical overcalcified coccoliths prevailed in the Levantine Basin, the South Aegean Sea, and the deep Ionian Sea. It is probable that the lightly calcified *E. huxleyi* morphotypes in the surface sediments of the North Aegean and Marmara Seas provide evidence of Black Sea water outflow into the NE Mediterranean over the deeper, less saline Levantine water layer.

A previous biometric analysis of *E. huxleyi* in North Aegean water samples (Karatsolis *et al*., 2017) revealed a bimodal distribution of the coccolith relative tube width, with lower values found in the surface layers, similar to typical Black Sea lightly calcified *E. huxleyi* morphotypes. Lightly calcified morphotypes are also characteristic of the Levantine water masses in the Aegean Sea during the warm season, while more heavily calcified coccoliths are found when surface temperatures are lower (Triantaphyllou *et al*., 2010). Apparently, processes in the water column and water-sediment interface affect the original coccolithophore assemblage distribution and coccolith primary calcification, resulting in the heavily calcified specimens observed in the sediments of the southeastern Mediterranean.

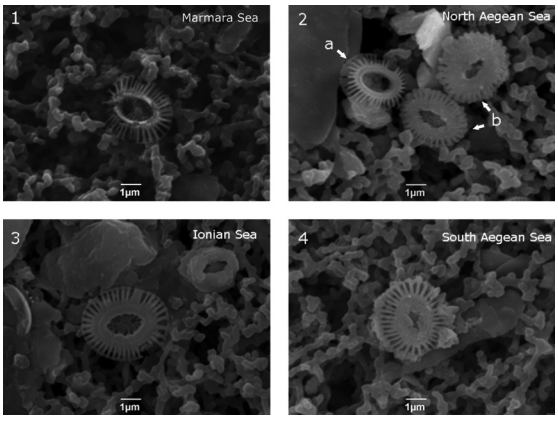


Figure 1: (1), (2a): *Emiliania huxleyi* lightly calcified coccoliths from Marmara Sea and North Aegean Sea assemblages. (2b), (3), (4): *Emiliania huxleyi* heavily calcified morphotypes from North Aegean, Ionian and South Aegean Seas, respectively

References

Karatsolis, B.-Th., Triantaphyllou, M.V., Dimiza, M.D., Malinverno, E., Lagaria, A., Mara, P., Archontikis, O. & Psarra, S. 2017. Coccolithophore assemblage response to Black Sea Water inflow into the North Aegean Sea (NE Mediterranean). *Continental Shelf Research*, http://dx.doi.org/10.1016/j.csr.2016.12.005.

Triantaphyllou, M.V., Dimiza, M.D., Krasakopoulou, E., Malinverno, E., Lianou, V. & Souvermezoglou, E. 2010. Seasonal control on *Emiliania huxleyi* coccolith morphology and calcification in the Aegean Sea (Eastern Mediterranean). *Geobios* **43**, 99–110.

Young, J.R., Poulton, A.J., Tyrell, T., 2014. Morphology of Emiliania huxleyi coccoliths on the northwestern European shelf – is there an influence of carbonate chemistry? Biogeosciences 11, 4771–4782. http://dx.doi.org/10.5194/bg-11-4771-2014.

Paleoclimatic conditions during the "warm Pliocene" interval (~4.1–3.2Ma) in the eastern Mediterranean (Cyprus): a combined alkenone and calcareous nannofossil study

Maria Athanasiou
National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; mairyatha@hotmail.com

Ioanna Bouloubassi
Université Pierre et Marie Curie-CNRS-IRD-MNHN, LOCEAN/IPSL, 75252 Paris, Cedex 05, France; Ioanna.Bouloubassi@locean-ipsl.upmc.fr

Alexandra Gogou
Hellenic Centre for Marine Research, Institute of Oceanography, 190 13 Anavyssos, Attiki, Greece; agogou@hcmr.gr

Vincent Klein
Université Pierre et Marie Curie-CNRS-IRD-MNHN, LOCEAN/IPSL, 75252 Paris, Cedex 05, France; vklod@locean-ipsl.upmc.fr

Margarita D. Dimiza
National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; mdimiza@geol.uoa.gr

Constantine Parinos
Hellenic Centre for Marine Research, Institute of Oceanography, 190 13 Anavyssos, Attiki, Greece; ksparinos@hcmr.gr

Elisavet Skampa
National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; skampaelisavet@gmail.com

Maria V. Triantaphyllou
National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; mtriant@geol.uoa.gr

The Pissouri south section (PSS) on the island of Cyprus is correlated with calcareous nannofossil biozones MNN14/15 and MNN16 and is astronomically dated between ~4.1–3.25Ma. Alkenone and nannofossil data from the PSS provided a detailed description of the paleoclimatic and paleoenvironmental conditions during this interval in the eastern Mediterranean. The cyclical lithologic alternations between the organic-rich laminated layers and grey marls of the PSS correspond to the Earth's orbital precession and reflect the deposition of sapropels in the area. These sapropel events took place under conditions of increased sea surface temperature (SST), enhanced water column stratification, and development of a productive deep chlorophyll maximum (DCM), as evidenced by the dominance of *Florisphaera profunda* (Athanasiou *et al*., 2015, 2017). Such conditions are triggered by freshwater discharges from the North African margin due to insolation-driven intensification of the African monsoon. The absence of *F. profunda* in Pliocene sapropels from the central Mediterranean highlights the sensitive response of the eastern basin to freshwater perturbations. Comparisons between alkenone and calcareous nannofossil assemblage patterns indicate that *Pseudoemiliania lacunosa* is the main alkenone producer in sapropel layers, although *Reticulofenestra* spp. contributions should not be overlooked.

This first Pliocene alkenone-SST record for the eastern Mediterranean documents the "warm Pliocene" period (~4.1–3.25Ma), which is characterized by a mean SST of about 26°C. Distinct SST minima at ~3.9Ma, 3.58Ma, and between 3.34–3.31Ma correspond to the MIS Gi16, MIS MG12, and MIS M2 global cooling episodes, which occurred before the onset of Northern Hemisphere glaciation. Our findings imply that the peak of the MIS M2 cooling in the eastern Mediterranean may be up to ~40kyr older than benthic stable oxygen isotope records have indicated.

References

Athanasiou, M., Bouloubassi, I., Parinos, K., Gogou, A., Dimiza, M., Klein, V., Skampa, E. & Triantaphyllou, M., 2017. Sea surface temperatures and environmental conditions during the "warm Pliocene" interval (~ 4.1–3.2Ma) in the Eastern Mediterranean (Cyprus). *Global and Planetary Change,* **150**(2017): 46–57.

Athanasiou, M., Triantaphyllou, M., Dimiza, M., Gogou, A. & Theodorou, G. 2015. Zanclean/Piacenzian transition on Cyprus (SE Mediterranean): calcareous nannofossil evidence of sapropel formation. *Geo-Marine Letters*, **35**: 367–385.

Lower-middle Miocene sapropelic layers (Nicosia, Cyprus) and paleoceanographic implications

Maria Athanasiou

National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; mairyatha@hotmail.com

Maria V. Triantaphyllou

National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; mtriant@geol.uoa.gr

Margarita D. Dimiza

National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; mdimiza@geol.uoa.gr

Alexandra Gogou

Hellenic Centre for Marine Research, Institute of Oceanography, 190 13 Anavyssos, Attiki, Greece; agogou@hcmr.gr

Efthymios Tsiolakis

Geological Survey Department, Cyprus Geological Survey, 1 Lefkonos Street, 2064 Strovolos Lefkosia Cyprus; etsiolakis@gsd.moa.gov.cy

The Kotaphi Hill section (KHS, Cyprus) with its marly-chalky cyclic alternations and numerous organic-rich siltstone intercalations is assigned to calcareous nannofossil Zones NN2-NN7, indicating a late Aquitanian-early Tortonian time span. The increased abundance of *Helicosphaera* spp., *Discoaster* spp., *Sphenolithus s*pp., and *Rhabdosphaera* spp. within the laminated siltstone layers at the upper KHS (c. 15.69 to younger than ~11.6Ma) are associated with sapropel deposition that was triggered by both increased primary productivity and water column stratification under warm oligotrophic conditions. The lower $\delta^{18}O_{\ O.\ universa}$ values that were observed in the same layers are interpreted as due to high freshwater input from the Nile River into the basin, combined with increased sea surface temperatures. The sapropel layers of the KHS record are considered to be the oldest (early Laghian) in the eastern Mediterranean, implying that sapropel deposition began earlier in the eastern than in the western part of the basin. The variations in the isotopic signals, along with an increase in cold nannofossil indicators at four distinct intervals, are probably linked to a series of cooling episodes that are globally recognized as Miocene oxygen isotope events Mi3a, Mi3b, Mi4, and Mi5, which reflect changes in paleoenvironmental conditions. An observed decrease in the values of $\delta^{18}O_{\ O.universa}$ and the concomitant increment of the fresh-water indicator *Helicosphaera* spp., along with the gradual increasing trend of warm calcareous nannofossil assemblages, imply a pronounced change towards warmer and more humid conditions after ~12.4Ma.

A high rank taxonomic classification of the Cenozoic coccolithophores and their Mesozoic roots

Marie-Pierre Aubry

Rutgers University, Department of Earth and Planetary Sciences, Busch Campus, Wright Laboratory, Piscataway, NJ 08853, USA; Aubry@eps.rutgers.edu

A new higher classification of the Cenozoic (extinct and extant) coccolithophores is presented that incorporates morphostructural information together with molecular data on living forms. It is largely based on the structure of the coccoliths that are secreted during the diploid phase of the coccolithophores, beginning with the basic shape of the elements of the marginal cycle, and continuing with their imbrication (or lack thereof) and the number of, and relationship between, cycles of the margin and central area. An important step taken here is the description and naming of heterococcoliths in terms of morphostructural units, i.e., natural entities whose evolution through time is distinct from the evolution of neighboring units in the same coccolith (for instance the evolution of the calyptra compared to that of the column in sphenoliths). The naming of structural units was introduced by Prins (1971) and Romein (1977), and that practice is systematically extended here to all heterococcoliths. Convergent evolution constitutes a major caveat in coccolithophore taxonomy. It has been circumscribed by careful analysis of morphostructural evolution in appropriate stratophenotypic contexts. Ten taxonomic orders were recognized, all of which were already present in the Mesozoic, although the Order Isochrysidales did not mineralize coccoliths until the early Eocene. Major revisions include the introduction of the Order Biscutales and the Order Pontosphaerales and the emendation of the Order Discoasterales and the Order Zygosdiscales. It is interesting that the number of families, as natural entities within orders, is not correlated with the number of species/genera in them. This is taken as an indication of "morphologic evolvability" within an order, thus reflecting the ability of its species to undergo adaptive evolution.

References

Prins, B. 1971. Speculations on relations, evolution, and stratigraphic distribution of discoasters. *In:* A. Farinacci (Ed.). *Proceedings of the II Planktonic Conference, Roma, 1970*, **1**: 1017–1037. Rome: Edizione Tecnoscienza.

Romein, A.J.T. 1979. Lineages in Early Paleogene calcareous nannoplankton. *Utrecht Micropaleontological Bulletins*, **22**: 1–231.

The haploid coccolithophore

Marie-Pierre Aubry

Rutgers University, Department of Earth and Planetary Sciences, Busch Campus, Wright Laboratory, Piscataway, NJ 08853, USA; Aubry@eps.rutgers.edu

It is well known that coccolithophores have a haploid-diploid life cycle, with both phases well represented in most species, and also that each phase is characterized by structurally distinct coccoliths. For a multitude of reasons, the coccoliths produced during the diploid phase are central to the study of various aspects of Earth history, so that the diploid coccolithophore is reasonably well known. In contrast, only limited information has been available for its haploid counterpart, which, when capable of mineralization, forms holococcoliths and cryptoliths. A compilation of the characters of living species in the haploid phase resulted in (1) a qualitative and quantitative analysis that looked for morphologic/structural commonality during this phase in relation to taxonomy, and (2) a comparison between the diploid and haploid phases in the same taxa. Perhaps unexpectedly, this has revealed a morphologic organization as rigid during the haploid phase as during the diploid one, albeit in a subtler manner. For instance, the arrangement of crystallites (fabric) in modern holococcoliths is characteristic at the rank of genus, family, or order depending on the taxa that are considered. Together with other characters, this allows consistent delineation among living coccolithophores of the same taxonomic groups as those delineated with heterococcoliths. This then can be extended to the fossil record, so that, based on fabric, size, and occurrences, it becomes possible to reconstruct the life cycles of extinct coccolithophores. A systematic comparison between extinct and modern holococcoliths reveals that the haploid coccolithophore exhibits the same evolutionary trends as the diploid organism, in particular with regard to size. It also implies a distinctive adaptive strategy of the haploid coccolithophore to life in oligotrophic waters. Most interestingly perhaps, this adaptive strategy would also seem to have been that which diploid coccolithophores of the Order Discoasterales developed.

Spatial and temporal variability in coccolithophore abundance and distribution in the NW Iberian Margin

Blanca Ausín
Universidad de Salamanca, Departamento de Geologia, Facultad de Ciencias, 37008 Salamanca, Spain; ETH Zurich, Department of Earth Sciences, 8092 Zurich, Switzerland; blanca.ausin@erdw.ethz.ch

José-A. Flores
Universidad de Salamanca, Departamento de Geologia, Facultad de Ciencias, 37008 Salamanca, Spain; flores@usal.es

Diana Zúñiga
University of Vigo, Applied Physics Department, E-36310 Vigo, Spain; Instituto de Investigaciones Marinas (IIM), Consejo Superior de Investigaciones Científicas (CSIC), E-36208, Vigo, Spain; diana.zuniga@uvigo.es

Catarina Cavaleiro
Instituto Português do Mar e da Atmosfera (IPMA), Div. Geologia e Georecursos Marinhos, 1749–077, Lisbon, Portugal; Universidade do Algarve, CCMAR - Centre of Marine Sciences, Campus de Gambelas, 8005-139 Faro, Portugal; University of Bremen, MARUM, Center for Marine Environmental Sciences, 28359 Bremen, Germany; catarina.cavaleiro@ipma.pt

Francisco de la Granda
Federal Maritime and Hydrographic Agency, 20359 Hamburg, Germany; Francisco.delagranda@bsh.de

Nicolas Villacieros-Robineau
Université Pierre et Marie Curie, LOCEAN-IPSL, 75005 Paris, France; nvrobineau@gmail.com

Fernando Alonso-Pérez
Instituto de Investigaciones Marinas (IIM), Consejo Superior de Investigaciones Científicas (CSIC), E-36208 Vigo, Spain; fernando@iim.csic.es

Maria Froján
Instituto de Investigaciones Marinas (IIM), Consejo Superior de Investigaciones Científicas (CSIC), E-36208 Vigo, Spain; mariafrojan@iim.csic.es

Belen Arbones
Instituto de Investigaciones Marinas (IIM), Consejo Superior de Investigaciones Científicas (CSIC), E-36208 Vigo, Spain; belen@iim.csic.es

Celia Santos
Instituto Português do Mar e da Atmosfera (IPMA), Div. Geologia e Georecursos Marinhos, 1749-077 Lisbon, Portugal; Universidade do Algarve, CCMAR - Centre of Marine Sciences. Campus de Gambelas, 8005-139 Faro, Portugal; University of Bremen, MARUM, Center for Marine Environmental Sciences, 28359 Bremen, Germany; celia.neto@ipma.pt

Carmen G. Castro
Instituto de Investigaciones Marinas (IIM), Consejo Superior de Investigaciones Científicas (CSIC), E-36208 Vigo, Spain; cgcastro@iim.csic.es

Fatima Abrantes
Instituto Português do Mar e da Atmosfera (IPMA), Div. Geologia e Georecursos Marinhos, 1749-077, Lisbon, Portugal; Universidade do Algarve, CCMAR - Centre of Marine Sciences, Campus de Gambelas, 8005-139 Faro, Portugal; fatima.abrantes@ipma.pt

Timothy Eglinton
ETH Zurich, Department of Earth Sciences, 8092 Zurich, Switzerland; timothy.eglinton@erdw.ethz.ch

For the first time, a systematic investigation of the ecology plus the spatial and temporal variability in coccolithophore abundance and distribution in the water column was performed for the NW Iberian margin. From July 2011 to June 2012, monthly sampling was conducted from several water depths at two stations at latitude 42ºN: one offshore (350m water depth) and one nearshore (75m water depth). Total coccolithophore abundances were higher offshore. Seasonal dynamics of the water column strongly influenced coccolithophore productivity at both stations. Coccolithophore abundance was found to increase during the summer at both locations, which coincided with an upwelling regime. However, such coccolithophore blooms are normally associated with the decline of upwelling events, which results in warmer water and poor nutrient conditions. During the winter, coccolithophore abundance decreased drastically offshore with the influence of the saltier and nutrient-poor Iberian Poleward Current. In contrast, nearshore coccolithophore abundance was affected by river discharge and surface sediment resuspension, which remobilized deposited coccoliths from surface sediments and masked the species composition and vertical distribution of the autochthonous coccolithophore assemblages in the water column. Coccolithophore assemblages at both locations are dominated by *Emiliania huxleyi,* followed by small *Gephyrocapsa* spp., *G. oceanica,* and *Florisphaera profunda.* Species absolute abundances and their strong seasonal signal lead to the identification of different assemblages offshore: (1) the "summer regime assemblage" that is favored by upwelling conditions and composed of *E. huxleyi* and small *Gephyrocapsa* spp. within the first 100m, and *G. oceanica*, *C. pelagicus* ssp. *braarudii,* and *Oolithotus fragilis* between 150–300m and (2) the "winter regime assemblage", which is characterized by a lower abundance of *E. huxleyi* and small *Gephyrocapsa* spp., and *R. clavigera* within the first 100m, and *F. profunda*, *G. flabellatus*, and *O. fragilis* between 150–300m.

Coccolith carbonate export dynamics at ODP Site 1089 (Southern Ocean) during the last deglaciation

Chiara Balestrieri
Università degli Studi di Padova, Dipartimento di Geoscienze, 35131 Padova, Italy; chiara.balestrieri@phd.unipd.it

Patrizia Ziveri
Universitat Autonoma de Barcelona, Institute of Environmental Science and Technology, Catalan Institution for Research and Advanced Studies, Bellaterra 08193, Barcelona, Spain; Patrizia.Ziveri@uab.cat

Peter Graham Mortyn
Universitat Autonoma de Barcelona, Institute of Environmental Science and Technology, Department of Geography, Bellaterra 08193, Barcelona, Spain; Graham.Mortyn@uab.cat

Eliana Fornaciari
Università degli Studi di Padova, Dipartimento di Geoscienze, 35131 Padova, Italy; eliana.fornaciari@unipd.it

Claudia Agnini
Università degli Studi di Padova, Dipartimento di Geoscienze, 35131 Padova, Italy; claudia.agnini@unipd.it

Paleoproductivity dynamics and carbonate system changes are crucial components in past ocean biogeochemistry. Coccolithophores play a key role in the global carbon cycle as primary producers and marine calcifiers (Baumann *et al*., 2004). We analyzed coccolith assemblages, their absolute abundances, and carbonate export for the last 25ky in the subantarctic South Atlantic in the TNO57-21 core, which was drilled as part of ODP Site 1089 (40.950°S; 9.883°E). The site is located at a 4,620m water depth, which is close to the CCD and to the carbonate saturation horizon, which is located at a 4,000m water depth in Cape Basin (Flores *et al*., 2003). Generally, this site experienced high productivity conditions during glacial periods, which is confirmed by coccolith export production that reached a peak at terminations (Flores *et al*., 2012). By contrast, during the last deglaciation (TI), low surface ocean pH occurred in the Southern Ocean (Martínez-Botí *et al*., 2015), and this could be expected to influence phytoplankton distribution, morphology, and carbonate export. We evaluated coccolith export production in order to differentiate any signals that may have influenced carbonate production at this site. We found that phases of enhanced glacial productivity coincided with periods of water mixing, which is indicated by a low relative abundance of *Florisphaera profunda* and high chlorophyll-*a* concentrations. During an interglacial, *Emiliania huxleyi* showed a decrease in platelet calcification and a drop in its relative abundance, which could be linked either to dissolution or to ecological changes.

References

Baumann, K.H., Boeckel, B. & Frenz, M. 2004. Coccolith contribution to South Atlantic carbonate sedimentation. *In*: H.R. Thierstein, & J.R. Young (Eds). *Coccolithophores from Molecular Processes to Global Impact*. Springer. Springer, Berlin, Heidelberg, New York, 368–402.

Flores, J.A., Filippelli, G.M., Sierro, F.J. & Latimer J.C. 2012. The "white ocean" hypothesis: a late Pleistocene Southern Ocean governed by coccolithophores and driven by phosphorus. Frontiers in Microbiology, **3**(2012), 233.

Flores, J.A., Marino, M., Sierro, F.J., Hodell, D.A. & Charles, C.D. 2003. Calcareous plankton dissolution pattern and coccolithophore assemblages during the last 600kyr at ODP Site 1089 (Cape Basin, South Atlantic): paleoceanographic implications. *Palaeogeography Palaeoclimatology Palaeoecology*, **196**:409–426.

Martínez-Botí, M.A., Marino, G., Foster, G.L., Ziveri, P., Henehan, M.J., Rae, J.W., Mortyn, P.G. & Vance D. 2015. Boron isotope evidence for oceanic carbon dioxide leakage during the last deglaciation. *Nature*, **518**(7538): 219–222.

Calcareous plankton fluxes in the upwelling area off NW Africa (Cape Blanc) – dynamics and trends from selected sediment trap series in the past 28 years

Karl-Heinz Baumann
University of Bremen, Department of Geosciences, 28334 Bremen, Germany; baumann@uni-bremen.de

Barbara Donner
University of Bremen, MARUM, Center for Marine Environmental Sciences, 28334 Bremen, Germany; donner@uni-bremen.de

Meral I. Köbrich
University of Bremen, Department of Geosciences, 28334 Bremen, Germany; koebrich@uni-bremen.de

Gerhard Fischer
University of Bremen, Department of Geosciences, 28334 Bremen, Germany; Gerhard.fischer@uni-bremen.de

Carbonate fluxes of coccolithophores, planktic foraminifers, and pteropods were determined from four annual time intervals (1989/90, 1998/99, 2002/03, and 2008/09) off Cape Blanc (21°15'N, 20°45'W) in the filamentous mixing area of one of the prominent eastern boundary upwelling systems. The sediment trap data were collected at a 3600m water depth and were used to reveal seasonal and inter-annual changes in species fluxes and assemblage composition, as well as long-term trends in carbonate fluxes.

The study and comparison of the selected time intervals, which were not influenced by any major climatic oscillation such as North Atlantic Oscillation, El Niño–Southern Oscillation, or Atlantic Multidecadal Oscillation, revealed variable flux patterns that reflect the prevailing hydrographic conditions of this dynamic offshore upwelling region. Seasonal variations, both in species fluxes and assemblage compositions, occurred in all the calcareous groups, whereas inter-annual fluctuations were less obvious, and all groups showed only minor variations in a surprisingly constant flux pattern. The coccolithophore assemblages were dominated by *Emiliania huxleyi*, a lower photic zone species, and gephyrocapsids. Coccolith flux was generally highest during winter/spring and early fall (up to $500 \times 10^7 m^{-2} d^{-1}$) and was reduced during summer and late fall. Highest fluxes of planktic foraminifers (up to $50 mg\, m^{-2} d^{-1}$) were observed during the summer (predominantly species preferring cooler water conditions) and the winter (warm water species). Pteropod flux showed the most constant pattern over the years with a distinct maximum (up to $180 mg\, m^{-2} d^{-1}$, fraction $< 1mm$) in late summer and a minimum in winter. No long-term trend of any carbonate producer was observed. The organism fluxes, as well as the general composition of the assemblages, have not changed, and the calculated carbonate fluxes of the major plankton groups (including the aragonitic pteropods) give no evidence of an increasing influence of ocean acidification or any ecosystem change.

Coccolithophore response to changes in surface water conditions in the North Atlantic (ODP Site 984) during Marine Isotope Stage 5

Karl-Heinz Baumann
University of Bremen, Department of Geosciences, 28334 Bremen, Germany; baumann@uni-bremen.de

Nele M. Vollmar
University of Bremen, Department of Geosciences, 28334 Bremen, Germany; nvollmar@uni-bremen.de

In order to reconstruct climatically induced sea-surface water conditions throughout Marine Isotope Stage (MIS) 5, quantitative coccolithophore analyses were performed at ODP Site 984, which is located south of Iceland and close to the modern locations of the Arctic and Polar hydrographic fronts. For this purpose, changes in the coccolith assemblages (e.g., numbers of coccoliths, coccolith accumulation rates, assemblage composition, and diversity), as well as variations in sizes and morphotypes of *Emiliania huxleyi* and *Gephyrocapsa muellerae,* were investigated.

The observed coccolith assemblages were dominated by *G. muellerae* and were generally characterized by only a few species. Three intervals of warm surface water expansion were identified that had increased coccolith numbers and elevated species diversities (Interstadials 5e, 5c, and 5a). Decreased numbers of coccoliths and low species diversity indicate an influence of progressive, cold-water mass expansions into subpolar latitudes, in particular during the last glacial and stadial stages (MIS stages/stadials 6, 5d, 5b, and 4). Differences in the composition of the coccolith assemblages also indicated that the main northward expansion of the warm surface currents occurred during MIS 5e and 5a, with highest coccolith production in stage 5a.

One intriguing result of this research was a significant gradual change in the size of *G. muellerae* that occurred from the beginning of MIS 5 to MIS 4. In addition, both *E. huxleyi* >4μm and *E. huxleyi* <4μm occurred in higher numbers during intervals of warmer surface waters. Their occurrence, therefore, puts into question the use of this morphotype as a cold-water indicator, at least for pre-MIS 5 intervals. It seems more likely that *E. huxleyi,* as well as *G. muellerae,* went through various evolutionary adaptations during MIS 5, which may also have led to an exchange in dominance between the two species at the end of MIS 5.

Coccolithophore behavior during short-term climate fluctuations over the last deglaciation: evidence from the Alboran Sea, western Mediterranean

Pietro Bazzicalupo
Università degli Studi di Bari Aldo Moro, Dipartimento di Scienze della Terra e Geoambientali, 70125, Bari, Italy; pietro.bazzicalupo@uniba.it

Patrizia Maiorano
Università degli Studi di Bari Aldo Moro, Dipartimento di Scienze della Terra e Geoambientali, 70125, Bari, Italy; patrizia.maiorano@uniba.it

Angela Girone
Università degli Studi di Bari Aldo Moro, Dipartimento di Scienze della Terra e Geoambientali, 70125, Bari, Italy; angela.girone@uniba.it

Maria Marino
Università degli Studi di Bari Aldo Moro, Dipartimento di Scienze della Terra e Geoambientali, 70125, Bari, Italy; maria.marino@uniba.it

Nathalie Combourieu-Nebout
Institut de Paléontologie Humaine, UMR 7194 MNHN, Paris, France; nathalie.nebout-combourieu@mnhn.fr

Alessandro Incarbona
Università degli Studi di Palermo, Dipartimento di Scienze della Terra e del Mare, 90134 Palermo, Italy; alessandro.incarbona@unipa.it

The time interval from the last deglaciation to the beginning of the Holocene is a period marked by well documented, short-term vigorous climatic fluctuations. During this period of time, the Mediterranean Sea was extremely sensitive to these rapid changes. The Alboran Sea (western Mediterranean) in particular is one of the most relevant sites due to its location at the junction of the Atlantic-Mediterranean water mass exchange.

We conducted a high-resolution investigation of the coccolitophore assemblage from Ocean Drilling Program (ODP) Site 976. The site provides an extremely detailed (multi-decadal scale) alkenone-based sea surface temperature (SST) record, and it is also very well chronologically constrained (Martrat *et al*., 2014).

All these characteristics make the site a perfect candidate for conducting a high-resolution analysis in order to assess how the coccolithophore assemblage was affected by short-term climatic fluctuations across the last termination.

The results, which were integrated with a planktonic foraminiferal assemblage analysis, show a high sensitivity of the calcareous plankton assemblage in recording stadial/interstadial phases at a hundred-year scale. The rapid shifts in climate sensitive taxa reinforce the hypothesis that the cold stadial that is associated with Heinrich 1 event was not a homogenous period.

A comparison between calcareous plankton distributions and the available pollen-based climate reconstruction (Combourieu Nebout *et al*., 2009) also was performed. The combined data set improves the understanding of land-sea interactions during a key climate phase.

References

Combourieu Nebout, N., Peyron, O., Dormoy, I., Desprat, S., Beaudoin, C., Kotthoff, U. & Marret, F. 2009. Rapid climatic variability in the West Mediterranean during the last 25000 years from high resolution pollen data. *Climate of the Past*, **5**: 503–521.

Martrat, B., Jimenez-Amat, P., Zahn, R. & Grimalt, J.O. 2014. Similarities and dissimilarities between the last two deglaciations and interglaciations in the North Atlantic region. *Quaternary Science Reviews*, **99**: 122–134.

Regularity in the quaternary variations of Noelarhabdaceae morphology

Luc Beaufort
Aix-Marseille University, CNRS, IRD, Col. France; CEREGE, Aix en Provence, France; beaufort@cerege.fr

Yves Gally
Aix-Marseille University, CNRS, IRD, Col. France; CEREGE, Aix en Provence, France; gally@cerege.fr

Nicolas Barbarin
Aix-Marseille University, CNRS, IRD, Col. France; CEREGE, Aix en Provence, France; TOTAL, Pau, France; nicolas.barbarin@external.total.com

Jean-Charles Mazur
Aix-Marseille University, CNRS, IRD, Col. France; CEREGE, Aix en Provence, France; mazur@cerege.fr

Clara Bolton
Aix-Marseille University, CNRS, IRD, Col. France; CEREGE, Aix en Provence, France; bolton@cerege.fr

It is now well established that environmental conditions drive changes in the coccolith morphology of *Emiliania huxleyi* and other Noelarhabdaceae taxa. Evolution also has played a very important role in shaping the morphology of coccolithophores. Here, we investigate the manner in which the interwoven influences of environment and evolution control coccolith shape variation on orbital timescales. The western Pacific warm pool was chosen because it is far from oceanic boundaries and because sea surface temperatures are relatively stable (2–3°C variation) at different time scales (from seasonal to 100kyr). We studied morphological changes in Noelarhabdaceae from three well dated cores that were retrieved around Papua New Guinea (PNG): MD97-2140 and MD05-2520, which were retrieved to the north of PNG and, cover the last 1.7Ma and 0.4Ma respectively, and MD05-2530, which was retrieved to the south of PNG and covers the last 0.8Ma. In every sample from those cores, the biometry of at least 300 Noelarhabdaceae coccoliths was estimated at a time resolution of less than 2kyr. Coccolith images were taken in cross-polarized light and were identified with a deep-learning software (SYRACO). Measurements of mass, length, and width were then produced automatically. A bimodal distribution in size was apparent in most of the samples with a mode separation of around 3μm. The mass and the size of the large and small groups show mirrored (opposite) fluctuations. The rhythms of these fluctuations closely follow precession and eccentricity cycles of the Earth's orbits around the sun. We therefore infer that seasonality played an important role in shaping coccoliths. The reason why large and small coccoliths have opposite long-term mass trends remains enigmatic. Two obvious possibilities are differential depth habitats and/or growth seasons. The relative importance of evolution and the environment on coccolith morphological patterns will be discussed in detail.

Calcareous nannofossil assemblages across the Paleocene-Eocene transition in the Kharouba section, northern Tunisia

Ilef Belhajtahar

Université de Tunis El Manar, Faculté des Sciences de Tunis, Département de Géologie, Campus Universitaire, 2092, Tunis, Tunisie; Université de Lyon, Université Claude Bernard Lyon 1, ENS de Lyon, CNRS, UMR 5276 LGL-TPE, F-69622 Villeurbanne, France; ilef.ibn-haj-tahar@etu.univ-lyon1.fr

Emanuela Mattioli

Université de Lyon, Université Claude Bernard Lyon 1, ENS de Lyon, CNRS, UMR 5276 LGL-TPE, F-69622 Villeurbanne, France; emanuela.mattioli@univ-lyon1.fr

Mohamed Soussi

Université de Tunis El Manar, Faculté des Sciences de Tunis, Département de Géologie, Campus Universitaire, 2092, Tunis, Tunisie; mohsou@yahoo.com

Najeh Ben Chaabane

Université de Tunis El Manar, Faculté des Sciences de Tunis, Département de Géologie, Campus Universitaire, 2092, Tunis, Tunisie; najeh.geo.tun@live.fr

The Paleocene-Eocene transition is marked by a global warming event (PETM), a carbon isotope ($\delta^{13}C$) negative excursion, and several environmental and biotic perturbations, which have been well documented in various environmental settings. This work focuses on the biostratigraphy and the biotic response of calcareous nannofossils to this thermal event in Tunisia, an area in the Tethys that has not been well investigated.

Quantitative and qualitative sample analyses revealed a high diversity in the calcareous nannofossils, which allowed us to attribute the section to Zones NP9 and NP10 (late Paleocene to early Eocene). This section is biostratigraphically continuous, and the Zone NP9/NP10 boundary is placed at the first appearance of *Rhomboaster bramlettei*. The top of the section is attributed to the highest part of Zone NP10.

Toweius spp. and *Coccolithus pelagicus* are the most abundant species in the section. Across the PETM, several calcareous nannofossil events and changes in the assemblage were recognized: the decrease in abundance of *Toweius* spp. and *Fasciculithus* spp., the presence of deformed *Discoaster* spp., as well as the abundance of *Discoaster araneus* and *Rhomboaster* spp., which are known to be excursion taxa. The increase in abundance of *Zygrhablithus bijugatus* and the gradual increase of *Toweius* spp. indicate the return to oligotrophic conditions above the PETM.

In conclusion, calcareous nannofossils in the Kharouba section show different responses and key shifts across the PETM than found in previously studied oceanic sites. There was a proliferation of relatively warm and oligotrophic taxa across the event, while above the PETM with a return to normal conditions, there was a proliferation of relatively cooler taxa. This section provides new information and documents events that are useful for correlation with other sites in the Tethyan Realm.

Microdiversity of cosmopolitan coccolithophores through an oligotrophic gradient in the Mediterranean Sea

El Mahdi Bendif
University of Oxford, Department of Plant Sciences, Oxford OX1 3RB, UK; elmhidi@gmail.com

Julien Laurent
Station Biologique de Roscoff, 29680 Roscoff, France; julienghm@gmail.com

Ian Probert
Station Biologique de Roscoff, 29680 Roscoff, France; probert@sb-roscoff.fr

Peter von Dassow
Pontificia Universidad Católica de Chile, Facultad de Ciencias Biológicas, Santiago, Chile; Station Biologique de Roscoff, 29680 Roscoff, France; Instituto Milenio de Oceanografía, Concepción, Chile; pvondassow@bio.puc.cl

Lluïsa Cros
Institut de Ciències del Mar, CMIMA (CSIC), Passeig Marítim de la Barceloneta, 37-45, 08003 Barcelona, Spain; lluisa@icm.csic.es

Jeremy R. Young
University College London, Department of Earth Sciences, London WC1E 6BT, UK; jeremy.young@ucl.ac.uk

Christian Jeanthon
Station Biologique de Roscoff, 29680 Roscoff, France; jeanthon@sb-roscoff.fr

Laurence Garczareck
Station Biologique de Roscoff, 29680 Roscoff, France; garczareck@sb-roscoff.fr

Colomban de Vargas
Station Biologique de Roscoff, 29680 Roscoff, France; vargas@sb-roscoff.fr

The phylogeography of keystone phytoplankton species has rarely been considered at an infra-specific level in climate change “hot spots”. By providing relevant information about genetic structuring, such studies can shed light upon how environmental changes are impacting distribution and diversity in phytoplankton populations. In this study, we investigated the microdiversity of the *Emiliania* complex in the oligotrophic waters of the Mediterranean Sea during the summer of 2008. We compared environmental libraries of mitochondrial DNA retrieved from samples collected along a west-to-east transect. Most of the sequences clustered either within the ubiquitous Alpha haplogroup or within an unexpected new haplogroup (termed Delta). Alpha haplotypes contributed primarily to the overall genetic differentiation that was reflected in a shift in dominance between two sub-haplogroups, alpha 1 and alpha 2. More prevalent in the eastern stations, alpha 2 was characterized by ultra-oligotrophy and higher light, temperature, and alkalinity, in contrast to alpha 1, which was more abundant in less oligotrophic conditions. Delta haplotypes were associated with western stations that had lower temperatures and higher nutrient and oxygen concentrations. Demographic modeling analyses suggest that the Alpha metapopulation experienced a recent expansion. Because environmental variations shape phylogeographic patterns, global warming and ocean acidification may selectively impact the diversity of this key component of the pelagic ecosystem.

Puzzling speciation and adaptive patterns in the *Gephyrocapsa* complex

El Mahdi Bendif
University of Oxford, Department of Plant Sciences, Oxford OX1 3RB, UK; elmhidi@gmail.com

Ian Probert
Station Biologique de Roscoff, 29680 Roscoff, France; probert@sb-roscoff.fr

Jeremy R. Young
University College London, Department of Earth Sciences, London WC1E 6BT, UK; jeremy.young@ucl.ac.uk

Colomban de Vargas
Station Biologique de Roscoff, 29680 Roscoff, France; vargas@sb-roscoff.fr

The haptophyte genus *Gephyrocapsa* comprises a complex of widely distributed bloom-forming coccolithophore species that have played a key role in global marine carbon fluxes over the last 3Ma. The most abundant species in modern oceans is *Gephyrocapsa huxleyi*, which has colonized very diverse ocean surface habitats, while its close relatives have remained more ecologically restricted. *Gephyrocapsa huxleyi* appears to have lost the ability to reproduce sexually in environments with low biotic/environmental pressures. This loss of sexual reproduction appears to have been a rapid microevolutionary process as compared to the establishment of the major phylogenetic groups within the *Gephyrocapsa* complex. Here, we present an attempt to describe the global diversity of *Gephyrocapsa* by coupling barcoding and phylogenomics approaches to metagenomics and relating physiological traits to an assessment of ecological niches. Data retrieved from several cruises highlight the existence of two major mitochondrial haplogroups within *G. huxleyi*, alpha and beta, respectively, which are associated with warm and cold (bipolar) water systems. At a finer phylogenetic level, haplotypes were related to hydrographic structures, especially to subtle changes in nutrient and carbonate species concentrations. Furthermore, multi-barcode and phylogenomic analyses revealed a deep phylogenetic divergence that is related to thermal clines with a slight incongruence when compared to mitochondrial barcodes, suggesting the potential for hybridization between alpha and beta haplogroups. Considering actual scenarios of global warming and ocean acidification, this study provides a relevant diversity baseline for future monitoring that aims to evaluate whether an important climate-regulating organism has the intrinsic ability to adapt and thus continue to modulate our climate.

Calcareous nannofossils at the Triassic-Jurassic boundary: stratigraphic and paleoceanographic characterizations

Cinzia Bottini

Università degli Studi di Milano, Dipartimento di Scienze della Terra, 20133 Milano, Italy; Cinzia.bottini@unimi.it

Elisabetta Erba

Università degli Studi di Milano, Dipartimento di Scienze della, 20133 Milano, Italy; Elisabetta.erba@unimi.it

Claudio Artoni

Università degli Studi di Milano, Dipartimento di Scienze della Terra 20133 Milano, Italy; Claudio.artoni@studenti.unimi.it

In this study, calcareous nannofossils were identified for the first time in the uppermost Triassic sequence of the Lombardy Basin (Southern Calcareous Alps, Italy). The new data and their correlation with available datasets for the Triassic-Jurassic boundary (TJB) interval made it possible to date the upper Zu Limestone and the Malanotte Formation. Two zones were recognized: the NT2b (latest Triassic) and the NJT1 (earliest Jurassic). Two species were found to be good markers for constraining the TJB interval: *Prinsiosphaera triassica* and *Schizosphaerella punctulata*. Nannofossil data were calibrated with C isotopic chemostratigraphy that was obtained for carbonate and organic matter. A size reduction in *P. triassica* and a decline in the abundance of Triassic nannofossils was detected soon after the precursor carbon isotope excursion (CIE) and culminated during the initial negative CIE, which is characterized by the lowest nannofossil abundances and small-sized *P. triassica*. The extinction of Triassic nannofossils occurred in distinctive steps within the initial negative CIE, while the Jurassic species *S. punctulata* was first observed at the base of the main negative CIE. The latest Triassic nannofossil decline in abundance, reduction in size, and series of extinctions represent a progressive deterioration that is associated with the Central Atlantic magmatic province (CAMP) volcanism. Our findings are consistent with nannofossil changes at supraregional scale and indicate that the massive CAMP flood basalts were preceded by initial volcanic pulses. We speculate that a combination of climate change, fertilization, and ocean acidification began to influence the calcification process prior to the initial negative CIE. Nannoplankton extinctions were not simultaneous, which might imply a limited capacity for adaptation in the early stages of their evolutionary history.

In addition, some possible new morphotypes were identified in the Rhaetian, which may be useful in characterizing Late Triassic assemblages, particularly the mass extinction at the TJB boundary interval.

The effect of mid Cretaceous paleoenvironmental changes on *Biscutum constans* size changes

Cinzia Bottini
Università degli Studi di Milano, Dipartimento di Scienze della Terra, 20133 Milano, Italy; cinzia.bottini@unimi.it

Giulia Faucher
Università degli Studi di Milano, Dipartimento di Scienze della Terra, 20133 Milano, Italy; giulia.faucher@unimi.it

In the last decades, many studies have focused on specific intervals of the geological record in order to identify size variations of selected species of nannofossils. Fluctuations in the mean size of *Biscutum constans* were identified in the early Aptian oceanic anoxic event (OAE) 1a and latest Cenomanian OAE 2, when *B. constans* reached its smallest mean size under "extreme" conditions in terms of greenhouse climate, excess CO_2, and accelerated nutrient recycling, as well as trace metals peaks. *Biscutum constans* is considered to be a mesotrophic species, and different hypotheses have been formulated to interpret its size changes, including ocean acidification, variation in light, and anomalies in trace metal concentrations. In order to understand better which factor/s may have influenced the size of *B. constans*, we decided to investigate a continuous record through the Aptian-Cenomanian. Very little is known about size variations in *B. constans* over longer periods of time (thousand/millions of years), and it is not clear if there were any changes in size during interludes of "stable" paleoenvironmental conditions. The chosen time interval was selected because it includes periods of stability and episodes of global environmental perturbation, such as OAE 1a, OAE 1b, OAE 1d, the Mid-Cenomanian Event, and OAE 2. We focused on the Umbria-Marche Basin (central Italy) and investigated the Piobbico core and the Monte Petrano section, which are stratigraphically well constrained and for which a complete characterization of paleotemperatures and paleofertility is available. Morphometrics revealed changes in the mean size of *B. constans*. After OAE 1a, which is characterized by dwarf specimens, *B. constans* showed a recovery, although the largest mean values were reached in the middle Albian. A relative decrease in size was detected just prior to OAE 1d. The next main shift coincided with OAE 2 and was marked by dwarf specimens. Statistical analyses are planned to detect any possible dependence upon temperature and nutrient variations.

Calcareous nannofossils from the proposed Kapurpurawan National Geological Monument, Ilocos Norte (northwestern Philippines)

Gretchen P. Callejo
University of the Philippines, National Institute of Geological Sciences, Diliman, Quezon City, Philippines, 1101; gpcallejo@up.edu.ph

Allan Gil S. Fernando
University of the Philippines, National Institute of Geological Sciences, Diliman, Quezon City, Philippines, 1101; agsfernando@yahoo.com; asfernando@up.edu.ph

Calcarenite units that were observed along the northwestern tip of Burgos, Ilocos Norte were previously mapped as the upper Miocene Pasuquin Limestone (BMG, 1985; Queaño, 2006; Queaño *et al*., 2014). Planktonic foraminiferal analyses by Pinet (1990) and Queaño (2006) confirmed the late Miocene age of the formation. A more recent planktonic foraminiferal study in the area, however, revealed a younger age of early Pliocene (Zones N18-N19), which extends the age of the Pasuquin Limestone to late Miocene to early Pliocene (Callejo *et al*., 2015).

To confirm an early Pliocene age for the formation, a calcareous nannofossil analysis of the calcarenite and associated marly limestone/calcilutite units was performed. The samples revealed poor to moderately preserved nannofossils. Despite the low nannofossil abundance, several markers were identified, including *Discoaster pentaradiatus*, *Sphenolithus abies*, and *Reticulofenestra pseudoumbilicus* (>7μm). This assemblage suggests that the samples are within nannofossil Zones NN10-NN15, which corresponds to a late Miocene to early Pliocene age.

The results of the calcareous nannofossil analysis confirm that the age of the Pasuquin Limestone is late Miocene to early Pliocene, and the definition of the formation should be extended and revised accordingly.

References

Bureau of Mines and Geosciences (BMG). 1985. *Geology and mineral resources of the Philippines.* vol. 1. Bureau of Mines and Geosciences, Manila, Philippines.

Callejo, G., Fernando, A. & De Silva, L. 2015. New age dates of the Kapurpurawan Rock Formation in Burgos, Ilocos Norte based on Foraminifera assemblage. Presented during the GEOCON 2015 on December 8–9, 2015.

Pinet, N. 1990. *Un exemple de grand decrochement actif en entexte de subduction oblique: la faille Philippine dans se partie Septentrionale*. PhD Thesis, Univ. de Nice: 390pp.

Queaño, K. 2006. *Tectonic modelling of Northern Luzon, Philippines and regional implications*. Master Thesis, University of Hong Kong: 500pp.

Queaño, K.L., Canarias, J. & Delos Reyes, J.K. 2014. Stratigraphy of northwestern Ilocos Norte: new data and interpretations. *CEGE Journal of the Mapua Institute of Technology*: 1–9.

Middle Eocene evolutionary lineages from the North Atlantic Ocean, IODP Site U1410: biostratigraphic and paleoecological constraints

Carlotta Cappelli

Università degli Studi di Padova, Dipartimento di Geoscienze, 35131 Padova, Italy; carlotta.cappelli@phd.unipd.it

Claudia Agnini

Università degli Studi di Padova, Dipartimento di Geoscienze, 35131 Padova, Italy; Stockholm University, Department of Geological Sciences, SE-106 91 Stockholm, Sweden; claudia.agnini@unipd.it

Paul R. Bown

University College London, Department of Earth Sciences, London WC1E 6BT, UK; p.bown@ucl.ac.uk

Yuhji Yamamoto

Kochi University, Center for Advanced Marine Core Research, Kochi 783-8502, Japan; y.yamamoto@kochi-u.ac.jp

According to global marine isotopic records, the middle Eocene represents the first phase in a long-term cooling that eventually led to the onset of Antarctic glaciation across the Eocene-Oligocene boundary (Zachos *et al*., 2001). Here, we aim to document the evolutionary changes that are displayed by two different calcareous nannofossil taxonomic groups (coccolithaceans and sphenoliths) during the Lutetian in order to strengthen the biostratigraphic framework and provide a better understanding of plankton evolution during this crucial stage. We studied calcareous nannofossil assemblages for Zones NP15-NP16 or CNE9-CNE12 (Martini, 1971; Agnini *et al*., 2014) in deep-sea successions recovered at Site U1410 (IODP Expedition 342; 41°19.6987′N, 49°10.1995′W, Norris *et al*., 2012) on the southeast Newfoundland Ridge (NW Atlantic). This site contains expanded middle Eocene successions of clay-rich nannofossil oozes that have exceptionally well preserved nannofossils, and is thus suitable for detailed morphologic studies, as well as standard quantitative analyses. Morphometric data were collected in order to characterize the central structure of the middle Eocene *Coccolithus-Cruciplacolithus-Chiasmolithus* plexus. In addition, our results provide insights on a sphenolith evolutionary lineage, which includes *Sphenolithus kempii* - *S. perpendicularis* - *S. furcatolithoides* morph. A - *S. cuniculus* - *S. furcatolithoides* morph. B. Based on general morphology and extinction pattern, we were able to define the successive steps observed in this lineage, which allowed us to improve biostratigraphic accuracy within the Lutetian Stage. This lineage also highlights interesting relationships between middle Eocene evolutionary trends and changes in paleoenvironmental conditions.

References

Agnini, C., Fornaciari, E., Raffi, I., Catanzariti, R., Pälike, H., Backman, J. & Rio, D. 2014. Biozonation and biochronology of Paleogene calcareous nannofossils from low and middle latitudes. *Newsletters on Stratigraphy*, **47**:131–18.

Martini, E. 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. *In*: A. Faranacci (Ed). *Proceedings of the Second Planktonic Conference Roma 1970.* Edizioni Tecnoscienza, Rome, **2**: 739–785.

Norris, R.D., Wilson, P.A., Blum, P. & the Expedition 342 Scientists. 2012. Paleogene Newfoundland Sediment Drifts and MDHDS Test. *Proceedings of the IODP*, **342**: College Station, TX (Integrated Ocean Drilling Program). doi: 10.2204/iodp.proc.342.2014 [http://publications.iodp.org/proceedings/342/342title.htm].

Zachos, J., Pagani, M., Sloan, L., Thomas, E. & Billups, K. 2001. Trends, rhythms, and aberrations in global climate 65Ma to Present. *Science*, **292**: 686–693.

The evolution of fasciculiths in the Danian Bottaccione section (Italy): a glance at biotic and geochemical evolution

Carlotta Cappelli
Università degli Studi di Padova, Dipartimento di Geoscienze, 35131 Padova, Italy; carlotta.cappelli@phd.unipd.it

Simone Galeotti
Università degli Studi di Urbino, Dipartimento di Scienze Pure e Applicate, 61029 Urbino, Italy; simone.galeotti@uniurb.it

Matteo Moretti
Università degli Studi di Urbino, Dipartimento di Scienze Pure e Applicate, 61029 Urbino, Italy; matteo.moretti@uniurb.it

Luca Lanci
Università degli Studi di Urbino, Dipartimento di Scienze Pure e Applicate, 61029 Urbino, Italy; luca.lanci@uniurb.it

Simonetta Monechi
Università degli Studi di Firenze, Dipartimento di Scienze della Terra, 50121 Firenze, Italy; simonetta.monechi@unifi.it

The Danian Stage is characterized by profound perturbations in biogeochemical cycles, which are documented by a number of negative carbon isotope excursions (CIEs). Calcareous nannofossils have been a primary component of marine calcareous phytoplankton since at least 200Ma and thus have played a primary role both as carbonate and organic carbon producers. This group, which was deeply affected by the Cretaceous-Paleogene mass extinction, began recovery immediately after the event, but a full reorganization of the calcareous nannofossil assemblages was not completed until the middle-late Danian, when the restoration of a new equilibrium in the global carbon cycle was achieved. Here, we present a high-resolution calcareous nannofossil dataset from the Bottaccione and Contessa Road pelagic sections (Gubbio, central Italy), two classical successions that have been used as references for the Paleogene geomagnetic polarity time scale. This study provides insights into the evolutionary relationship among fasciculiths and sheds light on the mode and timing of the appearances and disappearances of species belonging to the genera *Gomphiolithus*, *Diantholitha*, and *Lithoptychius* during the Danian (Zones NP1-NP4 or CNP1-CNP7, Martini, 1971; Agnini *et al.*, 2014). These data strengthen the available biostratigraphic-biochronologic framework, but their main value is through comparison with $\delta^{13}C$ and $CaCO_3$ records (Coccioni *et al*., 2012; Galeotti *et al*., 2015), which provided new insights into how a new equilibrium in the carbon biogeochemical cycles, which was reached after the K-Pg boundary, fits with the appearance of a new bauplan in calcareous nannoplankton.

References

Agnini, C., Fornaciari, E., Raffi, I., Catanzariti, R., Pälike, H., Backman, J. & Rio, D. 2014. Biozonation and biochronology of Paleogene calcareous nannofossils from low and middle latitudes. *Newsletters on Stratigraphy*, **47**:131–18.

Coccioni, R., Bancalà, G., Catanzariti, R., Fornaciari, E., Frontalini, F., Giusberti, L., Jovane, L., Luciani, V., Savian, J. & Sprovieri, M. 2012. An integrated stratigraphic record of the Palaeocene–lower Eocene at Gubbio (Italy): new insights into the early Palaeogene hyperthermals and carbon isotope excursions. *Terra Nova*, **24**(5): 380–386.

Galeotti, S., Moretti, M., Cappelli, C., Phillips, J., Lanci, L., Littler, K., Monechi, S., Petrizzo, M.R., Premoli Silva, I. & Zachos, J.C. 2015. The Bottaccione Section at Gubbio, Central Italy: a classical Paleocene Tethyan Setting revisited. *Newsletters on stratigraphy*, **48**: 325–339.

Martini, E. 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. *In*: A. Faranacci (Ed). *Proceedings of the Second Planktonic Conference Roma 1970.* Edizioni Tecnoscienza, Rome, **2**: 739–785.

Calcareous nannofossil biostratigraphy of the late Oligocene to early Miocene Lubuagan Formation (western Cagayan Valley Basin), Kalinga Province, Philippines

Abigael L. Castro

University of the Philippines, National Institute of Geological Sciences, Diliman, Quezon City, Philippines, 1101; National Museum of the Philippines, Geology and Paleontology Division, Manila, Philippines 1000; alcastro1@up.edu.ph

Allan Gil S. Fernando

University of the Philippines, National Institute of Geological Sciences, Diliman, Quezon City, Philippines, 1101; agsfernando@yahoo.com

The Cagayan Valley Basin is an archipelagic sedimentary basin (Tamesis, 1981) that is situated in the northern part of the Philippines. It is one of the country's largest offshore basins, and there are a number of studies on its general geology (Corby *et al*., 1951; Vergara *et al*., 1959; Durkee & Pederson, 1961), hydrocarbon potential (Tamesis, 1981; BED, 1986), and archaeological importance (Acabado, 2010). Detailed calcareous nannofossil biostratigraphic studies, however, are relatively few despite the recognized significance of such a study in establishing a comprehensive geologic history for the area. This study aims to establish a calcareous nannofossil biostratigraphy for sedimentary units in the Cagayan Valley Basin, starting with samples from the late Oligocene to early Miocene Lubuagan Formation.

Samples were collected from exposures of the interbedded sandstone-mudstone units of the Lubuagan Formation in Kalinga Province (western Cagayan Valley Basin) and were analyzed for calcareous nannofossils. For most samples, the nannofossil abundance and diversity were low. The nannofossils were well preserved, except for the discoasters, which were mostly fragmented. Nannofossil taxa that were observed in the samples include *Cyclicargolithus floridanus*, *Sphenolithus abies*, *S. heteromorphus*, *S. moriformis*, and *Reticulofenestra pseudoumbilicus*. Based on the presence of *S. heteromorphus*, nannofossil Zone NN4-NN5 was recognized, suggesting an early middle Miocene age for the younger deposits of the Lubuagan Formation. The older sections (i.e., Oligocene) of the Lubuagan Formation, on the other hand, were recognized based on the presence of *Sphenolithus ciperoensis*.

The ultimate goal of this study was to resolve the conflicting age assignments of the Lubuagan Formation as reported in various research studies. Maac (1988) assigned the Lubuagan Formation to the early-middle Miocene based on foraminiferal analysis. The study of Billedo (1994) assigned a late Oligocene-early Miocene age based on nannofossil analysis of samples from the southeastern part of the Cagayan Valley Basin. The stratigraphic column proposed in the PNOC-EC (2003) report restricted the age assignment to the middle Miocene.

References

Acabado, S. 2010. *The archaeology of the Ifugao Agricultural Terraces: antiquity and social organization*. PhD. Thesis, University of Hawai'i, Hawai'i, USA.

Billedo, E. 1994. *Geology of the northern Sierra Madre and the Polilio Group of islands (Eastern Mobile Belt)*. Ph.D. Thesis, Institut de Geodynamique-University of Nice-Sophia Antipolis, France.

Bureau of Energy Development, Philippines (BED). 1986. *Sedimentary Basins of the Philippines, their Geology and Hydrocarbon Potential, v. 2 (Luzon Basins).*

Corby, G.W., Kleinpell, R.M., Popenoe, W.P., Merchant, R., William, H., Teves, J., Grey, R. & Marquez, R. 1951. Geology and Oil Possibilities of the Philippines. *Department of Agriculture and Natural Resources Technical Bulletin*, **21**: 363pp.

Durkee, E.F. and Pederson, S.L. 1961. Geology of Northern Luzon. Bulletin of the American Association of Petroleum Geologists, **5**(2): 138–168.

Maac, Y. (1988). Paleontologic and paleoenvironment studies of the Tabuk-Batong Buhay route, Kalinga-Apayao. ITIT Project No. 8319 (Research on Stratigraphic Correlation of Cenozoic Strata in Oil and Gas Fields Philippines): 20–31.

Philippine National Oil Company-Exploration Corp. 2003. Reassessment of the Petroleum Prospectivity of the SC 37 Block, Cagayan Basin.

Tamesis, E.V., (1981). Hydrocarbon Potential of Philippine Basins. Energy. **6**(11): 1181–1206.

Vergara, J. F., D. Fajardo, and A. Blanquera. (1959). Preliminary report on the geology of eastern Cagayan region. The Philippine Geologist. **13**(2): 44–55.

Calcareous nannofossils from the Miocene of the Andaman and Nicobar Islands, India: biostratigraphic and paleoecological perspectives

Arindam Chakraborty
BirbalSahni Institute of Palaeosciences, Lucknow-226 007, India; University College London, Department of Earth Sciences, London WC1E 6BT, UK; arindam@bsip.res.in

Paul R. Bown
University College London, Department of Earth Sciences, London WC1E 6BT, UK; p.bown@ucl.ac.uk

Amit K. Ghosh
BirbalSahni Institute of Palaeosciences, Lucknow-226 007, India; akghosh_in@yahoo.com

Jeremy R. Young
University College London, Department of Earth Sciences, London WC1E 6BT, UK; jeremy.young@ucl.ac.uk

Neogene sediments from the Andaman and Nicobar Islands, specifically from lower to upper Miocene sequences, were analyzed for calcareous nannofossil content and found to contain well preserved and diverse fossil assemblages. The majority of the samples contained stratigraphic marker taxa that allowed us to identify successions within the lower to middle Miocene (Zone NN4) on Havelock Island (*Sphenolithus heteromorphus* and *Helicosphaera ampliaperta*), and upper Tortonian (late Miocene, Zone NN11A) on Neil Island (*Discoaster bergrennii/quinqueramus* and the absence of *Amaurolithus primus*). Rock surface observations with the SEM revealed the dominance of sphenoliths, reticulofenestrids, and the genus *Umbilicosphaera*. The presence of relatively unusual assemblage compositions, especially the presence of abundant sphenoliths and small reticulofenestrids, and rare discoasters, along with common diatoms, indicated high productivity surface waters and probable upwelling paleoenvironmental conditions. In the late Miocene, a low abundance of discoasters and a high abundance of small reticulofenestrids (<3μm) indicate eutrophic conditions. This may be due to the influence of intensified monsoonal activity because the onset of these high productivity surface water environments can be linked to an intensification of the Indian Summer Monsoon around 8 million years ago.

The microalgae strain bank ATHU-AL at the University of Athens (NKUA)

Xanthi Chantzistrountsiou

National and Kapodistrian University of Athens, Faculty of Biology, Department of Ecology & Systematics, Panepistimioupolis, Athens 157 84, Greece; xanthi.biol@gmail.com

Vasiliki Lamprinou

National and Kapodistrian University of Athens, Faculty of Biology, Department of Ecology & Systematics, Panepistimioupolis, Athens 157 84, Greece; vlampri@biol.uoa.gr

Eirene Gratsia

National and Kapodistrian University of Athens, Faculty of Biology, Department of Ecology & Systematics, Panepistimioupolis, Athens 157 84, Greece; gratsia.eir@gmail.com

Eleni Evrigeni

National and Kapodistrian University of Athens, Faculty of Biology, Department of Ecology & Systematics, Panepistimioupolis, Athens 157 84, Greece; levrigeni@gmail.com

Ioannis Tzovenis

National and Kapodistrian University of Athens, Faculty of Biology, Department of Ecology & Systematics, Panepistimioupolis, Athens 157 84, Greece; itzoveni@biol.uoa.gr

Athena Economou-Amilli

National and Kapodistrian University of Athens, Faculty of Biology, Department of Ecology & Systematics, Panepistimioupolis, Athens 157 84, Greece; aamilli@biol.uoa.gr

Microalgae and especially nannoplankton algae constitute one of the most important primary production components in all aquatic ecosystems. Lagoons, transitional ecosystems, and extreme aquatic habitats contain a unique set of diverse physical-chemical characteristics that affect the composition of the indigenous biocommunities. Microalgae from such environments show remarkable adaptability within a range of environmental conditions (e.g., salinity, temperature, and light), which in turn affect algae taxonomy and ecology. We present the process that was used to isolate, identify, and live preserve strains that belong to microalgae species of taxonomic, ecological, and commercial interest from coastal areas of Greece. More than 100 strains have been isolated and preserved as small-scale cultures in a strain bank under the name ATHU-AL that is housed in the Department of Ecology and Systematics, Faculty of Biology (University of Athens, NKUA). The preserved strains include representatives of the classes Chlorophyceae, Chlorodendrophyceae, Bacillariophyceae, Trebouxiophyceae, and Haptophyceae that were collected from several locations (e.g., Messolonghi, Epirus, Saronikos Gulf, and Samos Island), and also cyanobacteria from some extreme habitats in Greece, including caves and thermal springs. All of the strains were isolated by applying micropipette single-cell isolation and/or multiple dilution and are maintained in small-scale unialgal cultures, in steady conditions culture chambers. The strain bank cultures are renewed on a monthly basis under sterile conditions in order to serve as a live stock for species identification purposes under a polyphasic approach, using both classic and modern (e.g., molecular and biochemical) techniques. The strain bank ATHU-AL is being enriched constantly, allowing not only taxonomic and phylogenetic studies on selected algal strains, but also applied phycology research and potential commercial applications development.

Investigating the late Campanian-Maastrichtian cooling trend using clumped isotopes on the coccolith fraction of sediments from the Boreal Chalk Sea and Shatsky Rise

Shamar C. Chin
University of Nebraska - Lincoln, Department of Earth and Atmospheric Sciences, Lincoln, NE 68588, USA; shamar.chin@huskers.unl.edu

David K. Watkins
University of Nebraska - Lincoln, Department of Earth and Atmospheric Sciences, Lincoln, NE 68588, USA; dwatkins1@unl.edu

Our understanding of past climates is reliant upon the use of geochemical proxies. These proxies have been used extensively to interpret past conditions. However, there are uncertainties associated with them. Vital effects often affect the results in that there is a difference between the chemical properties of the biological and inorganic components (Tripati *et al*., 2010). Given these discrepancies, other methods need to be explored, and clumped isotopologues have proven to be a promising paleotemperature proxy. It should also be noted that coccoliths are less susceptible to dissolution than planktic foraminiferal calcite (Schmidt *et al*., 2006), making coccolith-derived sea surface temperatures a viable option for this study.

The late Campanian-Maastrichtian (~74–66Ma) interval of the Boreal Chalk Sea and ODP Leg 198 Site 1210 (Shatsky Rise) is the focus of this study. This interval is of interest because it was characterized by a cooling trend that marked a transition from the extreme greenhouse conditions associated with the mid-Cretaceous. For example, the North Atlantic (~35 °N) cooled by ~7 °C during this time (Linnert *et al*., 2014).

When compared to the North Atlantic, results from other studies show that the cooling trend was less pronounced in other ocean basins, including the Boreal Chalk Sea and Shatsky Rise. It is plausible that the cooling was more pronounced in the North Atlantic due to development of the Gulf Stream. This work is testing this hypothesis by using clumped isotopes on the coccolith fraction of sediments from these two sites. Centrifugation is being used to concentrate the coccoliths into a size fraction ranging from ~4–12μm, and the samples will be analyzed using the SEM to determine the extent of diagenesis. Clumped isotopes will then be used to derive paleotemperatures from the coccolith fraction, and the results will be compared to fully quantitative counts and paleoecological indices.

References

Linnert, C., Robinson, S.A., Lees, J.A., Bown, P.R., Pérez-Rodríguez, I., Petrizzo, M.R., Falzoni, F., Littler, K., Arz, J.A. & Russell, E.E. 2014. Evidence for global cooling in the Late Cretaceous. *Nature Communications*, **5**: 4194.

Schmidt, D.N., Lazarus, D., Young, J.R. & Kucera, M. 2006. Biogeography and evolution of body size in marine plankton. *Earth-Science Reviews*, **78**(3): 239–266.

Tripati, A.K., Eagle, R.A., Thiagarajan, N., Gagnon, A.C., Bauch, H., Halloran, P.R. & Eiler, J.M. 2010. 13 C–18 O isotope signatures and 'clumped isotope' thermometry in foraminifera and coccoliths. *Geochimica et Cosmochimica Acta*, **74**(20): 5697–5717.

Oligocene–lower Miocene calcareous nannofossils and sedimentology of the Transcarpathian Basin in Romania

Carmen Mariana Chira
Babes-Bolyai University, Cluj-Napoca, 400084, Romania; carmen.chira@ubbcluj.ro

Carlo Aroldi
Babes-Bolyai University, Cluj-Napoca, 400084, Romania; c.aroldi@alice.it

The present study is focused on several investigated sections in the Transcarpathian Basin: Colibiţa, Mureşenii Bârgăului (i.e., Aroldi *et al*., 2013), and the Tihuţa area. The analyzed successions are deep-water turbidite deposits of the Borşa Formation of Oligocene-early Miocene age. Paleogeographic reconstructions for the late Oligocene–early Miocene interval (Sandulescu & Micu, 1989) indicated that in the Maramures area, the source area of the sequences was situated in a more inner position than the Eastern Carpathians.

Colibiţa

The lithology includes alternations of sandstone beds and hemipelagic marls that are mainly organized into coarsening-upward cycles. The observed vertical trend is one of shallowing upward. The calcareous nannofossil assemblages contain *Zygrhablitus bijugatus* (Zones NP11-NP25), *Lanternithus minutus* (Zones NP14-NP23), *Isthmolithus recurvus* (Zones NP19-NP22), *Reticulofenestra umbilicus* (Zones NP16-NP22), *R. dictyoda* (Zones NP13-NP16), and *Discoaster* cf. *D. lodoensis* (Zones NP14-NP17), which assign an Oligocene age.

Mureşenii Bârgăului

The successions of this unit are organized into fining-upward cycles in its lower stratigraphic levels and coarsening-upward cycles in its upper stratigraphic levels. The vertical trend is also one of shallowing upward. The calcareous nannofossil assemblages belong to Zones NP25-NN2 (Oligocene-early Miocene) and contain: *Sphenolithus conicus* (Paleogene-Zone NN3), *S. predistentus* (Zones NP17-NP24), *Helicosphaera scissura* (Zones NN2-NN4), *H. mediterranea* (Zones NN2-NN4), *H. euphratis* (Zones NP18-NN5), *Discoaster deflandrei* (Eocene-Zone NN7), and *Cyclicargolithus floridanus* (Paleogene-Zone NN7).

Tihuţa

Massive, fine-grained, laterally continuous sandstone beds and hemipelagic marly levels are primarily organized into fining-upward successions. The vertical trend is one of deepening. In the Tihuta Pass area, the presence of Zones NN1 and NN2 was indicated by *Triquetrorhabdulus carinatus*, *Helicosphaera ampliaperta* (Zones NN2-NN4), and *H. mediterranea* (Zones NN2-NN5). A progradation of the depositional turbidite systems is supported by the biostratigraphic study of calcareous nannofossil assemblages that belong to Zones NP25-NN3.

References:

Aroldi, C., Chira, C.M. & Stefanut, V. 2013. Sedimentological features and calcareous nannoplancton from the Oligocene-Lower Miocene turbidite deposits of the Colibita – Muresenii Bârgăului area (Bistrita Nasaud). *Sesiunea Stiintifica Anuala "Ion Popescu Voitesti". Departamentul de Geologie al Universitatii Babes-Bolyai, Cluj-Napoca*, 1–3.

Sandulescu, M. & Micu, M. 1989. Oligocene paleogeography of the Eastern Carpathians. *In*: I. Petrescu, L. Ghergari, N. Meszaros, E. Nicorici & N. Suraru (Eds). *The Oligocene from the Transylvanian Basin. Geological Formations of Transylvania, Romania*, **2**: 79–86.

Middle Miocene paleoenvironments in the Strei Basin (Romania): calcareous nannofossils, micro- and macrofauna and sedimentology

Carmen Mariana Chira

Babes-Bolyai University, Cluj-Napoca, 400084, Romania; carmen.chira@ubbcluj.ro

Radu Negru

Dimitrie Cantemir University, Department of Geography, Tîrgu Mureş, Romania; negrurg@yahoo.com

Anca Andreea Balog

Technical University of Cluj Napoca, 400114, Cluj Napoca, Romania; anca.balog@dst.utcluj.ro

Horea Bedelean

Babes-Bolyai University, Cluj-Napoca, 400084, Romania; horea.bedelean@ubbcluj.ro

The investigated area in the Strei Basin is situated between the South Apuseni Mountains and the Sebeş Mountains. The Badenian deposits transgress onto the crystalline rocks of the Sebeş Mountains (Dragoş & Nedelcu, 1957; Gheorghiu, *et al*., 1962). The most representative section that was analyzed is from Ocolisu Mic. The samples from the lower and upper part of the section contained abundant discoasters and reticulofenestrids. The samples from the lower part of the section also had abundant *Coccolithus pelagicus* and ascidian spicules. *Umbilicosphaera jafari* and *U. rotula* were abundant in samples from the upper part of the section. The calcareous nannoplankton assigned this interval to Zone NN5.

The Badenian deposits contained rare *Neopycnodonte navicularis* bivalves, a stationary epifaunal suspension feeder. In this area, a one-meter-thick tuff level appears. Analyses performed on thin sections indicated a vitric-crystal rio-dacitic type for the tuff. The main depositional processes are represented by debris flows and suspension fallout. The facies associations, calcareous nannoplankton assemblages, and bivalves are indicative of upper slope to shelfal settings. Planktonic/benthic foraminifera ratio trends and the related environments within Ocolisu Mic section suggest that the microfossil communities lived in the following subenvironments: middle shelf, upper bathyal, inner shelf, and outer shelf (100–200m). The calcareous nannoplankton assemblages in the area of Ocolişu Mic belong to Zone NN5, which correlates with the Badenian mollusk Zone *Neopycnodonte navicularis*, confirming a Badenian age for the analyzed deposits.

References

Dragoş, V. & Nedelcu, I. 1957. Cercetari geologice in Bazinul Orastie. *Dări de Seama ale Sedintelor Comitetul Geologic*, **64**: 243–254.

Gheorghiu, C., Zberea, A., Visarion, M. & Calota, C. 1962. Date noi asupra structurii bazinului inferior al Streiului, ca rezultat al cercetarilor geologice si geofizice. *An. Inst. Geol. Rom*., Bucureşti, **XXXII**: 97–149.

Cretaceous calcareous nannofossil biostratigraphy off the coast of northeastern Honshu, Japan

Shun Chiyonobu

Akita University, Akita City, Japan; chiyo@gipc.akita-u.ac.jp

Tokiyuki Sato

Akita University, Akita City, Japan; toki@gipc.akita-u.ac.jp

Cretaceous calcareous nannofossils were studied from two exploratory wells located offshore from the cities of Kesennuma (MITI-Kesennuma-Oki well) and Kuji (Kuji-Oki well) in the northwestern Pacific Ocean. The Cretaceous deposits are composed mainly of alternating mudstones and calcareous sandstones. The basement in the area consists of granite (Sato, 1986). Calcareous nannofossils in these wells occurred in high abundance and diversity, although coccolith preservation was variable. We followed the taxonomic usage of Thierstein (1976). Most of the samples have good to moderate preservation. Nannofossil assemblages were characterized by abundant *Watznaueria barnesae*. Key species for a Cretaceous calcareous nannofossil zonation, as proposed by Thierstein (1976), Sissingh (1977), and Perch-Nielsen (1979), were identified in these wells. *Micura decussata*, *Marthasterites furcatus*, *Eiffellithus eximius*, *Eiffellithus turriseiffeli*, *Prediscosphaera cretacea*, *Cruciellipsis chiastia*, *Braarudsphaera africana*, and *Watznaueria britannica* were recognized in the MITI-Kesennuma-Oki and Kuji-Oki wells. On the basis of these species, the studied sections were assigned an age of Albian to Coniacian. These results indicated the existence of Cretaceous marine deposits off Honshu, Japan, above the Eurasian Plate and allowed reconstruction of the paleoenvironment in the northwestern Pacific region during the Cretaceous.

References

Perch-Nielsen, K. 1979. Calcareous nannofossils from the Cretaceous between the North Sea and the Mediteranean. *Aspecte der Kreide Europas. IUGS Series A*, **6**: 223–272.

Sato, T. 1986. Cretaceous calcareous nannofossil assemblages in the MITI Kesennuma-Oki. *Journal of the Japanese Association for Petroleum Technology*, **51**: 9–12.

Sissingh, W. 1977. Biostratigraphy of Cretaceous calcareous nannoplankton. *Geologie en Mijnbouw*, **56**: 37–65.

Thierstein, H.R. 1976. Mesozoic calcareous nannoplankton biostratigraphy of marine sediments. *Marine Micropaleontology*, **1**: 325–362.

Deglacial to Holocene oceanographic changes in the Gulf of Cádiz and the western Mediterranean as revealed by coccolithophores

Elena Colmenero-Hidalgo

Universidad de León, Área de Geodinámica Externa, Facultad de Ciencias Biológicas y Ambientales, Campus de Vegazana, S/N – 24071, León, Spain; Universidad de Salamanca, Área de Paleontología, Facultad de Ciencias, 37008 Salamanca, Spain; e.colmenero@unileon.es

Blanca Ausín

ETH Zurich, Department of Earth Sciences, 8092 Zurich, Switzerland; Universidad de Salamanca, Departamento de Geologia, Facultad de Ciencias, 37008 Salamanca, Spain; blanca.ausin@erdw.ethz.ch

Débora Simón-Baile

Universidad de las Fuerzas Armadas ESPE, Sangolqui, Ecuador; Universidad de Salamanca, Área de Paleontología, Facultad de Ciencias, 37008 Salamanca, Spain; debora.simon.baile@gmail.com

José-A. Flores

Universidad de Salamanca, Departamento de Geologia, Facultad de Ciencias, 37008 Salamanca, Spain; flores@usal.es

Francisco J. Sierro

Universidad de Salamanca, Departamento de Geologia, Facultad de Ciencias, 37008 Salamanca, Spain; sierro@usal.es

Maria Á. Bárcena

Universidad de Salamanca, Departamento de Geologia, Facultad de Ciencias, 37008 Salamanca, Spain; mbarcena@usal.es

Data on coccolithophore assemblages from the last 25,000 years, which can be found in sediment studies from both sides of the Straits of Gibraltar (Colmenero-Hidalgo *et al*., 2004, Simón-Baile, 2011; Ausín *et al*., 2015a, b), are reviewed in this study that is centered in the transition from the last deglaciation to the Holocene. The selected records are from core M39029–7 (Gulf of Cádiz, Atlantic Ocean), cores MD95-2043, HER-GC-T1, and CEUTA10PC08 (Alborán Sea, western Mediterranean Sea), and core MD99–2343 (north of Minorca, western Mediterranean Sea). In this area, the deglaciation interval and the early Holocene are characterized by an intensive reorganization of the water dynamics due to the climatic transition from the last glacial to the present interglacial and the subsequent rise in sea level and temperature. There were abrupt changes in coccolithophore production and preservation that were likely controlled by factors such as varying rates of surface and intermediate water exchange between the Mediterranean and the Atlantic and changes in the oxygen content of the deep-water masses. We were able to perform a west to east (Atlantic to western Mediterranean) reconstruction of the variations in temperatures and nutricline/pycnocline positions as the deglaciation progressed into the Holocene.

References

Ausín, B., Flores, J.-A., Sierro, F.J., Bárcena, M.A., Hernández-Almeida, I., Francés, G., Gitiérrez-Arnillas, E., Martrat, B., Grimalt, J.O. & Cacho, I. 2015a. Coccolithophore productivity and surface water dynamics in the Alboran Sea during the last 25,000kyr. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **418**: 126–140.

Ausín, B., Flores, J.-A., Sierro, F.J., Cacho, I., Hernández-Almeida, I., Martrat, B. & Grimalt, J.O. 2015b. Atmospheric patterns driving Holocene productivity in the Alboran Sea (Western Mediterranean): a multiproxy approach. *The Holocene*, **25**(4): 583–595.

Colmenero-Hidalgo, E., Flores, J.-A., Sierro, F.J., Bárcena, M.Á., Löwemark, L., Schönfeld, J. & Grimalt, J.O. 2004. Ocean surface water response to short-term climate changes revealed by coccolithophores from the Gulf of Cadiz (NE Atlantic) and Alboran Sea (W Mediterranean). *Palaeogeography, Palaeoclimatology, Palaeoecology*, **205**: 317–336.

Simón Baile, D. 2011. *Reconstrucción paleoceanográfica de los últimos 32ka en el Atlántico nororiental y Mediterráneo occidental a partir del desarrollo de técnicas geoquímicas en asociaciones de cocolitóforos*. PhD Thesis (unpublished), Universidad de Salamanca: 211pp.

Coccolithophore seasonality in the NW Mediterranean Sea

Lluïsa Cros
Institut de Ciències del Mar, CMIMA (CSIC), Passeig Marítim de la Barceloneta, 37-45, 08003 Barcelona, Spain; lluisa@icm.csic.es

José-M. Fortuño
Institut de Ciències del Mar, CMIMA (CSIC), Passeig Marítim de la Barceloneta, 37-45, 08003 Barcelona, Spain; jmanuel@icm.csic.es

Marta Estrada
Institut de Ciències del Mar, CMIMA (CSIC), Passeig Marítim de la Barceloneta, 37-45, 08003 Barcelona, Spain; marta@icm.csic.es

Coccolithophores, one of the primary groups of calcifying organisms on Earth today, show an outstanding diversity in the Mediterranean Sea. Here, we present a study of the coccolithophore community in the open waters of the NW Mediterranean Sea during three different seasonal periods of contrasting oceanographic conditions (March, May, and September of 2009).

The coccolithophore diversity and the HOLP index (the ratio between the number of holococcolithophores (HOL) and the total number of coccolithophores with HOL-HET life cycles) increased from the bloom (March) to post-bloom (May) to stratification (September) periods. In March, coccolithophore abundance was high but with low diversity (76.13% of the specimens consisted of *Syracosphaera marginiporata* and *Emiliania huxleyi*), and there was a low HOLP index (2.26 on average for samples from 0–20m depth), indicating that there were few specimens of the holococcolithophore phase. The highest values of both taxon richness (88) and HOLP index (45.93 on average for samples from 0–20m depth) occurred during the stratification period in September.

Cretaceous calcareous nannofossils from the São Paulo Plateau (DSDP Leg 39, Site 356): biostratigraphy and paleoecological implications

Adriano R.R. Cunha

Federal University of Rio de Janeiro, Biosedimentology and Calcareous Nannofossil Lab., Ilha do Fundão, Rio de Janeiro-RJ, Brazil; adriano_min@hotmail.com

Andre Luiz Gatto Motta

Federal University of Rio de Janeiro, Biosedimentology and Calcareous Nannofossil Lab., Ilha do Fundão, Rio de Janeiro-RJ, Brazil; andregato.geo@gmail.com

Maria Dolores Wanderley

Federal University of Rio de Janeiro, Biosedimentology and Calcareous Nannofossil Lab., Ilha do Fundão, Rio de Janeiro-RJ, Brazil; doloreswanderley@msn.com

Flávia Azevedo Pedrosa

Federal University of Rio de Janeiro, Biosedimentology and Calcareous Nannofossil Lab., Ilha do Fundão, Rio de Janeiro-RJ, Brazil; flaviapedrosa.geo@gmail.com

Over the years, calcareous nannoplankton has proved itself to be an accurate instrument for biostratigraphy and paleoecology due to its cosmopolitan nature and response to environmental and climate changes. In Brazil, these organisms are heavily employed by the oil industry in the marginal and oceanic basins due to the ease and low cost of their preparation. DSDP (Leg 39 - Site 356) cores from the São Paulo Plateau (upper Albian to lower Danian pelagic and hemipelagic limestones) were sampled, and qualitative and quantitative analyses will be conducted in order to identify representative taxa, detect biozones, and infer paleoecological conditions. Cascade counting will be performed for each sample. To assist in the correlation of data and detection of global patterns, the biozonations of Sissingh (1977), Perch-Nielsen (1985), and Burnet (1998) will be utilized for biostratigraphic positioning and relative dating (Figure 1). Applied statistics, abundance rates, and diversity indexes will be compared to the lithostratigraphic, isotopic, and magnetostratigraphic studies in order to construct a database that can be used to locate temporal events and infer paleoenvironmental patterns, which in turn can detect influences of different water masses on the Cretaceous section at the São Paulo Plateau. Finally, it is hoped we will be able to obtain a better understanding of the opening of the South Atlantic Ocean and how elevations and plateaus in the Southwest Atlantic Ocean may have affected ocean circulation.

References

Burnett, J.A. 1998. Upper Cretaceous. *In:* P.R. Bown (Ed). *Calcareous Nannofossil Biostratigraphy*. British Micropalaeontolical Society Publication Series. Chapman and Hall/Kluwer Academic Publishers, London: 132–199.

Fernando, A.G.S., Nishi, H., Tanabe, K., Moriya, K., Iba, Y., Kodama, K., Murphy, M. & Okada H. 2011. Calcareous nannofossil biostratigraphic study of forearc basin sediments: Lower to Upper Cretaceous Budden Canyon Formation (Great Valley Group), northern California, USA. *Island Arc*, **20**: 346–370.

Perch-Nielsen, K. 1985. Cenozoic Calcareous Nannofossils *In:* H.M. Bolli, J.B. Saunders, & K. Perch-Nielsen (Eds). *Plankton Stratigraphy*. Cambridge University Press, New York: 427–545.

Sissingh, W. 1977. Biostratigraphy of Cretaceous calcareous nannoplankton. *Geologie en Mijnbouw*, **56**: 37–65.

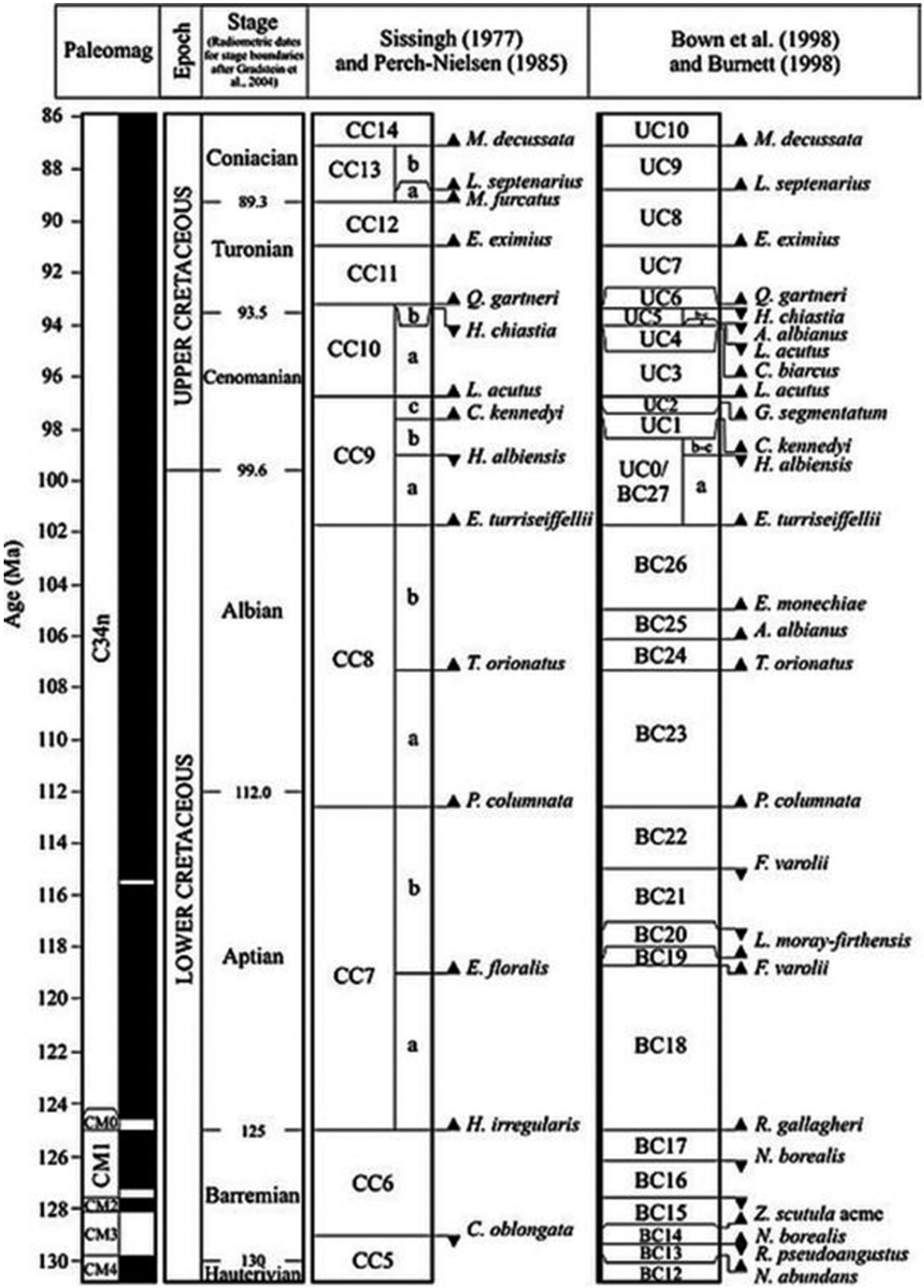


Figure 1: Correlated Biozonation from the Cretaceous, Sissingh (1977), Perch-Nielsen (1985), and Burnett (1998). (Modified from Fernando, A.G.S. *et al*., 2011)

Pleistocene calcareous nannofossil biochronology and biozonation

Eric de Kaenel

DPR, Chemin sous la Roche 4b, 1185 Mont-sur-Rolle, Switzerland; edekaenel@bluewin.ch

A new Pleistocene zonation, which is based on ODP Legs 154 and 161 and calibrated by cyclostratigraphy, is presented. This biozonation builds on the standard zonations of Martini (1971), Gartner (1977), Okada & Bukry (1980), Rio *et al*. (1990), and Young (1991). Some of the bioevents used in this zonation are from de Kaenel *et al*. (1999) and de Kaenel (2000). New analyses were carried out on sediments from ODP Legs 154 and 161, which provided additional data for a major revision of the Pleistocene reticulofenestrids. This in turn made it possible to establish new bioevents, thus increasing Pleistocene dating resolution. The standard zonal coding (NN) of Martini (1971) was used, and new subzones have been added that incorporate variations in morphology (size and coccolith outline) and abundance, as well as first and last occurrences.

References

de Kaenel, E. 2000. Mediterranean Pleistocene nannofossil biochronology. *8th International Nannofossil Association Conference, Bremen*, September 11–15, 2000 (abstract).

de Kaenel, E., Siesser, W.G. & Murat, A. 1999. Pleistocene calcareous nannofossil biostratigraphy and the western Mediterranean sapropels, Sites 974 to 977 and 979. *In*: R. Zhan, M.C. Comas, & A. Klaus (Eds). *Proceedings of the Ocean Drilling Program, Scientific Results*, **161**:159–183.

Gartner, S. 1977. Calcareous nannofossil biostratigraphy and revised zonation of the Pleistocene. *Marine Micropaleontology*, **2**: 1–25.

Martini, E. 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. *In*: A. Faranacci (Ed). *Proceedings of the Second Planktonic Conference Roma 1970.* Edizioni Tecnoscienza, Rome, **2**: 739–785.

Okada, H. & Bukry, D. 1980. Supplementary modification and introduction of code numbers to the low-latitude coccolith biostratigraphic zonation (Bukry, 1973; 1975). *Marine Micropaleontology*, **5**(3): 321–325.

Rio, D., Raffi, I. & Villa, G. 1990. Pliocene-Pleistocene calcareous nannofossil distribution patterns in the Western Mediterranean. *In*: K.A. Kastens, J. Mascle *et al*. *Proceedings of the Ocean Drilling Program, Scientific Results*, **107**: 513–533.

Young, J.R. 1991. A quaternary nannofossil range chart. *International Nannoplankton Association Newsletter*, **13**(1): 14–17.

Calcareous nannofossils from the late Campanian Manson impact structure at the eastern edge of the Western Interior Seaway

Richard A. Denne
Texas Christian University, Fort Worth, TX 76129, USA; r.denne@tcu.edu

Zachary A. Kita
University of Nebraska - Lincoln, Department of Earth and Atmospheric Sciences, Lincoln, NE 68588, USA; zachary.kita@gmail.com

The Manson crater is a buried impact structure with a 35km diameter that is found in north-central Iowa, USA, and which has previously been dated as late Campanian. Although the rocks within the crater were brecciated by the impact, the Cretaceous rocks represent the most easterly preserved rocks from the midcontinent portion of the Western Interior Seaway because Cretaceous rocks to the east of the crater have been removed by Pleistocene glaciation. Calcareous nannofossils were examined from nine cores that were drilled in the impact structure by the Iowa Geological Survey and the U.S. Geological Survey. The oldest nannofossil-bearing clasts contained an early Turonian assemblage from the Graneros Shale. Other clasts contained nannofossil assemblages representative of the middle Turonian (Greenhorn), Coniacian, Santonian, and early Campanian (Niobrara), and middle Campanian (Pierre Shale). Many of the clasts were highly fossiliferous, suggesting that the seaway margin lay some distance to the east of the impact site. No late Campanian nannofossils were identified in the study, suggesting that the site was subaerial at the time of impact. The lack of mixing within the matrix is also indicative of a subaerial impact. The matrix from subaqueous impact sites, such as Chicxulub, typically contain a mixed fossil assemblage that was derived from non-indurated sediments.

Calcareous nannofossil biostratigraphy of the Oligocene-Miocene interval in IODP Expedition 363 Hole U1490A, northern Eauripik Rise, western Pacific

Yvonne Ivy L. Doyongan

University of the Philippines, National Institute of Geological Sciences, Diliman, Quezon City, Philippines 1101; yldoyongan@up.edu.ph

Allan Gil S. Fernando

University of the Philippines, National Institute of Geological Sciences, Diliman, Quezon City, Philippines 1101; agsfernando@yahoo.com

IODP Expedition 363 Scientists

The upper Oligocene to Recent sedimentary succession in IODP Expedition 363 Hole U1490A (Eauripik Rise, western Pacific) recovered moderately to well-preserved calcareous nannofossils. Based on the presence of several marker taxa, the preliminary nannofossil biostratigraphy of the hole was established onboard, and is generally in good agreement with planktonic foraminiferal and paleomagnetic data (Rosenthal *et al*., 2017). Recent efforts in refining and calibrating nannofossil biohorizons lack sections in the western Pacific (e.g., Raffi *et al*., 2006; Agnini *et al*., 2014). The cores recovered and calcareous nannofossils observed from Hole U1490A, therefore, provide an opportunity to contribute to the ongoing improvement of existing nannofossil zonation schemes. This study focuses on the Oligocene-Miocene interval in order to establish a reference section for future biostratigraphic studies in the western Pacific, including the Philippines where there are a number of sedimentary basins that contain Oligocene and younger sedimentary successions.

References

Agnini, C., Fornaciari, E., Raffi, I., Catanzariti, R., Pälike, H., Backman, J. & Rio, D. 2014. Biozonation and biochronology of Paleogene calcareous nannofossils from low and middle latitudes. *Newsletters on Stratigraphy*, **47**:131–18.

Raffi, I., Backman, J., Fornaciari, E., Palike, H., Rio, D., Lourens, L. & Hilgen, F. 2006. A review of calcareous nannofossil astrobiochronology encompassing the past 25 million years. *Quaternary Science Reviews*, **25**: 3113–3137.

Rosenthal, Y., Holbourn, A.E., Kulhanek, D.K. & Expedition 363 Scientists. 2017. Expedition 363 Preliminary Report: Western Pacific Warm Pool. International Ocean Discovery Program. dx.doi.org/10.14379/iodp.pr.363.2017.

Application of high-resolution biostratigraphy to differentiate and correlate reservoir units in Raven Field, Nile Delta, Egypt

Wagih El Fiki
BP Egypt, North 90 Street, 1st District, Cairo, Egypt 11835; elfiwm@bp.com

Essam Tawfik
BP Egypt, North 90 Street, 1st District, Cairo, Egypt 11835; essam.tawfik@se1.bp.com

Samy Ahmed
BP Egypt, North 90 Street, 1st District, Cairo, Egypt 11835; Samy.Ahmed@uk.bp.com

Tarek Afifi
BP Egypt, North 90 Street, 1st District, Cairo, Egypt 11835; Afift1@BP.com

Raven Field lies in the West Nile Delta of Egypt. This field is being developed to provide greater stability for the energy supply of Egypt. The Raven reservoir sits within nannofossil Zones NN4b, NN4a, NN3a, and NN2 that straddle the Langhian and basal Burdigalian. The reservoir is comprised of channelized turbidite sands that were deposited in an upper slope environment. Biostratigraphy was used to assign international zones to exploratory and appraisal wells. Prior to the main development of the drilling campaign, the Reservoir Management Team challenged the biostratigrapher to see if biostratigraphy could be used to subdivide the multiple reservoir channels in the field in order to assist in the selection of casing points and well TDs. This study applied high-resolution calcareous nannofossil and foraminiferal analyses to investigate the possibility of intra-reservoir "bioevent" correlation, using precise taxonomic concepts to define a new succession of bioevents within the reservoir intervals. A quantitative analysis was conducted on eight existing appraisal wells that included 500 cutting samples and 41 supplemental core samples.

Eighteen new bioevents were identified within the reservoir sand units in order to differentiate eight different channel sand packages that were encountered in eight existing appraisal wells. The new bioevent scheme was then applied successfully to more recent Raven development wells.

A robust biostratigraphic correlation is very useful when making interpretations about reservoir heterogeneity, connectivity, and size. In addition, a more detailed zonation provides wellsite biostratigraphy that can assist in making operational drilling decisions by reducing stratigraphic uncertainty around casing point and TD calls.

A look into coccolith sizes and shapes: the morphological responses of coccolithophore algae calcification to trace metal concentrations

Giulia Faucher
Università degli studi di Milano, Dipartimento di Scienze della Terra, 20133 Milano, Italy; giulia.faucher@unimi.it

Elisabetta Erba
Università degli studi di Milano, Dipartimento di Scienze della Terra, 20133 Milano, Italy; elisabetta.erba@unimi.it

Coccoliths are formed through an intracellular growth process. This begins with nucleation of a proto-coccolith ring of simple crystals. It continues by upward and outward growth of these crystals into a complex unit that results in completed coccoliths. Coccolithophore algae frequently produce incomplete and malformed coccoliths: incomplete coccoliths occur if the growth process is arrested due to premature extrusion of the coccolith or death of the cell, while malformation is due to "irregular coccolith formation as a result of departure from the normal growth process" (Young & Westbroek, 1991), implying a malfunction of the coccolith-shaping machinery. When malformations are taken into account, most studies focused on the identification of changes in the shape of the individual elements. However, the main feature of malformed coccoliths is an altered symmetry of the shield. The latter is generally not investigated because it often is too inconspicuous to be unambiguously identified.

Here, we present a new method to quantitatively characterize coccolith shapes and discriminate between normal and malformed specimens and the degree of malformation.

Cultured algae of three different species, *Emiliania huxleyi, Gephyrocapsa oceanica,* and *Coccolithus pelagicus*, were typified using SEM pictures. First, we analyzed coccoliths grown under optimal conditions (control/ambient water) to assess the variability in size and morphology in the absence of ambient perturbations.

Subsequently, the method was applied to coccolithophore algae grown under excess trace metal concentrations to quantify the percentage and type of malformed coccoliths. Our results on living coccolithophore algae demonstrate that elevated trace metal concentrations do affect coccolith size and/or weight of the tested species. However, differences in species-specific responses were observed, which suggest that there were different sensitivities to trace metal content. Finally, an increased number of aberrant coccoliths points to an altered calcite content in the coccoliths and therefore a decrease in the cellular calcification rate.

References

Young, J.R. and Westbroek, P. 1991. Genotypic variation in the coccolithophorid species *Emiliania huxleyi*. *Marine Micropaleontology*, **18**(1–2): 5–23.

Stratigraphic distribution of a four-rayed symmetric discoaster in IODP 363 sites in the Indian Ocean and Pacific Ocean

Allan Gil S. Fernando

University of the Philippines, National Institute of Geological Sciences, Diliman, Quezon City 1101 Philippines; agsfernando@yahoo.com, asfernando@up.edu.ph

Tom Dunkley Jones

University of Birmingham, School of Geography, Earth and Environmental Sciences, Edgbaston, Birmingham B15 2TT, United Kingdom; t.dunkleyjones@bham.ac.uk

Luc Beaufort

Aix-Marseille University, CNRS, IRD, Col. France; CEREGE, Aix en Provence, France; beaufort@cerege.fr

Denise K. Kulhanek

International Ocean Discovery Program, Texas A&M University, College Station TX 77845, USA; kulhanek@iodp.tamu.edu

IODP Expedition 363 Scientists

The stratigraphic distribution, occurrence, and biostratigraphic significance of a previously undescribed, bilaterally symmetric, 4-rayed discoaster at IODP Expedition 363 Sites in the eastern Indian Ocean (offshore northwest Australia) and western Pacific Ocean are discussed. The discoaster was observed within nannofossil Zones NN16 to NN18 (late Pliocene to early Pleistocene). Similarity in ray tip morphology suggests that the discoaster could represent either a variety of *Discoaster brouweri* or a previously undocumented species. Further analysis of its occurrence in higher resolution samples from other scientific ocean drilling sites in the Indian, Atlantic, and Pacific Oceans could provide more valuable information about its biostratigraphic significance, geographic distribution, and relationship with other *Discoaster* species.

Calcareous nannofossil biostratigraphy of Middle to Late Cretaceous sections in the Philippines

Allan Gil S. Fernando

University of the Philippines, National Institute of Geological Sciences, Diliman, Quezon City 1101 Philippines; agsfernando@yahoo.com, asfernando@up.edu.ph

Clarence Y. Magtoto

University of the Philippines, National Institute of Geological Sciences, Diliman, Quezon City 1101 Philippines; renz_y_magtoto@yahoo.com

Adrian Raymund C. Fernandez

University of the Philippines, National Institute of Geological Sciences, Diliman, Quezon City 1101 Philippines; fernandez.adong@yahoo.com

Mirko Alessandro C. Uy

University of the Philippines, National Institute of Geological Sciences, Diliman, Quezon City 1101 Philippines; amcuy2@up.edu.ph

A detailed calcareous nannofossil biostratigraphic analysis was conducted on selected Cretaceous sections in the Philippines in order to refine the ages of these sedimentary units and to determine the paleoceanographic and/or paleoclimatic significance of the calcareous nannofossil assemblages. For this study, two sections were examined: (1) Upper Cretaceous deep-sea limestones of the Kinabuan Formation (Luzon Island), and (2) Middle Cretaceous mudstone and fine-grained sandstone interbeds of the Yop Formation (Catanduanes Island). The Middle Cretaceous section on Catanduanes Island is also significant since it was previously thought to straddle the Cenomanian-Turonian boundary, and consequently the oceanic anoxic event 2 (OAE2; Fernando *et al*., 2016). Higher resolution samples that were collected during recent fieldwork will be used to establish a more detailed nannofossil biostratigraphy of the section, which will then be compared with available geochemical/isotope data in order to verify the existence of OAE2 in this part of the western Pacific Region.

References

Fernando, A.G.S., Magtoto, C.Y., Guballa, J.D.S. & Peleo-Alampay, A.M. 2016. Calcareous nannofossils from Cretaceous units in Catanduanes Island, Philippines. *Bulletin of the National Museum of Nature and Science. Series C*, **42**: 1–13.

Numerical tactics to disentangle Lower-Middle Jurassic nannoplankton biogeographic relationships

Jorge Ferreira

Université de Lyon, Université Claude Bernard Lyon 1, ENS de Lyon, CNRS, UMR 5276 LGL-TPE, F-69622 Villeurbanne, France; zygodiscus@gmail.com

Emanuela Mattioli

Université de Lyon, Université Claude Bernard Lyon 1, ENS de Lyon, CNRS, UMR 5276 LGL-TPE, F-69622 Villeurbanne, France; emanuela.mattioli@univ-lyon1.fr

Raw counts of calcareous nannofossils were used to test for spatial and temporal differences during the ~8 my across the middle Toarcian to lower Aalenian (Lower-Middle Jurassic). Four complementary numerical approaches were used in order to investigate and graphically represent multivariate data in a two-dimensional coordinate system from six western Tethys sites. Three of the locations displayed Mediterranean affinity (Portugal, Italy, and Algeria), whereas the other three yielded typical NW Tethyan margin assemblages (Germany, northwestern France, and southern France). The first set reflects a semi-arid climate and the second a humid climatic belt. Based on a distance matrix and built upon the concept of similarity within and among groups, the different datasets, each one representing a whole assemblage in a given site, were first grouped through clustering and ordination methods. Then, the main species responsible for any differences and groupings were identified through a similarity/dissimilarity breakdown. Finally, significant differences among the six assemblages were assessed through statistical tests and linked to western Tethyan water mass displacements.

Our results show a clear split between southern and northern biogeographic structures, which supports numerous earlier publications. The primary species that showed these differences were the pairs *Schizosphaerella* and *Lotharingius velatus* (bearing a southern Tethys margin affinity) and *Lotharingius sigillatus* and *Crepidolithus crassus* (bearing a northern Tethys margin affinity). Consideration of the global time interval, ranking and ordination techniques, as well statistic tests, showed a tight taxonomic nesting among northern assemblages, whereas southern assemblages displayed a looser and more taxonomically divergent similarity. Our results strongly support an important southward incursion of NW Tethyan water masses during the middle Toarcian. Coeval with the global sea-level drop, both northern and southern water masses mixed before splitting into two distinct biogeographic structures during the lower Aalenian.

European Marine Observation and Data Network (EMODNET): a two-way opportunity for nannoworkers with the project

Andrea Fiorentino
Geological Survey of Italy – ISPRA, Roma, Italy; andrea.fiorentino@isprambiente.it

The experience of past years in the marine geology community, including geological habitat mapping, a field shared with marine biologists, evidenced a lack of information concerning the water column and planktonic assemblages. In particular, habitat mapping, which focuses on benthic biocoenoses and their relation with the substrate, is limited to only a few characteristics (depth, hard vs soft bottom, and sediment grainsize).

Altogether, it appears that scientists in each discipline approach their field as an isolated item that is separated from the surrounding environment. Geologists consider deposits that underlie the seafloor and stop at the sediment/water interface, and habitat mappers start from the sediment/water interface and limit their study to benthic assemblages, regardless of what overlies them.

This approach does not take into account the role that planktonic assemblages and the dynamics acting along the water column play in supplying material to the seafloor, influencing chemical equilibrium of waters at the sea bottom, and the composition of sediments.

Since 2009, the European Marine Observation and Data Network Project (http://www.emodnet.eu/) has aimed at the production of harmonized maps that incorporate multiple features of European seas. The project is subdivided into bathymetry, geology, biology, physics, chemistry, seabed habitats, and human activities lots, each of them managed through a portal and an additional coastal mapping project.

The Geological Survey of Italy participates in the Geology Lot and contributes its knowledge of geological features, such as sediment grain size, sedimentation rate, lithology, stratigraphy, tectonics, geohazards (volcanism, seismicity, submarine landslides, and tsunamis), georesources, and coastal evolution.

The Biology Lot considers data on numerous marine species, including nannoplankton. However, this lot has not begun yet, and there is space for expanding and developing the contribution that planktonic assemblages might provide to the community.

The Cretaceous paleobiogeography of *Braarudosphaera bigelowii*

Maria de Lurdes Fonseca
Universidade de Lisboa, Instituto Dom Luiz, Faculdade de Ciências, Instituto Superior de Ciências Sociais e Políticas, Lisboa, Portugal;
mlfonseca.mail@gmail.com

Mário A. Cachão
Universidade de Lisboa, Instituto Dom Luiz, Faculdade de Ciências, Departamento de Geologia, Faculdade de Ciências, Lisboa, Portugal;
mcachao@fc.ul.pt

Over the last 82 years, a massive amount of data concerning *Braarudosphaera bigelowii* has been collected. Thousands of nannofossil biostratigraphic accounts have reported the presence (or absence) of this species in the fossil record all over the world. Nonetheless, progress in understanding the paleoecology and paleogeography of *B. bigelowii* has been limited. The casuistic-based model of micropaleontological research has led, on one hand, to a useful accumulation of local and regional data but, on the other, to limited attempts at globally compiling and analyzing those disparate resources.

This study is based on the systematic data mining of international, regional, and local data sets and represents the first long-term reconstruction of the paleogeography of a coccolithophore species. The generated database includes 480 locations where *B. bigelowii* was found in Cretaceous strata. In addition, 501 locations where *B. bigelowii* was not found were considered for more precise determination of progression along expansion routes.

Results show that *B. bigelowii* evolved during the early Berriasian on the eastern margin of the Iberian plate. Claims of a Jurassic origin were found to be unsubstantiated. The stage-by-stage expansion routes it took during the Cretaceous in the process of colonizing most of the world's continental shelves will be presented and detailed. By the late Maastrichtian, every continent and ocean except the Arctic had been reached.

Expansion occurred in pulses that closely followed the Cretaceous oceanic anoxic events (OAE). The expansion rate into new locations strongly correlates with the growth rate of strata with a high abundance of *B. bigelowii*, and both are consistently linked to biotic crises. Oceanic expansion is a circular, worldwide phenomenon that can be correlated with neritic expansion only during the Early Cretaceous.

Braarudosphaera bigelowii is shown to be, in general, a good proxy for shallow water and low salinity during the Cretaceous, with the exception of low biotic diversity ecosystems and during biotic crises.

This publication is supported by FCT- project UID/GEO/50019/2013 - Instituto Dom Luiz.

Warming-driven nannofossil crisis in the early Toarcian of northern Spain

Ángela Fraguas
Universidad Complutense de Madrid, Departamento de Paleontología, Facultad de Ciencias Geológicas, 28040 Madrid, Spain; arfragua@ucm.es

María José Comas-Rengifo
Universidad Complutense de Madrid, Departamento de Paleontología, Facultad de Ciencias Geológicas, 28040 Madrid, Spain; mjcomas@ucm.es

Juan J. Gómez
Universidad Complutense de Madrid, Departamento de Estratigrafía, Facultad de Ciencias Geológicas, Instituto de Geociencias, 28040 Madrid, Spain; jgomez@ucm.es

Antonio Goy
Universidad Complutense de Madrid, Departamento de Paleontología, Facultad de Ciencias Geológicas, 28040 Madrid, Spain; angoy@ucm.es

The early Toarcian (Early Jurassic) was characterized by significant seawater warming, a transgressive peak, and a mass extinction event, which affected many different groups of marine organisms. Furthermore, major perturbations in the global carbon cycle have been inferred based on the negative carbon isotope excursion that is recorded in rocks and organic matter. A quantitative analysis of early Toarcian calcareous nannofossil assemblages from the Camino section (Basque-Cantabrian Basin, northern Spain) was performed to interpret the paleoenvironmental changes that occurred during this time interval. A total of 28 smear slides were prepared, and 300 nannofossils were counted from each smear slide. The nannofossil data were treated statistically, and the results were compared to the stable isotope data.

During the earliest Toarcian, the nannofossil assemblages were dominated by *Schizosphaerella punctulata*, *Calcivascularis jansae*, and *Lotharingius hauffii*, which are deep, intermediate, and shallow-dwelling taxa, respectively, (Casellato & Erba, 2015) and probably thrived in rather cold waters. The progressive decrease in the relative abundances of *S. punctulata* and *C. jansae* coincided with a progressive increase in paleotemperatures, as indicated by the $\delta^{18}O_{bel}$ values and higher percentages of *Biscutum* spp. and *Similiscutum* spp., which are shallow, meso-eutrophic taxa (Casellato & Erba, 2015), and *Calyculus* spp., an intermediate-dweller that could thrive under low-salinity conditions (Mattioli *et al*., 2008) when seawaters were warmer. Coinciding with the highest temperatures and around the extinction boundary, the "*Schizosphaerella* crisis" occurred, *C. jansae* became extinct, and the nannofossil assemblages were dominated by *Lotharingius* and *Crepidolithus* species, opportunistic (Fraguas *et al*., 2012) and shallow and deep-dwellers, respectively (Mattioli *et al*., 2008), which probably occupied the abandoned ecological niches of *S. punctulata* and *C. jansae*.

These results suggest a clear relationship between the increase in paleotemperature and changes in the nannofossil assemblages, confirming the hypothesis of Fraguas *et al*. (2012). However, possible changes in other paleoenvironmental parameters cannot be discarded.

This work was supported by the Spanish research project CGL2015-66604-R.

References

Casellato, C.E. & Erba, E. 2015. Calcareous nannofossil biostratigraphy and paleoceanography of the Toarcian Oceanic Anoxic Event at Colle di Sogno section (Southern Alps, Italy). *Rivista Italiana di Paleontologia e Stratigrafia*, **105**: 343–376.

Fraguas, A., Comas-Rengifo, M.J., Gómez, J.J. and Goy, A. 2012. The calcareous nannofossil crisis in Northern Spain (Asturias province) linked to the Early Toarcian warming- driven mass extinction. *Marine Micropaleontology*, **94–95**: 58–71.

Mattioli, E., Pittet, B., Suan, G. & Mailliot, S. 2008. Calcareous nannoplankton changes across the Early Toarcian oceanic anoxic event in the western Tethys. *Paleoceanography*, **23**(3): PA3208.

The lower Eocene Sopelana section: new insights into environmental effects and biotic response of astronomically driven climate change

Gloria Franceschetti

Università degli Studi di Firenze, Dipartimento di Scienze della Terra, 50121 Firenze, Italy; gloria.franceschetti@unifi.it

Naroa Martinez-Braceras

University of the Basque Country (UPV/EHU), Department of Stratigraphy and Paleontology, Faculty of Science and Technology, E48080 Bilbao, Spain; naroa.martinez@ehu.eus

Aitor Payros

University of the Basque Country (UPV/EHU), Department of Stratigraphy and Paleontology, Faculty of Science and Technology, E48080 Bilbao, Spain; a.payros@ehu.eus

Simonetta Monechi

Università degli Studi di Firenze, Dipartimento di Scienze della Terra, 50121 Firenze, Italy; simonetta.monechi@unifi.it

The lower Eocene Sopelana section (Basque-Cantabrian basin) contains approximately 30m of a rhythmic alternation between pelagic marls and limestones that are organized in thirteen well defined bundles, each generally containing five limestone-marl couplets. This arrangement strongly suggests that the couplet formation was driven by astronomical precession cycles (21ky each) and the bundles by eccentricity cycles (100ky) (Martínez-Braceras *et al*., 2017). The studied section was assigned by Elorza *et al*. (1984) to the early Ypresian *Morozovella subbotinae* planktonic foraminiferal Zone.

The aims of this study were to investigate the orbitally controlled sedimentary cyclicity of the Sopelana section using geochemical proxies, to define a detailed chronology based on calcareous nannofossil biostratigraphy, and to characterize the nannofloral assemblage changes. The geochemical analysis, based on the carbonate content of the beds, was performed with a resolution of 1–1.5ky and allowed reliable identification of orbital cycles as the main forcing mechanism that controlled sedimentation. Semiquantitative calcareous nannofossil analyses were performed on 66 samples, which provided a more accurate age for the Sopelana section. *Rhomboaster* spp. and *Fasciculithus* spp. were present from the base of the section, which suggests placement of the lowermost part of the section in Zone CNE1, just above the Paleocene-Eocene boundary. Using the well-documented *Rhomboaster-Tribrachiatus* lineage, the section extends from Zones CNE1 to CNE3 of Agnini *et al*. (2014) or Zones NP10 to NP11 (Martini, 1971), a span of about 1Ma, which confirms the age obtained by counting short eccentricity bundles.

The bio-litho-cyclostratigraphic data of the Sopelana section can be correlated with the coeval Zumaia section, which is located 60 km to the east. This confirms that the studied beds are the result of supra-regional sedimentary processes rather than due to local diagenesis, and that there was homogeneity of the sedimentary and biotic processes throughout the Basque-Cantabrian basin in Ypresian times.

References

Agnini, C., Fornaciari, E., Raffi, I., Catanzariti, R., Pälike,H., Backman, J., Rio, D. 2014. Biozonation and biochronology of Paleogene calcareous nannofossils from lowand middle latitudes. Newsletters on Stratigraphy 47,131–181.

Elorza, J.J., Orue-Etxebarria, X. and Lamolda, M.A. 1984. Existencia de una fracturacion intensa en el area de Sopelana-Meñakoz. I Congreso Español de Geologia, **3**: 177–188.

Martínez-Braceras, N., Payros, A., Miniati, F., Arostegi, J. and Franceschetti, G. 2017. Contrasting environmental effects of astronomically driven climate change on three Eocene hemipelagic successions from the Basque–Cantabrian Basin. *Sedimentology*, **64**(4): 960–986.

Martini, E. 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. *In*: A. Faranacci (Ed). *Proceedings of the Second Planktonic Conference Roma 1970.* Edizioni Tecnoscienza, Rome, **2**: 739–785.

The roles of coccolith organic components in calcite crystallization

Assaf Gal

Weizmann Institute of Science, Departments of Plant and Environmental Sciences, Rehovot, Israel; assaf.gal@weizmann.ac.il

Damien Faivre

Max-Planck Institute of Colloids and Interfaces, Department of Biomaterials, Potsdam, Germany; Damien.Faivre@mpikg.mpg.de

André Scheffel

Max-Planck Institute of Molecular Plant Physiology, Potsdam, Germany; Scheffel@mpimp-golm.mpg.de

Calcite crystallization in coccolithophores is a remarkable example of the ability of organisms to control inorganic precipitation. The coccolith crystals, which form intracellularly inside a specialized vesicle, show species-specific morphology and nano-patterning unequaled by any synthetic crystallization approach. It is well established that the initial crystals form on the periphery of an organic scale, the base plate, and that organic macromolecules within the coccolith vesicle take part in crystal growth.

We used *Pleurochrysis carterae* as a test coccolithophore species to investigate the functional role of organic macromolecules in the formation of coccolith calcite. Mature coccoliths were harvested from laboratory cultures, and by dissolving the calcite we isolated the insoluble organic fraction that consisted of the base plates and the soluble fraction that consisted mainly of polysaccharides. Attempting to induce re-mineralization *in vitro* demonstrated that the base plate does not have any detectable propensity to nucleate calcite on its surface. However, when the soluble macromolecules and calcium ions are added to the base plates, a specific reaction occurred where calcium-loaded soluble macromolecules became aggregates at the base plate periphery, exactly where the crystals were growing *in vivo*. This macromolecular recognition reaction shows that the recognition of the crystallization site is dependent on both organic fractions (Gal *et al*., 2016).

We then added carbonate ions to this synthetic system in order to induce calcium carbonate precipitation. At specific conditions of calcium and carbonate concentrations, the dense calcium phase at the rim of the base plate served as a privileged environment that supported the nucleation and growth of calcite. Remarkably, crystallization was restricted only to this nanoscale interphase, raising the possibility that a similar process occurs *in vivo*.

References

Gal, A., Wirth, R., Kopka, J., Fratzl, P., Faivre, D. & Scheffel, A. 2016. Macromolecular recognition directs calcium ions to coccolith mineralization sites. *Science*, **353**(6299): 590–593.

Coccolithophore ecology - insights from seasonality and biogeography on local and global scales

Ines Galović
Croatian Geological Survey, 10000 Zagreb, Croatia; ingalovic@hgi-cgs.hr

The global regression at the end of the Badenian and tectonic events at the Badenian-Sarmatian boundary resulted in a glacio-eustatic lowstand that may have isolated the Paratethys. These events led to the development of the following endemic coccoliths: *Calcidiscus pataecus*, *Rhabdosphaera poculi*, and *Noelaerhabdus bozinovicae*. The diverse warm-water Badenian species (sphenoliths, discoasters, rhabdospheres, and umbilicospheres) were gradually replaced with species more typical of temperate areas with seasonal changes that occurred during the mid Sarmatian (*Coccolithus*, *Reticulofenestra*, and *Calcidiscus*). The Paratethys was again linked to the Mediterranean Sea in the early Sarmatian by a narrow marine connection far to the East, due to tectonic movements along the southern Anatolian fault system. A connection with the Mediterranean is confirmed by the presence of *Calcidiscus macintyrei* and *Coccolithus miopelagicus* and connection with the Indo-Pacific by the presence of *Discoaster* spp. The periodic mixing of Central Paratethys waters with the Eastern Paratethys caused the migration of *Braarudosphaera bigelowii* and *Reticulofenestra pseudoumbilicus*. Laminated marly layers in the Vienna Basin reflect a maximum flooding surface in the Zone NN7a-NN7b transition, while a maximum transgression occurred in the mid Sarmatian Subzone NN7b in the North Croatian Basin. Increased alkalinity allowed the preservation of *Catinaster coalitus* in the late Sarmatian. In most parts of the North Croatian Basin, as in the entire Paratethys, the drastic decrease in the number of species and genera, with monospecific and endemic development, characterized a shallower and more restricted stratified environment with large salinity fluctuations during the Sarmatian-Pannonian transition. These events were caused by regional tectonic movements at the end of Sarmatian. In deeper marine parts with periodic marine communication during the warmer season, the short appearance of *Nicklithus amplificus*, *Amaurolithus tricorniculatus*, and *Ceratolithus armatus* marked the final Paratethys-Tethys closure at the beginning of the Pannonian.

Coccolithophores and environmental changes during middle Miocene major events - responses and records at the marginal Paratethys

Ines Galović
Croatian Geological Survey, 10000 Zagreb, Croatia; ingalovic@hgi-cgs.hr

This study deals with complex oceanographic systems that existed in the restricted Paratethys during the middle Miocene climate transition (MMCT) and the resulting regional and global events that influenced species diversity. The latest Badenian was characterized by stable marine conditions and diverse warm-water taxa (*Acanthoica* spp., *Calcidiscus leptoporus*, *Calciosolenia brasiliensis*, *Coronosphaera mediterranea*, *Helicosphaera carteri*, *Rhabdosphaera clavigera*, *Syracosphaera* spp., holococcoliths, and *Discosphaera tubifera*) that are typical for the subtropical gyre. Global cooling, regional regression, and local tectonic events, with a possible short-term closing of the Paratethys within the Badenian-Sarmatian transition (Zone NN6d), caused decreased species diversity and endemism. These changes are known as the Badenian-Sarmatian Extinction Event (BSEE) and saw the last appearances of *Cyclicargolithus floridanus*, *Acanthoica* spp., and *Syracosphaera* spp. Enhanced atmospheric CO_2 drawdown increased the productivity in temperate forms (*Coccolithus pelagicus*, *Calcidiscus pataecus*, and *Reticulofenestra pseudoumbilicus*), which supports the presence of the MMCT and a temperate climate. After the lowstand, sea level rose in Subzone NN7a with a maximum highstand in Subzone NN7b, which was the last period of relatively warm climate in the subtropical gyre. This is based on an increased abundance of *Helicosphaera carteri* and species of the diatom genus *Rhizosolenia* at the marginal part of the gyre, which balanced the eddy heat flux divergence that supplied the interior of the basin with warmer water. After this, the circum Mediterranean climate remained basically the same. Because of the warm marine current inflow from the Mediterranean and Indo-Pacific into the Paratethys, the North Croatian gyre system was restored, which brought a relatively warmer climate until the middle Sarmatian and extended the MMCT. Gradually this was replaced with a more temperate climate with seasonal changes and coastal upwelling. During the late Sarmatian, conditions oscillated, but warm-water coccoliths were still present in Zone NN8 (*Sphenolithus abies*, *Syracosphaera clathrata*, and *Reticulofenestra minuta*) that sporadically continued into the Pannonian.

Early Zanclean nannofossils from Car Nicobar Island, northern Indian Ocean, with remarks on the evolutionary significance of the genus *Ceratolithus*

Amit K. Ghosh

BirbalSahni Institute of Palaeosciences, Lucknow-226 007, India; akghosh_in@yahoo.com

Arindam Chakraborty

BirbalSahni Institute of Palaeosciences, Lucknow-226 007, India; University College London, Department of Earth Sciences, London WC1E 6BT, UK; arindam@bsip.res.in

Paul Bown

University College London, Department of Earth Sciences, London WC1E 6BT, UK; p.bown@ucl.ac.uk

Jeremy Young

University College London, Department of Earth Sciences, London WC1E 6BT, UK; jeremy.young@ucl.ac.uk

Abundant, well preserved calcareous nannofossils of Zanclean (early Pliocene) age have been recovered from two outcrops on Car Nicobar Island. The presence of species of the genus *Ceratolithus*, i.e., the horse-shoe-shaped nannoliths, in association with sphenoliths and large reticulofenestrids is indicative of Pliocene sediments. Based on the presence of *Ceratolithus armatus* and the absence of *Ceratolithus cristatus,* the Mus Jetty A Section of Car Nicobar Island is assigned to Zone NN12. The base of the Mus Jetty B Section is characterized by nannofossils of Zone NN12. In this outcrop, the first occurrence (base) of *Ceratolithus cristatus* is indicative of Zone NN13. The change in morphological features in the ceratoliths demonstrates an evolutionary trend within the genus *Ceratolithus*: a gradual change in the size of the apical beak or rostrum, which shows how *Ceratolithus armatus* evolved from *Ceratolithus cristatus.*

Middle and late Eocene calcareous nannoplankton in the Jaca Basin (south-central Pyrenees Eocene Basin): a biostratigraphic and environmental approach

Alba González-Lanchas
Universidad de Salamanca, Departamento de Geología, Facultad de Ciencias. 37008 Salamanca, Spain; lanchas@usal.es

Eduard Remacha
Universitat Autónoma de Barcelona, Departamento de Geología, 08193 Bellaterra, Barcelona, Spain; eduard.remacha@uab.cat

Francisco J. Sierro
Universidad de Salamanca, Departamento de Geología, Facultad de Ciencias, 37008 Salamanca, Spain; sierro@usal.es

José-A. Flores
Universidad de Salamanca, Departamento de Geologia, Facultad de Ciencias, 37008 Salamanca, Spain; flores@usal.es

In the Paleogene of the south-central Pyrenees foreland basin system, the Jaca thrust-sheet top basin is located in the west. In the north, the basin overlies an assemblage of Paleozoic rocks that are unconformably overlain by Upper Cretaceous sediments. To the south, it is bounded by the Pyrenean frontal thrust. In general terms, the Jaca basin can be regarded as an ESE-WNW elongated dissymmetrical synclinorium. In its northern limb, a wedge of deep-marine clastic systems forms the Eocene Hecho Group, which is progressively wedged out and replaced in the southern limb by carbonate ramps (Guara Formation). This work focuses on the upper Lutetian clastic succession of the upper Hecho Group that is exposed along the Jaca transect (N-S) in the footwall of the Oturia thrust.

Samples were collected, starting in the Roncal-Fiscal megaturbidite (MT-5) key bed, continuing upward, and moving south within the Jaca thrust hanging wall until reaching the complete replacement of turbidite systems by deltas during Bartonian times. The deep-marine sediments, which are the core of this study, contained a remarkable assemblage of calcareous nannoplankton that was dominated by *Coccolithus pelagicus*, *C. formous*, *Reticulofenestra* spp., and *Cyclicargolithus floridanus*, and accompanied by occasional specimens of *Sphenolithus furcatolithoides*, *S. spiniger*, *S. strigosus*, and *Chiasmolithus solitus*, *C. gigas*, and *C. grandis*. Reworked Cretaceous nannofossils are also consistently present in the samples, but at lower abundances than the Eocene taxa.

Our preliminary results, based on a detailed biostratigraphic study of the sequence and a characterization of the main bioevents and chronologically dated nannofossil horizons, suggest that deposition of these sediments occurred during Zones NP15 to NP17. Our new age model for the Jaca basin provides a means to compare stratigraphic events with other regional sections, thus providing a better understanding of the lateral and temporal evolution of these depositional systems.

Nannofossil biostratigraphy of the upper Campanian–Maastrichtian in NW Bulgaria (SE Europe)

Georgi Granchovski

Bulgarian Academy of Sciences, Geological Institute, 1113 Sofia, Bulgaria; georgi2801@geology.bas.bg

Kristalina Stoykova

Bulgarian Academy of Sciences, Geological Institute, 1113 Sofia, Bulgaria; stoykova@geology.bas.bg

Two continuous sections (Kladorub and Beloptichene) from the Campanian-Maastrichtian boundary interval in NW Bulgaria (SE Europe) were investigated for their nannofossil content. The studied sediments belong to the Kladorub Formation (upper Campanian–lower Eocene), which is comprised of alternating silty to fine sandy marls and marly limestones that occasionally are interbedded with thin sandstone layers. Previous studies on the Upper Cretaceous portion of the Kladorub Formation have used local zonations, and little information on taxonomic diversity and abundance of the nannofossil assemblages was provided.

The aim of the present study was to conduct a detailed examination of upper Campanian–Maastrichtian calcareous nannofossils in these sections and to assess the applicability of cosmopolitan zonation schemes, particularly Burnett's (1998) Upper Cretaceous zonation, for this stratigraphic interval in Bulgaria. The recovered nannofloras were taxonomically diverse and exhibited moderate to good preservation, which made possible precise taxonomic identifications and biostratigraphic analyses. As a result, the presence of several previously undocumented, biostratigraphically significant taxa have been recorded. In the Kladorub section, all diagnostic nannofossil events from Burnett's zonation for the upper Campanian–Maastrichtian interval have been recognized. In the Beloptichene section, where the Upper Cretaceous strata are tectonically overlain by lower Paleocene terrigenous sediments, the Kladorub Formation only extends from the upper Campanian to the lower Maastrichtian.

The resulting biostratigraphic framework can now be correlated with previously published local zonation schemes for NW Bulgaria and elsewhere and can serve as a basis for further multidisciplinary studies on the Campanian-Maastrichtian boundary.

References

Burnett, J.A. 1998. Upper Cretaceous. *In:* P.R. Bown (Ed.). *Calcareous Nannofossil Biostratigraphy*. British Micropalaeontolical Society Publication Series. Chapman and Hall/ Kluwer Academic Publishers, London: 132–199.

Calcareous nannofossil biostratigraphy and paleoceanographic clues from the latest Pliocene-Pleistocene from IODP Expedition 349 Site U1431D, South China Sea

Jose Dominick S. Guballa

University of the Philippines, National Institute of Geological Sciences, Diliman, Quezon City, Philippines 1101; jsguballa@up.edu.ph

Alyssa M. Peleo-Alampay

University of the Philippines, National Institute of Geological Sciences, Diliman, Quezon City, Philippines 1101; ampanigs@yahoo.com

IODP Expedition 349 Scientists

Calcareous nannofossils were utilized to refine the initial biostratigraphic results from IODP Expedition 349 Site U1431D from the South China Sea and infer paleoceanographic clues, using preliminary sediment geochemistry and core physical properties. An additional nannofossil marker (FO *Gephyrocapsa* spp. >4μm) was found (10H-7W, 22–23cm; 87.32 mbsf), while the FO of *Gephyrocapsa* spp. >5.5μm was observed to occur much higher in the section than the LO of *Calcidiscus macintyrei*. This refinement of the calcareous nannofossil biostratigraphy was used to determine the timing of paleoceanographic events. *Florisphaera profunda* was the dominant calcareous nannofossil observed, suggesting an overall oligotrophic condition for Site U1431D from 2.65–0.01Ma. An apparent cyclical pattern occurred in nannofossil absolute abundances from 2.65–1.65Ma. However, Site U1431D was essentially barren of nannofossils from 1.65–0.6Ma, with only a few intermittent low-abundance spikes in calcareous nannofossils. The start of the barren interval coincides with a steady increase in density of the turbidite layers (Liu *et al*., 2016) and the onset of larger amplitudes in sea-level change (de Boer *et al*., 2014). Nannofossils increased in abundance at ~0.48Ma, when high-frequency oscillations between different calcareous nannofossil species were observed. This coincides with Marine Isotope Stage (MIS 12), one of the largest glacial episodes in the last 0.50Ma. Apparent ~150–200kyr cycles in abundances were observed at 0.46–0.01Ma, with a sudden decrease in L* reflectance (measure of lightness of sediments) and nannofossils at around 0.43Ma, which may correspond to the dissolution episode at the Mid-Bruhnes Event (MBE).

References

de Boer, B., Stocchi, P. & van de Wal, R.S.W. 2014. A fully coupled 3-D ice-sheet-sea-level model: algorithm and applications. *Geoscientific Model Development*, **7:** 2141–2156.

Liu, Z., Zhang, X., Colin, C., Peleo-Alampay, A.M., Guballa, J.D.S., Li, P., Zhao, Y. & Liu, C. 2016. Occurrence of Quaternary turbidite deposits in the central South China Sea: Response to global sea-level changes. *American Geophysical Union Fall Meeting*, San Francisco, California (abstract).

Molecular phylogenetic position of *Reticulofenestra sessilis*

Kyoko Hagino

Kochi University, Center for Advanced Marine Core Research, Kochi 783–8502, Japan; hagino@kochi-u.ac.jp

El Mahdi Bendif

University of Oxford, Department of Plant Sciences, Oxford OX1 3RB, UK; elmahdi.bendif@ox.ac.uk

Ian Probert

Station Biologique de Roscoff, 29682 Roscoff, France; probert@sb-roscoff.fr

Jeremy R. Young

University College London, Department of Earth Sciences, London WC1E 6BT, UK; jeremy.young@ucl.ac.uk

Here we report on a newly isolated culture strain of *Reticulofenestra sessilis* (Prymnesiophyceae), a coccolithophore that is known to form symbiotic colonies around a diatom (Figure 1a). The clonal culture strain Usa-1 (Figure 1b), which was collected from subsurface seawater from offshore Usa (Kochi, Japan), was isolated from a colony that surrounded a diatom of the genus *Thalassiosira*. The diatom cell, which co-occurred with the colony of *R. sessilis*, died in the early stage of culture experiments, and the cells of *R. sessilis* grew in the f/2 medium without diatoms. Phylogenetic reconstructions, based on classical ribosomal markers (18S and 28S rRNA), suggest that *R. sessilis* has a closer affinity to *Gephyrocapsa oceanica, G. muellerae*, and *Emiliania huxleyi* than to *G. ericsonii* and *G. parvula* (the latter species until recently was classified in the genus *Reticulofenestra*). Phylogenies constructed with cytoplasmic markers (mitochondrial cox1, cox3, and plastidial tufa) confirmed the clustering of *R. sessilis* with *G. oceanica, G. muellerae*, and *E. huxleyi,* but sequences were highly divergent, and the exact phylogenetic position within this clade was not stable between the markers. Our results provide new evidence on reticulate evolution within the *Gephyrocapsa* complex, giving further support for the hypothesis of past hybridization between some members of the family Noëlaerhabdaceae. The fact that the two extant species, which were classified until recently within the genus *Reticulofenestra* on the basis of morphological similarity of their coccoliths (noëlaerbdacean coccoliths without slits between shield elements and without a disjunct bridge) but do not form a distinct clade with any of the genetic markers tested, highlights the evolutionary plasticity of coccolith morphology in this lineage.

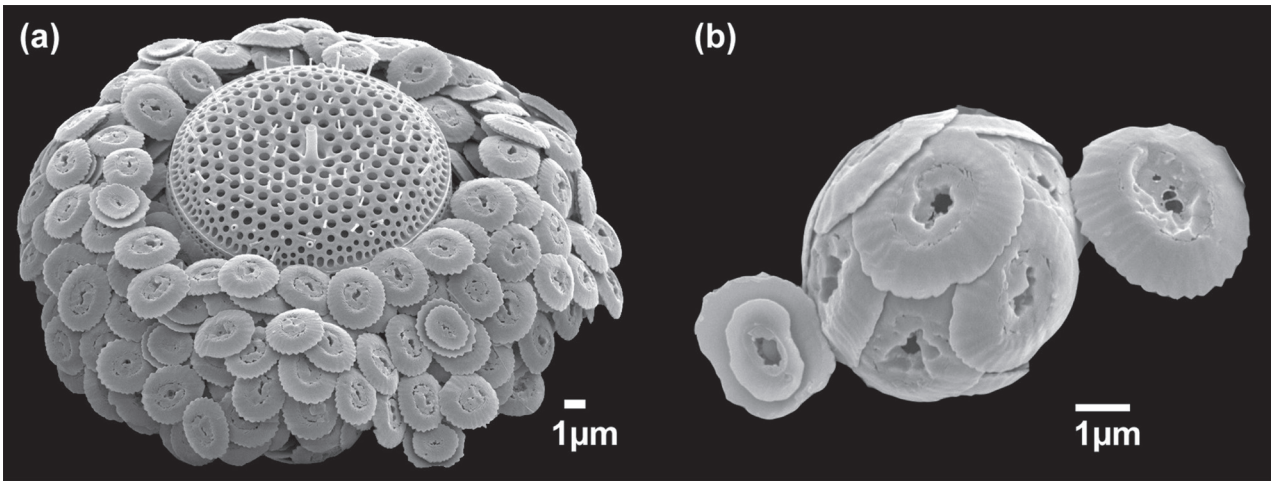


Figure 1: SEM images of *Reticulofenestra sessilis*. (a) A colony of *R. sessilis* surrounding a diatom from lower photic zone of the Gulf of Mexico, and (b) *R. sessilis* strain Usa-1 established in this study

Paleoenvironmental conditions during the Aptian-early Albian in the Essaouira-Agadir Basin, western Morocco

Walid Hassanein
Cairo University, Faculty of Science, Geology Department, Giza, Egypt; walidgkassab@yahoo.com

Fabienne Giraud
Université Grenoble-Alpes, ISTerre, UMR 5275, IRD, BP 53, 38041 Grenoble cedex 9, France; fabienne.giraud-guillot@univ-grenoble-alpes.fr

Etienne Jaillard
Université Grenoble-Alpes, ISTerre, UMR 5275, IRD, BP 53, 38041 Grenoble cedex 9, France; etienne.jaillard@univ-grenoble-alpes.fr

Emmanuel Robert
Université de Lyon, Université Claude Bernard Lyon 1, ENS de Lyon, CNRS, UMR 5276 LGL-TPE, F-69622 Villeurbanne, France; emmanuel.robert@univ-lyon1.fr

Mohamed Aly
Cairo University, Faculty of Science, Geology Department, Giza, Egypt; mf_alyaly@yahoo.com

Mohamed Hammed
Cairo University, Faculty of Science, Geology Department, Giza, Egypt; salehhammed@gmail.com

Moussa Masrour
Université Ibn Zohr, Faculté des Sciences, Département de Géologie, B.P. 8106, Cité Dakhla, Agadir, Maroc; moussamasrour5@gmail.com

The aim of this study was to reconstruct the paleoenvironmental evolution of the Essaouira-Agadir Basin (EAB) during the Aptian-Albian and propose a functioning model for sedimentation in its mixed carbonate/clastic ramp.

Nine sections were studied to define the sedimentary facies, and 189 samples were collected and analyzed for calcareous nannofossils and 218 samples for geochemistry (calcium carbonate content and stable isotopes) from six sections.

The facies and depositional environments of the Aptian-early Albian successions were identified on the basis of their lithology, sedimentary structures, fossil content, and microfacies. It was possible to identify: (1) four types of key surfaces that are related to subaerial or submarine erosion, (2) four sedimentary carbonated facies in the Aptian that correspond to outer to inner ramp depositional environments, and (3) four early Albian sedimentary facies, which are represented by sandstones and shales that correspond to a deep-marine outer ramp-basin depositional setting. There is a deepening upward trend that is related to sea-level rise during the early Albian.

During the Aptian, the EAB carbonate ramp was characterized by high carbonate production within a large photic zone, low terrigenous influx due to the shallow depth of the basin, warm sea-surface conditions, and a slow rise in sea level. During the early Albian, there was an increase in both the accommodation space and siliciclastic input in the EAB. Dysoxic sediments were observed, carbonate production decreased, a rapid rise in sea level occurred, and upwelling currents were present. Enhanced nutrient input into the basin, which can be related to both increasing siliciclastic influx and upwelling, led to an increase in nannofossil primary productivity. A decrease in sea surface temperature, which is suggested by a higher abundance of cold taxa and the migration of cosmopolitan biota from the Boreal realm, was also recognized.

Integrated stratigraphy of the uppermost Barremian-lower Albian in the Essaouira-Agadir Basin (western Morocco) and correlations with northern Tethyan basins

Walid Hassanein

Cairo University, Faculty of Science, Geology Department, Giza, Egypt; walidgkassab@yahoo.com

Fabienne Giraud

Université Grenoble-Alpes, ISTerre, UMR 5275, IRD, BP 53, 38041 Grenoble cedex 9, France; Fabienne.Giraud-Guillot@univ-grenoble-alpes.fr

Emmanuel Robert

Université de Lyon, Université Claude Bernard Lyon 1, ENS de Lyon, CNRS, UMR 5276 LGL-TPE, F-69622 Villeurbanne, France; emmanuel.robert@univ-lyon1.fr

Etienne Jaillard

Université Grenoble-Alpes, ISTerre, UMR 5275, IRD, BP 53, 38041 Grenoble cedex 9, France; etienne.jaillard@univ-grenoble-alpes.fr

Moussa Masrour

Université Ibn Zohr, Faculté des Sciences, Département de Géologie, B.P. 8106, Cité Dakhla, Agadir, Maroc; moussamasrour5@gmail.com

Mohamed Aly

Cairo University, Faculty of Science, Geology Department, Giza, Egypt; mf_alyaly@yahoo.com

Mohamed Hammed

Cairo University, Faculty of Science, Geology Department, Giza, Egypt; salehhammed@gmail.com

The latest Barremian-lower Albian interval of the southern Tethyan margin is poorly understood because sedimentary successions are frequently incomplete, and dating is difficult. The Essaouira-Agadir Basin (EAB) contains numerous, fossiliferous, and accessible outcrops of the Lower Cretaceous series. The aim of this work was to establish an integrated stratigraphic framework for this time interval in the EAB based on (1) high-resolution ammonites and calcareous nannofossil biostratigraphy, (2) identification of sedimentary discontinuities, and (3) carbon isotope stratigraphy. This study, which provided an excellent opportunity to calibrate the different stratigraphic records, resulted in a coherent scheme for the uppermost Barremian-lower Albian interval.

Six sections, located along two different transects (east-west and south-north), were selected that contained proximal to distal environments. In the EAB, the late Barremian was defined by ammonite zone *sarasini* and nannofossil Zone NC5. The Barremian-Aptian boundary was defined by ammonites. The early Aptian was defined by the ammonite zones *deshayesi* to *furcata*, and was bounded by a first minimum $d^{13}C$ value at the base and a first maximum value at the lower-upper Aptian boundary. The upper Aptian interval was defined by four ammonite zones (*martini*, *melchioris*, *nolani*, and *jacobi*), two discontinuity surfaces, four maximum and minimum $d^{13}C$ values, and by the upper part of nannofossil Zone NC6 to the lowermost part of nannofossil Zone NC8. The Aptian-Albian boundary was placed within a discontinuity surface (base of the *tardefurcata* ammonite Zone) and was recognized by the first occurrence (FO) of the nannofossils *Prediscosphaera columnata* and *Hayesites albiensis* and by a marked decrease in $d^{13}C$ values. Early Albian times were represented by the *tardefurcata* and *mammillatum* ammonite zones and by minimum $d^{13}C$ values.

Diachronism of some nannofossil bioevents, which was observed between the EAB and other Tethyan basins, is also discussed.

Calcareous nannoplankton in the chalk grounds from a Romanesque Madonna of the *Sedes Sapientiae* type

Katarína Holcová
Charles University, Prague, Czech Republic; Academy of Fine Arts, ALMA Laboratory, Prague, Czech Republic; holcova@natur.cuni.cz

Janka Hradilová
Academy of Fine Arts, ALMA Laboratory, Prague, Czech Republic; hradilovaj@volny.cz

The oldest preserved polychrome carving of a Madonna of the *Sedes Sapientiae* type from a private Czech collection was dated using the ^{14}C radiocarbon method to 990–1180 AD. Linden (*Tilia* sp.) was identified as the wood used for the Madonna. The oldest Romanesque polychromy layer represents a siliceous ground with a white chalk prevailing in its upper part. The chalk contains calcareous nannoplankton dominated by *Watznaueria barnesiae*. The co-occurrence of *Eiffellithus turriseiffelii* and *E. monechiae* indicates a late Albian-Cenomonian age.

We used three criteria to identify the origin of the Madonna: (1) the painting technique indicated that the origin of the Madonna was Western Europe; (2) the biogeographic distribution of *Tilia*; and (3) the distribution of exposed late Albian-Cenomanian chalk-like sediments in Europe. A synthesis of these data indicates that the origin of the Romanesque material was in the Jura Mountains or the Paris Basin with their chalk deposition, or possibly the Haute-Alpes and southern Pyrenees (marls to limestone deposits).

A later added Gothic ground differs considerably from the ground of the original painting – it contains more chalk. In the calcareous nannoplankton assemblages, *Arkhangelskiella* spp. dominated and was represented by *A. cymbiformis*, *A. maastrichtiensis*, and *A. confusa*. These species indicate a Campanian-Maastrichtian age for the chalk material. The origin of the material is probably from a northwestern European chalk 'province' because this material was widely used in Gothic painting. The well-preserved nannoplankton that we found are significant in their difference from broken specimens that were described by Švábenická (1994) from Czech Gothic panel paintings (14th and 15th centuries). This probably indicates the use of a different technology.

References

Švábenická, L. 1994. Coccoliths in the chalk material of high Gothic paintings (14th and 15th centuries, Bohemia). Věstník Českého geologického ústavu, **69**(3): 47–51.

Calcareous nannoplakton from the Triassic-Jurassic boundary interval (Kardolina section, Western Carpathians)

Katarína Holcová
Charles University, Prague, Czech Republic; holcova@natur.cuni.cz

Jozef Michalík
Earth Sciences Institute of Slovak Academy of Sciences, Bratislava, Slovak Republic; Jozef.Michalik@savba.sk

The Kardolína section, from the Belianske Tatras Mountains, Slovak Republic, yielded an almost complete record of the Rhaetian marine transgression onto the Western Carpathian segment of the Austro-Carpathian shelf, and included the Triassic-Jurassic boundary interval. A multidisciplinary study has provided detailed information about the environmental changes at the end of the Triassic when the carbonate ramp experienced a deeper, dysoxic basin. Calcareous nannoplankton were recorded throughout the entire section (a total of 109 samples in 93m of section), although preservation was not perfect. Nannoplankton abundances varied between 0.5–4 specimens/100 fields of view (coccoliths) and 0.5–40 specimens/100 fields of view (calcareous spheres).

Based on abundance and species composition of calcareous nannoplankton assemblages, five intervals were distinguished through the Kardolina sections:

(1) Calcareous nannoplankton appeared in "coprolite shales" 15m above a basal transgressive layer where stabilization of normal marine conditions is indicated. The nannoplankton included small coccoliths and rare spheres.
(2) An interval that was nearly barren of nannoplankton that is interpreted to be a lagoonal environment.
(3) An interval where *Prinsiosphaera triassica* of various sizes dominated the nannoplankton assemblage. Some other coccoliths also occurred locally. Within this interval, nannoplankton were missing from the "spherule beds" (volcanic glass?) that had high oscillating δO^{18} and δC^{13} values.
(4) Nannoplankton disappeared 10m below the Triassic-Jurassic boundary, where the amount of organic matter significantly increased.
(5) The Hettangian interval where nannoplankton reappeared 4m above the Triassic-Jurassic boundary and included small coccoliths, one specimen of *Watzenauria* sp., and representatives of Polycyclolithaceae.

Microfossils from the Precambrian-Early Cambrian, Chengjiang, China

Kazuki Hoshina
Yamagata University, Department of Earth & Environmental Sciences, Yamagata, Japan; hsnkzk523@ezweb.ne.jp

Yuanda Lei
Jinan University, Institute of Groundwater & Earth Sciences, Guangzhou, China; leiyuanda2006@126.com

Huai-Zhi Wu
Nanjing Institute of Geology & Paleontology, Chinese Academy of Sciences, Xuanwu Qu, Nanjing Shi, Jiangsu Sheng, China; whc640217@aliyun.com

Shijun Jiang
Jinan University, Institute of Groundwater & Earth Sciences, Guangzhou, China; ssj0047@my.fsu.edu

Richard W. Jordan
Yamagata University, Yamagata, Japan; sh081@kdw.kj.yamagata-u.ac.jp

The Maotianshan, Ma'anshan, and Xiaolantian sections are part of the Chengjiang Fossil Site in Chengjiang County, Yunnan Province, China, and represent the most important record of Early Cambrian fauna. Already over 200 species belonging to 16 phyla have been discovered, mainly from the Yu'anshan Member. However, there is little documentation about the microfossils, such as the small shelly fossils (SSFs) in the Zhongyicun Member (earliest Cambrian) and acritarchs in the Xiaowaitoushan Member (latest Precambrian; Ediacaran). Rock samples from the Yu'anshan Member at Maotianshan were obtained in 2016, and contained fossil animals such as *Isoxys*, *Yunnanocephalus*, and *Waptia*. In 2017, a much more comprehensive suite of samples was collected from the Xiaolantian section across the Cambrian-Precambrian boundary (every 1m) and from the Xiaowaitoushan Member (every 2 to 5m), representing a section about 150m in length along the footpath. Over 80 well-preserved fossil specimens were also obtained from the Ma'anshan shale section, consisting largely of the fossil animal genera *Kunmingella*, *Eoredlichia*, *Maotianshania*, and *Ambrolinevitus* and the algal genus *Yuknessia*. There is evidence that the deposition of these assemblages represents rapid downslope burial.

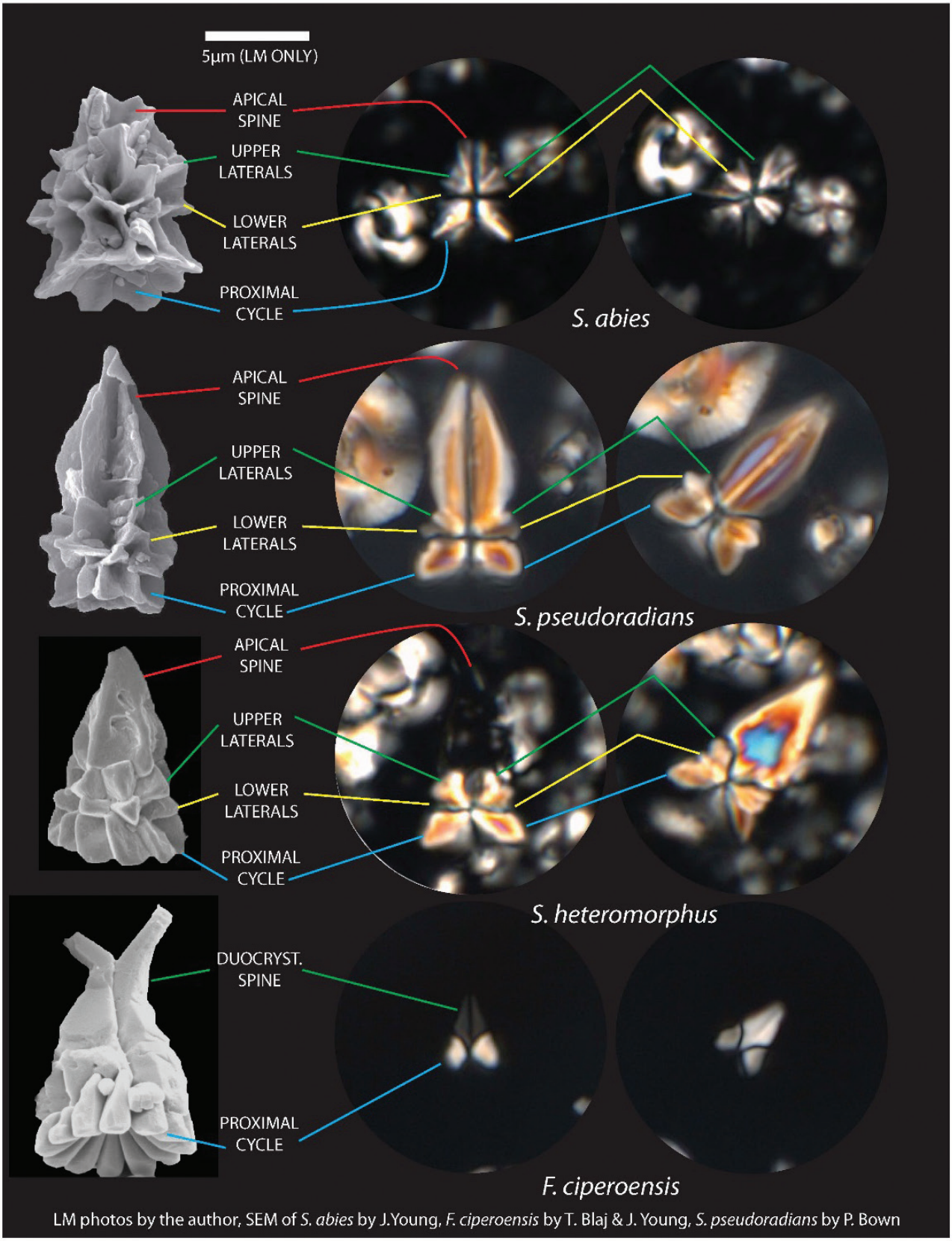
Ultrastructure within the Family Sphenolithaceae

Richard W. Howe
36 Waverley St, South Perth, WA 6151Australia; richardhowe@me.com

The Family Sphenolithaceae includes the Cenozoic genera *Sphenolithus* and *Furcatolithus*, which have many biostratigraphically important species. In plan view, all sphenoliths share a proximal cycle of elements that are arranged radially, are adpressed, and generally show slight imbrication. In lateral view, the proximal cycle elements are approximately trapezoidal in shape. From species to species, the elements of the proximal cycle vary in height and the lateral extension of the base of the elements relative to the top. All members of the genus *Sphenolithus* have two lateral element cycles (lower and upper) above the proximal element cycle. The lateral cycle elements are low and approximately triangular in plan view. In some species, the upper lateral cycle extends vertically and may have spinose extensions that radiate both vertically and laterally. Above the upper lateral cycle, an apical element cycle or spine is present. In the genus *Furcatolithus*, the apical elements and lower lateral element cycle are absent, and the remaining upper lateral element cycle extends vertically to form a bifurcated duocrystalline structure that is unrelated to the apical elements in *Sphenolithus*.

Much confusion exists concerning the upper and lower lateral cycles and their distinction from each other and from the proximal cycle in cross-polarized light. Many workers refer to the four bright elements seen in the base of the sphenolith as the upper and lower quadrants or "quads". The lower quads are the birefringent elements of the proximal cycle, while the upper quads are the birefringent elements of the two lateral element cycles. Many species' descriptions refer to the size ratios between the upper and lower quads. When a sphenolith is rotated relative to the polarizer, the lower and upper lateral element cycles alternate their birefringence relative to each other. Effectively, the bright "upper quads" are reflecting the birefringence of different elements as the sphenolith is rotated, making the size ratio between the upper and lower quads an unreliable criterion for distinguishing species.

An improved understanding of Sphenolithaceae ultrastructure and how it is seen under cross-polarized light has clarified the distinction between *Sphenolithus* and *Furcatolithus*. Thus, in order to reliably distinguish species, there is a need for a clear characterization of the lower and upper lateral element cycles within *Sphenolithus*.



LM photos by the author, SEM of *S. abies* by J.Young, *F. ciperoensis* by T. Blaj & J. Young, *S. pseudoradians* by P. Bown

Dissolution and calcification patterns in calcareous nannofossils during the middle Eocene C21r-H6 hyperthermal event (~47.4Ma) at the Gorrondatxe section (Bay of Biscay, western Pyrenees)

Beñat Intxauspe-Zubiaurre

University of the Basque Country (UPV/EHU), Department of Stratigraphy and Paleontology, Faculty of Science and Technology, E-48080 Bilbao, Spain; benat.intxauspe@ehu.eus

José-A. Flores

Universidad de Salamanca, Departamento de Geologia, Facultad de Ciencias, 37008 Salamanca, Spain; flores@usal.es.

Aitor Payros

University of the Basque Country (UPV/EHU), Department of Stratigraphy and Paleontology, Faculty of Science and Technology, E-48080 Bilbao, Spain; a.payros@ehu.eus.

The carbonate content of calcareous nannofossils is directly affected by seawater chemistry (Riebesell *et al*., 2004). One of the factors that affects seawater chemistry and coccolithophore calcification is global warming, as can be seen in present day oceans (Langer *et al*., 2006). Dissolution on the seabed and burn down are also characteristics of abyssal settings, which partially or completely remove coccoliths from deep-sea deposits (Colosimo *et al*., 2006). Similar processes and results have also been deduced for Eocene hyperthermal events, such as the PETM and ETM2 (Zachos *et al*., 2005). This study reports changes in coccolith carbonate mass from a hemipelagic setting (Gorrondatxe at 1500m paleodepth) during a minor Eocene hyperthermal event, namely the C21r-H6 event (47.44–47.32Ma). Image analysis techniques (Fuertes *et al*., 2014), which were used to decipher changes in the carbonate mass of selected calcareous nannofossil taxa, showed species-specific results. *Chiasmolithus solitus* lost 50% of its $CaCO_3$ mass during the C21r-H6 event, and many specimens also lost their crossed central bars. *Reticulofenestra* spp. (3–5μm) showed a similar pattern, but the amount of mass lost during the event was not as high as in *Chiasmolithus solitus*. *Toweius pertusus*, which was interpreted as reworked, mirrored *Chiasmolithus solitus*, showing that the $CaCO_3$ mass loss occurred on the seabed rather than in the water column. Previous to the hyperthermal event, all taxa show higher mass peaks. It can be concluded that the lysocline rose to a 1500m paleobathymetry in the Bay of Biscay during the C21r-H6 event. Formation of corrosive bottom water in the North Atlantic Ocean is regarded as responsible for the rise of the lysocline (Nunes & Norris, 2006).

References

Colosimo, A.B., Bralower, T.J. & Zachos, J.C. 2006. Evidence for lysocline shoaling at the Paleocene/Eocene Thermal Maximum on Shatsky Rise, Northwest Pacific. *Proceedings of Ocean Drilling Program, Scientific Results*, **198**: 1–36.

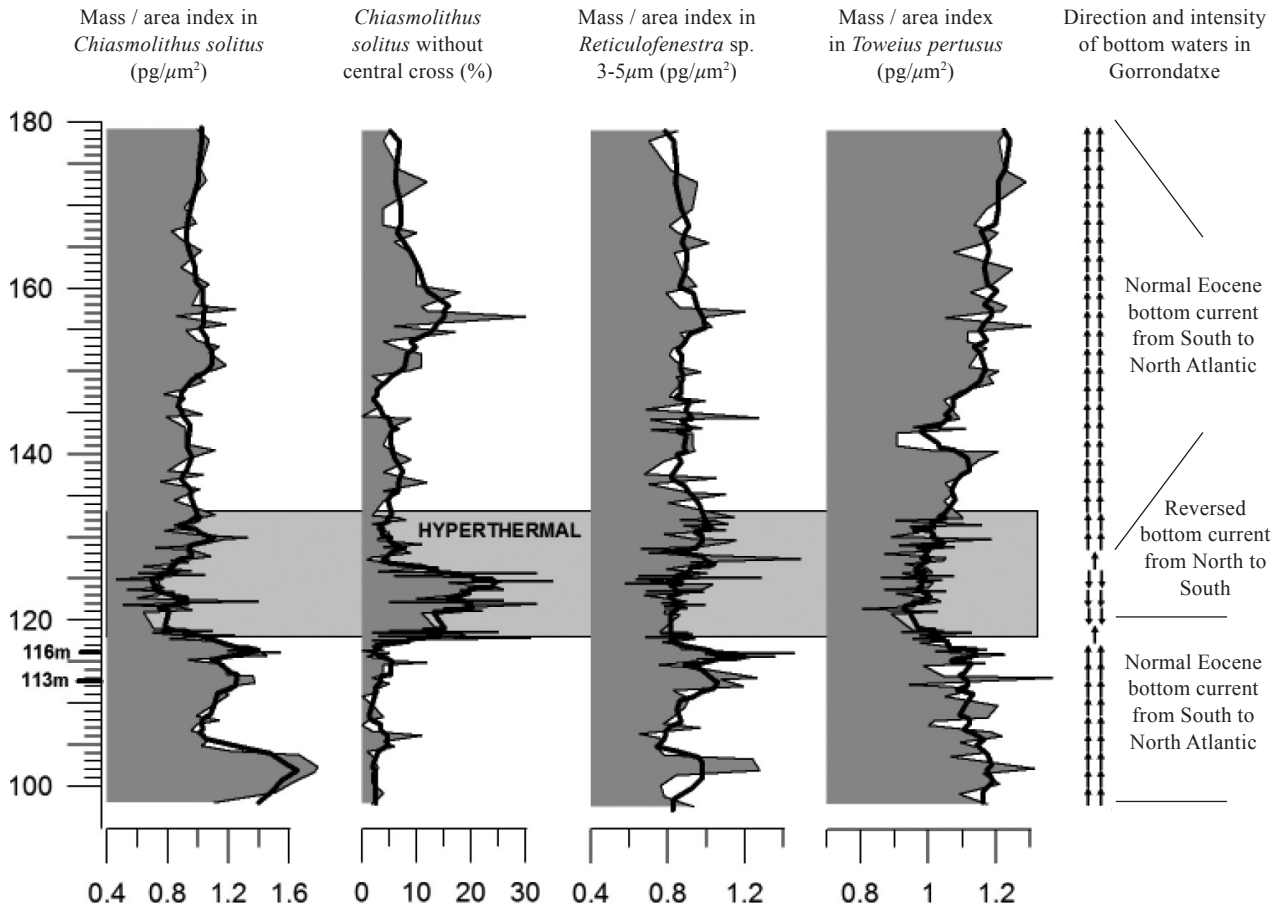
Fuertes, M.A., Flores, J.A. & Sierro, F.J. 2014. The use of circularly polarized light for biometry, identification and estimation of mass of coccoliths. *Marine Micropaleontology*, **113**: 44–55.

Langer, G., Geisen, M., Baumann, K.H., Klas, J., Riebesell, U., Thoms, S. & Young, J.R. 2006. Species-specific responses of calcifying algae to changing seawater carbonate chemistry. *Geochemistry, Geophysics, Geosystems*, **7**: 1227–1238.

Nunes, F. & Norris, R.D. 2006. Abrupt reversal in ocean overturning during the Palaeocene/Eocene warm period. *Nature*, **439**: 60–63.

Riebesell, U. 2004. Effects of CO_2 enrichment on marine phytoplankton. *Journal of Oceanography*, **60**: 719–729.

Zachos, J.C., Röhl, U., Schellenberg, S.A., Sluijs, A., Hodell, D.A., Kelly, D.C., Thomas, E., Nicolo, M., Raffi, I., Lourens, L.J., McCarren, H. & Kroon, D. 2005. Rapid acidification of the ocean during the Paleocene-Eocene Thermal Maximum. *Science*, **308**: 1611–1615.


Mass / area index in *Chiasmolithus solitus* (pg/μm^2)
Chiasmolithus solitus without central cross (%)
Mass / area index in *Reticulofenestra* sp. 3-5μm (pg/μm^2)
Mass / area index in *Toweius pertusus* (pg/μm^2)
Direction and intensity of bottom waters in Gorrondatxe
180
160
140
120
116m
113m
100
HYPERTHERMAL
0.4 0.8 1.2 1.6
0 10 20 30
0.4 0.8 1.2
0.8 1 1.2
Normal Eocene bottom current from South to North Atlantic
Reversed bottom current from North to South
Normal Eocene bottom current from South to North Atlantic

Nannostratigraphy of a marly shale flyshoid from Afzalabad in northern Birjand (eastern Iran)

Farah Jalili

University of Birjand, Department of Geology, Birjand, Iran; farah_jalili@birjand.ac.ir

Fatemeh Hadavi

Ferdowsi University of Mashhad, Department of Geology, Mashhad, Khorasan Razavi, Iran; fhadavi@um.ac.ir; hadavi 231@yahoo.com

Flyschoid deposits in eastern Iran resulted from the Alpine–Himalayan orogeny that was the product of a long-term convergence between Eurasia and parts of Gondwana and the closure of the Neo-Tethys Ocean. The studied sequence is located in eastern Iran (Sistan suture zone) in the village of Afzal Abad (northern Birjand) and consists of 4300m of shales and marls with interlayers of sandstones or only sandstone units of varying thicknesses. The nannofossils are moderately preserved and diverse. As a result of this study, 44 genera and 108 species of calcareous nannofossils were identified and photographed. Based on the nannofossils, the section is placed within Zones NP11–NP19 and NN8–NN10 of Martini (1971), or the Ypresian to Priabonian and the Tortonian.

References

Martini, E. 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. *In*: A. Faranacci (Ed.). *Proceedings of the Second Planktonic Conference Roma 1970.* Edizioni Tecnoscienza, Rome, **2**: 739–785.

Latest Early Cretaceous calcareous nannofossils from southern Tibet, China

Shijun Jiang
Jinan University, Institute of Groundwater and Earth Sciences, Guangzhou, China; ssj0047@my.fsu.edu

Denise K. Kuhanek
International Ocean Discovery Program, Texas A&M University, College Station, TX 77845, USA; kulhanek@iodp.tamu.edu

David K. Watkins
University of Nebraska-Lincoln, Department of Earth & Atmospheric Sciences, Lincoln, NE 68588, USA; dwatkins@unl.edu

Richard W. Jordan
Yamagata University, Yamagata, Japan; sh081@kdw.kj.yamagata-u.ac.jp

Kazuki Hoshina
Yamagata University, Department of Earth & Environmental Sciences, Yamagata, Japan; hsnkzk523@ezweb.ne.jp

Cretaceous marine sediments are widely distributed in the Tethyan Himalayan region. They outcrop in the southern Tibet region of Tingri and consist of the following successions from the bottom upward: the Gucuocun, Gambacunkou, Jiubao, and Zhepure Shanpo Formations. The ages of these formations have been poorly constrained due to a scarcity of macrofossils. Fifty-one samples, which were collected from the Gangbacunkou Formation in the Kangsha Section, Tingri, are primarily gray calcareous marl and marly limestone. Routine calcareous nannofossil biostratigraphic examination, using the "double-slurry" technique, revealed that calcareous nannofossils occurred at varying abundances throughout the section. The most common taxa include *Watznaueria barnesiae*, *Discorhabdus ignotus*, *Watznaueria fossacincta*, *Prediscosphaera columnata*, *Retecapsa* sp., *Biscutum constans*, *Braarudosphaera hockwoldensis*, *Hayesites irregularis*, *Tranolithus orionatus*, *Zeugrhabdotus diplogrammus*, *Zeugrhabdotus xenotus*, *Helenea chiastia*, and *Cylindralithus* sp. The co-occurrence of the marker species *H. irregularis* (last occurrence dated at 100.84Ma) and *T. orionatus* (first occurrence at 110.74Ma) constrains the study interval to nannofossil Subzones CC8b to CC9a, which fall within the middle-late Albian Stage. This study highlights the usefulness of calcareous nannofossils in dating lithological units in southern Tibet.

Gephyrocapsa physiology over the past 400ka

Xiaobo Jin
Tongji University, State Key Laboratory of Marine Geology, Shanghai 200092, China; 386jinxiaobo@tongji.edu.cn

Chuanlian Liu
Tongji University, State Key Laboratory of Marine Geology, Shanghai 200092, China; liucl@tongji.edu.cn

Hongrui Zhang
Tongji University, State Key Laboratory of Marine Geology, Shanghai 200092, China; 103443_rui@tongji.edu.cn

Gephyrocapsa species, some of the most common coccolithophores in the modern ocean, especially in tropical, nutrient replete coastal and upwelling waters, had distinct morphotypes throughout the Pleistocene that can be used to reconstruct paleo-sea surface temperatures and atmospheric CO_2 concentrations. The physiological effects (calcification and photosynthesis) on the carbon and oxygen fluxes through cellular membranes and their isotope fractionation between organic and inorganic carbon were also considered. For alkenone based pCO_2 reconstructions, the physiology of Noelaerhabdaceae depends upon the "b" value, and it is calibrated with cell size surface area and volume ratio, which is probably linked to coccolithophore growth conditions. In different ecological niches, *Gephyrocapsa* morphotypes have different physiological processes. We investigated *Gephyrocapsa* over the past 400ka in a west Pacific core (157˚58.91'E, 01˚25.0'S, depth: 1897m) that had well-preserved coccoliths in order to observe physiological variance with respect to glacial-interglacial cycles. The physiology should also be reflected in the changes from *Gephyrocapsa caribbeanica* to *Gephyrocapsa oceanica*, which may be important for calibrating "b" values for alkenoe-CO_2 methodology over the several hundred ka during which paleo-pCO_2 was recorded in ice bubbles.

The degree of coccolith calcification was determined from morphological parameters (shield thickness, length, and area) observed with polarized light. The photosynthesis intensity of *Gephyrocapsa* was evaluated with ^{13}C and ^{18}O isotopes, which previous studies have shown are linked to growth rates. A recent study showed that the isotopic composition of the cellular carbon pool, utilized by calcification, is greatly controlled by the strength of Rayleigh fractionation around the chloroplast, namely the photosynthesis intensity. Coccolith isotopic analyses need nearly mono-specific samples. *Gephyrocapsa* coccoliths were isolated using the different sinking velocities of varying-sized coccoliths. Sediments were first suspended in flasks, and the upper ~6cm of the water column was piped out, removing *Florisphaera profunda* and small placoliths (<2.5μm) after ~16 hours standing (7–9 repeats) at 20°C. Then ~6cm of the water column was extracted (2 hours standing, 2 repeats) and filtered on 3μm pore-sized polycarbonate membranes. The preliminary results are shown in Figure 1.

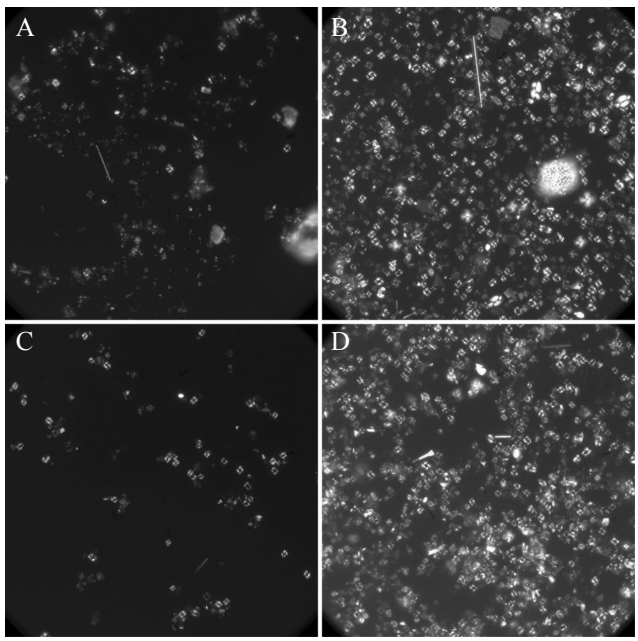


Figure 1: (A) Untreated samples with ~60% *Florisphaera profunda* relative abundance; (B) Treated samples using the first procedure and *Florisphaera profunda* <5%; (C) Second procedure to remove large particles for optical analysis; (D) Refined *Gephyrocapsa* coccoliths on membranes for isotopic analysis

Phytoplankton biogeography in the western Pacific and Indian Ocean

Richard W. Jordan

Yamagata University, Yamagata, Japan; sh081@kdw.kj.yamagata-u.ac.jp

Ryohei Fujita

Yamagata University, Yamagata, Japan; ry-f.escher@docomo.ne.jp

A recent analysis of 153 filtered, surface seawater samples, collected in December 1996 to February 1997, along north-south and south-north transects, has revealed a number of interesting points. First, diatoms dominated the assemblages at most stations, even those in oligotrophic areas, with coccolithophorids and dinoflagellates rarely abundant. Second, the diatom assemblages and absolute abundances changed drastically upon entering coastal/shallow waters, from low abundances of open-ocean *Mastogloia* and *Nitzschia* to higher abundances on the shelf or in marginal seas of colonial taxa like *Chaetoceros*, *Bacteriastrum,* and *Thalassiosira*. Third, the sea surface temperature and salinity records were closely associated with changes in the phytoplankton assemblage and absolute abundance. In addition to the surface water samples, two hydrocasts were analyzed in the Sulu Sea and South China Sea. These revealed the presence of tropical Parmales, which were seemingly restricted to the deep photic zone by low water temperature and high silicate concentrations.

By combining this dataset with those previously compiled for the Southern Ocean (Indian Sector) and subarctic Pacific and Bering Seas, a generalized picture of phytoplankton biogeography can be visualized that has a distinct latitudinal zonation. Furthermore, clear differences are apparent with regard to vertical distribution, and coccolithophorids, for example, often are found below the top 10m in subtropical/tropical waters but within the top 10m in temperate/subpolar waters. Silicoflagellates also show some discrete patterns in which *Octactis* prefers coastal waters, *Dictyocha* prefers warmer waters, and *Stephanocha* prefers cooler waters.

Modeling Mediterranean pelagic phytoplankton

Sofia Kalaroni
Hellenic Centre for Marine Research, Institute of Oceanography, Anavyssos 19013, Attica, Greece; skalaroni@hcmr.gr

Konstantinos Tsiaras
Hellenic Centre for Marine Research, Institute of Oceanography, Anavyssos 19013, Attica, Greece; ktsiaras@hcmr.gr

George Petihakis
Hellenic Centre for Marine Research, Heraklion 71003, Crete, Greece; gpetihakis@hcmr.gr

Athena Economou-Amilli
National and Kapodistrian University of Athens, Faculty of Biology, Department of Ecology & Systematics, Panepistimioupolis, Athens 15784, Greece; aamilli@biol.uoa.gr

George Triantafylloy
Hellenic Centre for Marine Research, Institute of Oceanography, Anavyssos 19013, Attica, Greece; gt@hcmr.gr

Ecosystem models form a valuable tool for understanding marine ecosystem dynamics and addressing management questions that are related to dynamic feedbacks between physical and biotic processes. A generic biogeochemical model is presented here that is based on the European Seas Ecosystem Model (ERSEM), which is currently coupled with the Mediterranean basin scale hydrodynamic model of the operational "POSEIDON" forecasting system. The ERSEM model applies a 'functional' group approach where biotic groups are distinguished not by species but by their functional role (producers, consumers, and decomposers) in the ecosystem, using size as the primary characteristic. The ecological characteristics described are not site specific and respond to the varying physico-chemical environment from coastal and river influenced areas up to the open sea. The simulation results were validated against available remote sensing (ocean color) and in situ data. The model qualitatively reproduces the observed patterns of the Mediterranean Sea surface nutrients and chlorophyll concentration, and is consistent with estimates of primary and bacterial productivity. Despite some discrepancies between the model simulation and in situ measurements, the model successfully reproduces the pelagic plankton food web dynamics that captures the seasonal and spatial overarching trend among autotrophs and heterotrophs. The mean simulated Mediterranean phytoplankton biomass is characterized by the dominance of picoplankton and nanoplankton in oligotrophic areas, followed by diatoms and dinoflagellates that coexist alongside them in more productive areas. Heterotrophic nanoflagellates, which follow a similar pattern to picoplankton and heterotrophic bacteria, show a higher relative abundance in oligotrophic areas, whereas microzooplankton present an opposite distribution and are more abundant in more productive areas, due to the greater variety of their diet (nanoplankton, microphytoplankton, and heterotrophic nanoflagellates). Mesozooplankton present a slightly greater increasing gradient toward the productive areas, as they feed mainly on diatoms and dinoflagellates, along with microzooplankton. As a next step, the assimilation of remote sensing (ocean color) data could provide an operational forecast for ecosystem dynamics.

Calcareous nannofossils from Oligocene-middle Miocene sediments from the Albanian-Thessalian Basin (Albania): biostratigraphy and paleoecological implications

Mădălina-Elena Kallanxhi

Babeș-Bolyai University, Department of Geology, Cluj-Napoca 400084, Romania; madalina_kallanxhi@yahoo.com

Stjepan Ćorić

Geological Survey of Austria, Neulinggasse 38, A-1030 Vienna, Austria; stjepan.coric@geologie.ac.at

The Albanian-Thessalian intramontane Basin (Albania) represents the continuation of the Mesohellenic Trough (Greece). It evolved as a narrow marine basin and preserves three main sedimentary sequences (Pashko *et al*., 1973) of about 4.7km in thickness (the middle Eocene sequence, the late Rupelian to Aquitanian sequence, and the Burdigalian to Langhian sequence). The investigated transects crop out on both sides of Morava Mountain, which is well known for its continuously exposed litho-formations, belonging to the second and third sedimentary sequences.

A total of 453 samples were collected from several outcrops and were processed for calcareous nannofossils. Quantitative and semi-quantitative analyses were performed on all samples that contained calcareous nannofossils.

The calcareous nannofossil assemblages allowed placement in six standard biozones. The Oligocene epoch was recognized by the presence of NP24 – *Sphenolithus distentus* Zone and NP25 – *Sphenolithus ciperoensis* Zone, while the Miocene contained four biozones: NN2 – *Discoaster druggii* Zone, NN3 – *Sphenolithus belemnos* Zone, NN4 – *Helicosphaera ampliaperta* Zone, and NN5 – *Sphenolithus heteromorphus* Zone. The most important primary and secondary index species that were identified in the study material are *Cyclicargolithus abisectus, Helicosphaera ampliaperta*, *H. mediterranea*, *H. recta*, *H. walberdorfensis*, *H. waltrans*, *Reticulofenestra bisecta*, *Sphenolithus belemnos*, *S. ciperoensis*, *S. conicus*, *S. delphix*, *S. dissimilis*, *S. distentus*, *S. heteromorphus*, *S. predistentus*, *Triquetrorhabdulus carinatus, and Zygrhablithus bijugatus.*

Fluctuations in calcareous nannofossil abundance and the paleoecological preferences of the most abundant taxa were considered for paleoenvironmental reconstruction of the investigated outcrops.

This work was possible due to the financial support of the Sectorial Operational Program for Human Resources Development 2007–2013, co-financed by the European Social Fund, under the project number POSDRU/159/1.5/S/132400 with the title “Young successful researchers – professional development in an international and interdisciplinary environment”.

References

Pashko, P., Papa, A., Huta, B. & Myftari, A. 1973. Stratigraphy of the Paleogene and Neogene deposits from tectonic zone of Mirdita. *Archives of Albanian Geological Survey*: 564pp.

Biostratigraphy and paleoenvironment of middle Miocene deposits from the southern Pannonian Basin (Bosnia and Herzegovina) based on calcareous nannofossils

Mădălina-Elena Kallanxhi

Babeș-Bolyai University, Department of Geology, Cluj-Napoca 400084, Romania; madalina_kallanxhi@yahoo.com

Stjepan Ćorić

Geological Survey of Austria, Neulinggasse 38, A-1030 Vienna, Austria; stjepan.coric@geologie.ac.at

Oleg Mandic

Natural History Museum Vienna, Department of Geology and Paleontology, 1010 Wien, Austria; oleg.mandic@nhm-wien.ac.at

Quantitative and semi-quantitative analyses were performed on calcareous nannofossils from 370 samples that were collected from middle Miocene sediments at the Ugljevik section (Bosnia and Herzegovina). During the middle Miocene, the studied section was located in the southern part of the Pannonian Basin (Central Paratethys domain).

The calcareous nannofossil assemblages were dominated in general by *Reticulofenestra minuta*, followed in lower amounts by *Coccolithus pelagicus*, *Reticulofenestra pseudoumbilicus,* and *R. haqii.* Continuously present within the section, but less abundant, were *Umbilicosphaera jafari*, *Helicosphaera carteri*, *H. walbersdorfensis*, *Coronosphaera mediterranea*, *Holodiscolithus macroporus*, *Reticulofenestra gelida*, *Sphenolithus moriformis,* and *R. antarctica.* The following species and taxonomical groups were rare and sporadic: *Acanthoica cohenii*, *Braarudosphaera bigelowii*, *Calcidiscus* spp. (*Calcidiscus leptoporus*, *C. macintyrei*, *C. premacintyrei*, *C. tropicus*, and *C. pataecus*), *Discoaster* spp. (*Discoaster adamanteus*, *D. deflandrei*, *D. exilis*, *D. musicus,* and *D. variabilis*), *Hayella challengeri*, *Pontosphaera multipora*, *P. discopora*, *R. producta*, *Rhabdosphaera sicca*, *Sphenolithus heteromorphus*, *S.* cf. *abies,* and *Umbilicosphaera rotula*. These species indicate placement in Zones NN5 (*Sphenolithus heteromorphus*) and NN6 (*Discoaster exilis*) for the sedimentary succession.

The paleoecological preferences for the most abundant taxa, coupled with obvious shifts in their abundance and in assemblage composition through the studied interval, were considered for paleoenvironmental interpretation. High amounts of *R. minuta* (up to 90%) were documented in the lower half of the section, indicating a eutrophic environment with a terrigenous nutrient-rich input. In the second half of the section, the assemblages were mainly dominated by *C. pelagicus*, *R. pseudoumbilicus*, *R. haqii*, and helicoliths, suggesting fluctuations between shallower and more marine environments and changes in nutrient-type availability, sea surface temperatures, and upwelling intensity. Short intervals with elevated numbers of *U. jafari* were recorded in the middle part of the section, indicating a probable nearshore, hypersaline marine environment.

Didemnind ascidian spicules represented a secondary component of the microfossil assemblages from the Ugljevik section, and the parataxonomical classification of Varol & Houghton (1996) was used for tentative taxa identification.

References

Varol, O. and Houghton, S.D., 1996. A review and classification of fossil Didemnid Ascidian spicules. Journal of Micropalaeontology, **15**: 135–149.

Paleocene–Eocene calcareous nannofossil biostratigraphy from the Gams area (Gosau Group, Northern Calcareous Alps, Austria)

Mădălina-Elena Kallanxhi
Babeș-Bolyai University, Department of Geology, 400084 Cluj-Napoca, Romania; madalina_kallanxhi@yahoo.com

Veronika Koukal
University of Vienna, Department of Geodynamics and Sedimentology, A-1090, Vienna, Austria; veronika.koukal@univie.ac.at

Michael Wagreich
University of Vienna, Department of Geodynamics and Sedimentology, A-1090, Vienna, Austria; michael.wagreich@univie.ac.at

The sedimentary succession of the Gosau Group at Gams in the Northern Calcareous Alps (NCA) comprises deposits of late Turonian to early Eocene (Ypresian) age (Egger *et al*., 2004). In the Gams area, Cretaceous-Paleogene boundary intervals (K/Pg), as well as Paleocene-Eocene-boundary intervals (P/E), are exposed. The Nierental Formation and the Zwieselalm Formation in the eastern outcrop area (upper Gosau Subgroup, Campanian – Ypresian) are composed of deep-water deposits, mainly coarse mass flow deposits, sandy turbidites, and hemipelagites.

Samples were collected from several outcrops and investigated for their calcareous nannofossil and calcareous dinoflagellate content. The investigated interval covers a stratigraphic age from Selandian to early Ypresian.

Biostratigraphically, the calcareous nannofossil assemblages allowed correlation of the studied outcrops to five standard biozones: NP5 – *Fasciculithus tympaniformis* Zone, NP6 – *Heliolithus kleinpelli* Zone, NP9 – *Discoaster multiradiatus* Zone, NP10 – *Tribrachiatus contortus* Zone, and NP11 – *Discoaster binodosus* Zone. The NP7 – *Discoaster mohleri* Zone and NP8 – *Heliolithus riedelii/ Discoaster nobilis* Zone were not identified in this area, which may indicate a gap in the succession and/or a carbonate-free interval barren of nannofossils. In addition, the following calcareous dinoflagellate species were identified: *Calciodinellum albatrosianum, Cervisiella operculata, Pernambugia* cf. *tuberosa, Thoracosphaera heimii, Thoracosphaera* cf. *prolata,* and *Thoracosphaera* spp.

References

Egger, H., Rögl, F. & Wagreich, M. 2004. Biostratigraphy and facies of Paleogene deep-water deposits at Gams (Gosau Group, Austria). *Annalen des Naturhistorischen Museums in Wien. Serie A für Mineralogie und Petrographie, Geologie und Paläontologie, Anthropologie und Prähistorie*: 281–307.

Calcareous nannofossil biohorizons from the late Neogene to Quaternary in and around the Japanese islands and comparison with oxygen isotope and magnetostratigraphic records

Koji Kameo
Chiba University, Department of Earth Sciences, 1-33, Yayoi, Inage, Chiba, 263-8522, Chiba, Japan; kameo@faculty.chiba-u.jp

Shun Chiyonobu
Akita University, Akita City, Japan; chiyo@gipc.akita-u.ac.jp

Thick, continuous Neogene and Quaternary formations are widely distributed in and around the Japanese islands, and many studies have been conducted on the calcareous nannofossils in these formations in order to obtain their geologic ages. Calibrated ages of individual biohorizons from other areas (e.g., Raffi *et al*., 2006) were used in these studies because no useful age data existed for the northwestern Pacific region. This study improves on Kameo *et al*. (2015) and aims at summarizing useful calcareous nannofossil biohorizons around the Japanese islands that are based on a direct correlation with oxygen isotope and magnetic reversal records. We examined samples primarily from Pliocene and Pleistocene strata in the Boso Peninsula in central Japan. Deep-sea cores that were obtained by the NanTroSEIZE project, which was conducted around the Nankai Trough in the southwestern part of Japan, were also used. Twelve useful and traceable nannofossil biohorizons were found in the Pleistocene, and eight were found in the Pliocene. Comparative studies of biohorizons with stable isotope records are possible in the Pleistocene and the upper Pliocene sequences in the Boso Peninsula (e.g., Kameo & Okada, 2016). In the lower Pliocene, however, it is only possible to correlate biohorizons with magnetic reversal records in the NanTroSEIZE cores because there is no available oxygen isotope data. Most of the Pliocene and Pleistocene biohorizons proposed by many authors can be applied to the study area, but biohorizons based on occurrences of *Amaurolithus* and *Ceratolithus* species were not identified. On the other hand, there are some traceable biohorizons that correspond to abrupt morphologic changes in *Reticulofenestra* specimens.

References

Kameo, K. & Okada, M. 2016. Calcareous nannofossil biochronology from the upper Pliocene to lower Pleistocene in the southernmost Boso Peninsula, central part of the Pacific side of Japan. *Journal of Asian Earth Sciences*, **129**: 142–151.

Kameo, K., Okada, Y., Chiyonobu, S & Okada, M. 2015. Neogene and Quaternary calcareous nannofossil datums recognized in and around the Pacific side of Japanese islands. *Geological Society of Japan*, 122nd Annual Meeting: 229 (abstract).

Raffi, I., Backman, J., Fornaciari, E., Palike, H., Rio, D., Lourens, L. & Hilgen, F. 2006. A review of calcareous nannofossil astrobiochronology encompassing the past 25 million years. *Quaternary Science Reviews*, **25**: 3113–3137.

Possible effects of Kolumbo submarine volcano emissions (Cyclades, Aegean Sea) on coccolithophore assemblages

Boris Theofanis Karatsolis
National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; bkaratsolis@gmail.com

Margarita D. Dimiza
National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; mdimiza@geol.uoa.gr

Paraskevi Nomikou
National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; evinom@geol.uoa.gr

Paraskevi Polymenakou
Hellenic Centre for Marine Research, Institute of Marine Biology, Biotechnology and Aquaculture, Gournes Pediados, 71500 Heraklion Crete, Greece; polymen@hcmr.gr

Manolis Mandalakis
Hellenic Centre for Marine Research, Institute of Marine Biology, Biotechnology and Aquaculture, Gournes Pediados, 71500 Heraklion Crete, Greece; mandalakis@hcmr.gr

Odysseas A. Archontikis
National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; odysseas67@windowslive.com

Elisa Malinverno
Università degli Studi di Milano-Bicocca, Department of Earth and Environmental Sciences, 20126 Milano, Italy; elisa.malinverno@unimib.it

Theo J. Mertzimekis
National and Kapodistrian University of Athens, Department of Physics, Panepistimioupolis, 157 84 Athens, Greece; tmertzi@phys.uoa.gr

Eirini P. Pappa
National and Kapodistrian University of Athens, Department of Physics, Panepistimioupolis, 157 84 Athens, Greece; e.p.pappa@hotmail.gr

Maria V. Triantaphyllou
National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; mtriant@geol.uoa.gr

This study presents the species distribution and morphology of coccolithophores in the area of Kolumbo. Kolumbo is situated in the middle part of the Hellenic Volcanic Arc and is the largest submarine volcano in a series of at least 19 volcanic cones (Kolumbo volcanic chain) that trend NE away from Santorini within the extensional, fault-bounded Anhydros Basin (Nomikou *et al*., 2012, 2013). Sensitivity of the calcification processes to ocean acidification makes coccolithophores one of the first organisms to be affected by increasing CO_2 levels in the ocean. Submarine volcanoes, such as Kolumbo, are well known to emit significant amounts of CO_2, thus locally contributing to the production of this greenhouse gas (Carey *et al*., 2013). Coccolithophores were collected from 5–90m depths during two sampling periods at three different stations and studied using the scanning electron microscope (SEM). Focus was on the malformation of *Emiliania huxleyi*. Additionally, the pH, the main nutrients, and the total pigment concentrations were counted at the sampled stations. A pigment that is mainly present in coccolithophores, 19' hexanoloxy fucoxanthin, appeared in significant values, indicating the importance of these organisms in the total phytoplankton makeup of the area. Preliminary results indicated that although malformations were present, they cannot be directly linked to significant changes in the pH values or to limitation of the main nutrients. The Kolumbo hydrothermal emissions, which consist of more than 99% CO_2, are trapped in a dense lake inside the area of the crater at depths greater than 350m (Carey *et al*., 2013). Thus, the CO_2 produced by the volcanic field is restricted and does not influence the upper 100m of the water column. Malformed coccoliths have been documented in several locations in the Aegean Sea (Dimiza *et al*., 2012), and the reason for their common appearance in the Aegean needs further investigation.

References

Carey, S., Nomikou, P., Croff Bell, K., Lilley, M., Lupton, J., Roman, C., Stathopoulou, E., Bejelou, K. & Ballard, R. 2013. CO_2 degassing from hydrothermal vents at Kolumbo submarine volcano, Greece, and the accumulation of acidic crater water. *Geology*, **41**:1035–1038.

Dimiza, M., Triantaphyllou, M. & Krasakopoulou, E. 2012. Coccolith malformation in the Aegean Sea. *Scientific Annals of the School of Geology*, **101**: 23–30.

Nomikou, P., Papanikolaou, D., Alexandri, M., Sakellariou, D. & Rousakis, G. 2013. Submarine volcanoes along the Aegean volcanic arc. *Tectonophysics*, **597–598**: 123–146.

Nomikou, P., Carey, S., Papanikolaou, D., Bell, K.C., Sakellariou, D., Alexandri, M. & Bejelou, K. 2012. Submarine volcanoes of the Kolumbo volcanic zone NE of Santorini Caldera, Greece. *Global and Planetary Change*, **90–91**: 135–151.

Tracing NE Aegean water masses using phytoplankton (coccolithophore and silicoflagellate) assemblages

Boris Theofanis Karatsolis

National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; bkaratsolis@gmail.com

Maria Triantaphyllou

National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; mtriant@geol.uoa.gr

Margarita D. Dimiza

National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; mdimiza@geol.uoa.gr

Elisa Malinverno

Università degli Studi di Milano-Bicocca, Dipartimento di Scienze dell'Ambiente e della Terra, 20126 Milano, Italy; elisa.malinverno@unimib.it

Odysseas A. Archontikis

National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; odysseas67@windowslive.com

Stella Psarra

Hellenic Centre for Marine Research, Institute of Oceanography, Anavyssos 19013, Attiki, Greece; spsarra@hcmr.gr

This study presents the species composition of living coccolithophore and silicoflagellate communities in the NE Aegean Sea and investigates their spatial and temporal variations. Samples were collected along a transect with stations located where low-salinity Black Sea surface water (BSW) inflows over the deeper, Levantine Water (LW) layer. Coccolithophores in the area were collected during three sampling periods (October, March, and July) and studied with the SEM. R-mode hierarchical cluster analysis distinguished four coccolithophore groups (I, IIa, IIb, and IIc) with different ecological preferences (Karatsolis *et al*., in press).

In the winter period, biometric analysis of the relative tube width of *Emiliania huxleyi* clearly distinguished between specimens of Black Sea origin, with characteristically low relative tube widths, and typical overcalcified LW winter morphotypes (Triantaphyllou *et al*., 2010). This enabled us to trace the BSW influence on winter and autumn coccolithophore assemblages. In the summer period, BSW mass inflow had the effect that typical LW holococcolithophore species (Groups IIa and IIb) had low values in their normal surface water ecological niche and higher numbers at greater depths, indicating that the LW was flowing under the less saline BSW, which acted like a surface lid (Karatsolis *et al.*, in press). During the spring sampling period, the vertical distribution and morphology of the silicoflagellate species was also studied (Malinverno *et al*., 2016). The silicoflagellate assemblage was dominated by *Dictyocha stapedia* and *Stephanocha speculum*. While specimens of *D. stapedia* had typical morphologies that have been described in other areas of the Mediterranean Sea, populations of *S. speculum* displayed peculiar, predominantly 7-sided morphologies. Some of these features have been described for *S. speculum* at high latitudes, but the combined characters make these specimens slightly different from the high-latitude populations. Similar morphologies have been observed in the western Black Sea, and we infer that the peculiar specimens in the NE Aegean represent an additional indicator of the BSW impact in the area.

References

Karatsolis, B.T., Triantaphyllou, M.V., Dimiza, M.D., Malinverno, E., Lagaria, A., Mara, P., Archontikis, O. & Psarra, S. In press. Coccolithophore assemblage response to Black Sea Water inflow into the North Aegean Sea (NE Mediterranean), *Continental Shelf Research.*

Malinverno, E., Karatsolis, B.T., Dimiza, M.D., Lagaria, A., Psarra, S. & Triantaphyllou, M.V. 2016. Extant silicoflagellates from the Northeast Aegean (eastern Mediterranean Sea): Morphologies and double skeletons. *Revue de Micropaléontologie*, **59**: 253–265.

Triantaphyllou, M.V., Dimiza, M.D., Krasakopoulou, E., Malinverno, E., Lianou, V. & Souvermezoglou, E. 2010. Seasonal control on *Emiliania huxleyi* coccolith morphology and calcification in the Aegean Sea (Eastern Mediterranean). *Geobios* **43**, 99–110.

Middle Devonian miospore assemblage biozones in Sahara synclines (Algeria): geological implication and evidence for stages boundaries

Mohamed O. Kermandji

University of Frère Mentouri Constantine 1, Department of Biology, Faculty of Nature and Life, 25000 Constantine, Algeria; omeedmohamed1@gmail.com

Adnan M. Hassan Kermandji

University of Frère Mentouri Constantine 1, Department of Biology and Plant Ecology, Faculty of Nature and Life, 25000 Constantine, Algeria; omeedomid@gmail.com

F. Khelifi Touhami

University of Frère Mentouri Constantine 1, Department of Biology, Faculty of Nature and Life, 25000 Constantine, Algeria; Khelifi_t_fatima@yahoo.com

The classic exposed Devonian sedimentary sequences of Oued Saoura in the western Sahara (Algeria) and the Devonian succession in the Steh borehole of the eastern Sahara syncline (Algeria) were studied. The results showed that most palynomorphs occurred in grey to dark grey clayey siltstone and very fine argillaceous sandstone layers. These fossils were mainly mature to highly mature and poorly preserved. Samples from the Steh borehole were moderately to well preserved. The assemblages contained associations of miospores, tetrads, plant remains (cuticles, tissues, and tubular structures), and a few acritarch individuals. The miospore assemblages were identified and keyed into previously described palynostratigraphic miospore assemblage biozones based on deep wells from the Tidikelt Plateau, central Sahara and Oued Saoura outcrops (Hassan Kermandji *et al.*, 2008, 2009) and from the Old Red Sandstone Continent and adjacent regions (Richardson & McGregor, 1986) and from the marine Devonian of the Ardenne-Rhenish regions (Streel *et al.*, 1987).

The biostratigraphic data confirm that the basal strata of the Teferguenite Formation that are exposed at Mongar Debad are of Eifelian age. Miospore taxa in the sequence above the basal strata of the same formation indicate a Givetian age.

The diagnostic elements of the miospore assemblages of Middle Devonian age in Algeria are similar to contemporaneous miospore assemblages from Libya, Tunis, and Saudi Arabia, which implies a correlation within northern Gondwanan and possibly the Northern Hemisphere. The miospore taxa were able to delineate the boundary between Eifelian and Givetian strata.

References

Kermandji, A.M.H., Kowalski, W.M. & Touhami, F.K. 2008. Miospore stratigraphy of Lower and early Middle Devonian deposits from Tidikelt, Central Sahara, Algeria. *Geobios*, **41**(2), 227–251.

Kermandji, A.H., Touhami, F.K., Kowalski, W.M., Abbés, S.B., Boularak, M., Chabour, N., Laifa, E.L. & Hannachi, H.B. 2009. Stratigraphy of the Lower Devonian of Tidikelt Plateau of In Salah (Central Sahara Algeria). *Comunicações Geológicas*, 67–82.

Richardson, J.B. & McGregor, D.C. 1986. Silurian and Devonian spore zones of the Old Red Sandstone continent and adjacent regions. *Geological Survey of Canada,* (364).

Streel, M., Higgs, K., Loboziak, S., Riegel, W. & Steemans, P. 1987. Spore stratigraphy and correlation with faunas and floras in the type marine Devonian of the Ardenne-Rhenish regions. *Review of Palaeobotany and Palynology*, **50**(3): 211–229.

Recovery of plankton cell and coccolith size after the Cretaceous-Paleogene mass extinction (IODP Expedition 342 Sites 1403 and 1407, North Atlantic)

Hojung Kim
University College London, Department of Earth Sciences, London WC1E 6BT, UK; hojung.kim.09@ucl.ac.uk

Paul Bown
University College London, Department of Earth Sciences, London WC1E 6BT, UK; p.bown@ucl.ac.uk

Samantha J. Gibbs
University of Southampton, National Oceanography Centre, Southampton, UK SO14 SO14 3ZH; samantha.Gibbs@noc.soton.ac.uk

The Cretaceous-Paleogene (K/Pg) mass extinction event, the most significant geological event to have affected calcareous nannoplankton, caused the extinction of over 90% of species. Because calcareous nannoplankton are major contributors to both primary and carbonate production, these rapid and devastating extinctions resulted in a major disruption of the marine biogeochemical cycles as evidenced by stable isotope excursions and the carbonate crash. The extinction eliminated the vast majority of open ocean taxa, and recovery initiated in new lineages that were characterized by very small cell size and minute coccoliths (<3μm). The initial few million years after the extinction saw a rapid diversification in species and increases in cell and coccolith size. In this study, we were able to quantify the speed and method of this recovery from a recently drilled Cretaceous-Paleogene section (IODP Expedition 342 Sites U1403 and U1407) that is located on the J-Anomaly Ridge in the northeast Atlantic Ocean. The succession includes an intact spherule layer and very well preserved microfossils. We focused on a variety of morphometric traits, including coccolith length and width, and cellular traits, including cell geometry (cell size and number of coccoliths per cell) and compared the evolutionary rates among the newly evolved lineages (*Prinsius*, *Coccolithus*, *Cruciplacolithus*, *Chiasmolithus*, and *Toweius*) and survivor taxa (*Cyclagelosphaera*, *Markalius*, and *Zeugrhabdotus*). These new data will provide us with an insight into the post-mass-extinction recovery of the marine ecosystem, including the rate at which pelagic carbonate production by coccolithophores was re-established.

Biometry of the genus *Gephyrocapsa* during the past 2 million years - implications for taxonomy, stratigraphy, and evolution.

Hanno Kinkel
GEOMAR Helmholtz Centre for Ocean Research, Kiel, Germany; hkinkel@geomar.de

Karl-Heinz Baumann
University of Bremen, Department of Geosciences, 28334 Bremen, Germany; baumann@uni-bremen.de

K.J. Sebastian Meier
Kiel University, Institute for Geosciences, Kiel, Germany; smeier@gpi.uni-kiel.de

Jeremy R. Young
University College London, Department of Earth Sciences, London WC1E 6BT, UK; jeremy.young@ucl.ac.uk

The evolution of the coccolithophore genus *Gephyrocapsa* in the northern Atlantic was investigated with biometric methods. Coccolithophore assemblages from four different ODP/DSDP sites were analyzed, revealing sixteen distinct morphotypes. Nine of those could be assigned to established *Gephyrocapsa* species, and we added the biometric information to the existing description of the species. Of the remaining morphotypes, four are introduced as new species, and the rest represent variations of existing species.

The genus *Gephyrocapsa* Kamptner currently includes six extant and ten fossil valid species, as well as a large number of different morphotypes that have been assigned by various authors. In general, classification of gephyrocapsids is based on variations in morphology, including the length and width of the distal shield, the length and width of the central area, and the angle between the long axis and the bridge that spans the central area. In addition, other morphological features, such as ornamentation, shape of the bridge, and slits in the distal shield, have been used to separate species.

During the Quaternary, with increasing morphological differentiation within this genus, there was a rise in its number of species. The diversification within this genus is interpreted as an adaptive radiation that occurred as species of this genus were becoming the most abundant taxa in the coccolithophore assemblages of the North Atlantic.

We will discuss in particular the recurring increase in size of certain morphotypes, which appears to be of global nature and compare this to existing data and similar patterns in other coccolithophore genera at this time and during other times in the geologic past.

Winter-spring living coccolithophores from Thermaikos Gulf, NW Aegean Sea

Olga Koukousioura

Aristotle University of Thessaloniki, Department of Geology, Thessaloníki 541 24, Greece; okoukous@geo.auth.gr

Margarita D. Dimiza

National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; mdimiza@geol.uoa.gr

Maria V. Triantaphyllou

National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; mtriant@geol.uoa.gr

Ioannis Michailidis

Aristotle University of Thessaloniki, Department of Geology, Thessaloníki 541 24, Greece; ismichai@geo.auth.gr

Vassiliki-Grigoria Dimou

National and Kapodistrian Aristotle University of Thessaloniki, Department of Geology, Thessaloníki 541 24, Greece; dagrigor@geo.auth.gr

Valentini Navrozidou

Aristotle University of Thessaloniki, Department of Geology, Thessaloníki 541 24, Greece; vnavrozidou@geo.auth.gr

Miltiadis Seferlis

The Goulandris National History Museum, Greek Biotope/Wetland Centre, 57001 Thermi, Thessaloníki, Greece; seferlis@ekby.gr

The Thermaikos Gulf is a semi-enclosed, shallow basin in the northwestern part of the Aegean Sea. The environmental setting of the area is defined by the three major rivers (Axios, Aliakmon, and Pinios) that flow into the basin. During the wet period (winter and spring), the freshwater intrusion can extend southwards enough to seal a major part of the gulf's surface waters (salinities <25psu). On the other hand, more saline waters from the northern Aegean Sea flow towards the northeast, entering the inner Thermaikos Gulf. The aim of this study was to explore changes in the coccolithophore abundance and composition, as compared to a multi-parameter environmental dataset (temperature, salinity, pH, turbidity, nutrients, and chlorophyll-*a*), during the winter-spring period. Sampling of the top 20m of the water column was carried out on a monthly basis (January-June 2016) at a station located in Thessaloniki Bay (inner part of the Thermaikos Gulf). Coccolithophore assemblages are dominated mostly by *Emiliania huxleyi*, and other species present include *Gephyrocapsa oceanica*, *Helicosphaera carteri*, and various species of *Syracosphaera*, such as *S. molischii*, *S. histrica*, and *S. anthos*. During winter-early spring (January to March), *E. huxleyi* displayed concentrations of up to 24×10^3 cells/l, similar to the typical *E. huxleyi* Aegean values. Extremely high cell densities of *E. huxleyi* (419×10^3 cells/l) were observed in April, following chlorophyll-*a* maxima. Biometric analyses were performed on *E. huxleyi* coccoliths, and they showed that the assemblage was dominated by over-calcified morphotypes during the winter/early spring months (e.g., Triantaphyllou *et al*., 2010). Lightly calcified morphotypes (relative tube width values < 0.1) dramatically increased (95%) in April and had morphological features similar to those of *E. huxleyi* coccoliths that were found in Black Sea waters flowing into the North Aegean (Karatsolis *et al*., in press). The observed "bloom" of *E. huxleyi* lightly calcified morphotypes reflects the exceptional environmental conditions that prevailed in the semi-closed inner Thermaikos Gulf with respect to the open Aegean Sea, thus providing further evidence of the species' biogeography.

References

Karatsolis, B.-Th., Triantaphyllou, M.V., Dimiza, M.D., Malinverno, E., Lagaria, A., Mara, P., Archontikis, O. & Psarra, S. in press. Coccolithophore assemblage response to Black Sea Water inflow into the North Aegean Sea (NE Mediterranean). *Continental Shelf Research*, http://dx.doi.org/10.1016/j.csr.2016.12.005.

Triantaphyllou, M.V., Dimiza, M.D., Krasakopoulou, E., Malinverno, E., Lianou, V. & Souvermezoglou, E. 2010. Seasonal control on *Emiliania huxleyi* coccolith morphology and calcification in the Aegean Sea (Eastern Mediterranean). *Geobios* **43**: 99–110.

Early Holocene calcareous nannofossil assemblages as indicators of past sea surface temperature and nutrient conditions in the New Zealand region

Denise K. Kulhanek
International Ocean Discovery Program, Texas A&M University, College Station TX 77845, USA; kulhanek@iodp.tamu.edu

Laura Dávila Castro
Texas A&M University, Department of Geology & Geophysics, College Station, TX 77843, USA; ldavila@tamu.edu

Nathan T. Lakin
Texas A&M University, Department of Geology & Geophysics, College Station, TX 77843, USA; nlakin@tamu.edu

Daniel Morelos
Texas A&M University, Department of Geology & Geophysics, College Station, TX 77843, USA; more_dann@tamu.edu

Joe G. Prebble
GNS Science, Lower Hutt, New Zealand; J.Prebble@gns.cri.nz

Helen Bostock
NIWA, Wellington, New Zealand; Helen.Bostock@niwa.co.nz

Giuseppe Cortese
GNS Science, Lower Hutt, New Zealand; g.cortese@gns.cri.nz

The early Holocene (~12–6ka) in the New Zealand region was a time when sea surface temperatures (SSTs) were as much as 3ºC warmer than today, but CO_2 concentrations were lower (e.g., Bostock *et al*., 2013). The early Holocene is important because it is the most recent interval in which temperatures in the southwest Pacific were in the range predicted for the coming century, making it an analog for future climate. In this study, we use calcareous nannofossil assemblages to infer changes in SST and nutrient conditions along a latitudinal transect of five piston cores that span from north of New Zealand to near the Polar Front. We have ~12–15 samples from each piston core that were radiocarbon dated to between ~6 and 13cal kyrs BP, plus a core top sample that represents modern conditions. We prepared samples using the drop method of Bordiga *et al*. (2015) that allows calculation of absolute abundances. We examined samples using either a Zeiss transmitted light microscope or a scanning electron microscope and counted a minimum of 300 specimens per sample. The assemblages included *Emiliania huxleyi*, *Gephyrocapsa oceanica*, *Gephyrocapsa muellerae*, *Gephyrocapsa* spp. <3μm, *Calcidiscus leptoporus*, *Coccolithus pelagicus*, *Helicosphaera carteri*, and *Florisphaera profunda*. Variations in the assemblages indicated that temperatures warmed after ~12cal kyrs BP and began to cool again after 8cal kyrs BP, which suggests that the subtropical front shifted southward at that time. The most northerly site also showed an increase in the abundance of *Florisphaera profunda* after 8cal kyrs BP, which suggests deeper surface-water stratification and decreased upwelling. These data will be combined with other micropaleontological and geochemical proxy data to have a better understanding of how oceanographic conditions changed in the early Holocene in the New Zealand region in order to improve predictions of how a warmer climate might impact marine resources in the future.

References

Bordiga, M., Bartol, M. & Henderiks, J. 2015. Absolute nannofossil abundance estimates: Quantifying the pros and cons of different techniques, *Revue de micropaléontologie*, **58**: 155–165.

Bostock, H., Barrows, T.T., Carter, L., Chase, Z., Cortese, G., Dunbar, G.B., Ellwood, M., Hayward, B., Howard, W., Neil, H.L., Noble, T.L., Mackintosh, A., Moss, P.T., Moy, A.D., White, D., Williams, M.J.M. & Armand, L.K. 2013. A review of the Australian/New Zealand sector of the Southern Ocean over the last 30ka (Aus-INTIMATE Project), *Quaternary Science Reviews*, **74**: 35–57.

The silicon requirement of coccolithophore calcification

Gerald Langer
The Marine Biological Association of the United Kingdom, Plymouth PL1 2PB, UK; gerlan@mba.ac.uk

Ian Probert
Station Biologique de Roscoff, 29680 Roscoff, France; probert@sb-roscoff.fr

Colin Brownlee
The Marine Biological Association of the United Kingdom, Plymouth PL 1 2PB, UK; cbr@mba.ac.uk

Charlotte E. Walker
The Marine Biological Association of the United Kingdom, Plymouth PL1 2PB, UK; chawal@mba.ac.uk

Glen L. Wheeler
The Marine Biological Association of the United Kingdom, Plymouth PL1 2PB, UK; glw@mba.ac.uk

Some coccolithophores, such as *Coccolithus braarudii*, need silicon in order to grow and to calcify, while others, such as *Emiliania huxleyi*, do not. Here we present a survey of a number of species across the phylogenetic tree that shows a distinct cluster-pattern of species that require silicon and those that do not. The specific reason for coccolithophore silicon requirement is still unknown. We show that silicon plays a key role in coccolith morphogenesis and argue that some morphogenetic processes can be excluded as the site of silicon action.

Sedimentary mechanisms for the late Miocene deep-sea nannofossil oozes from the South China Sea

Chuanlian Liu
Tongji University, State Key Laboratory of Marine Geology, Shanghai, 200092; liucl@tongji.edu.cn

Xinquan Zhou
Tongji University, State Key Laboratory of Marine Geology, Shanghai, 200092; 54zhouxq@tongji.edu.cn

Hongrui Zhang
Tongji University, State Key Laboratory of Marine Geology, Shanghai, 200092; 103443_rui@tongji.edu.cn

Zhifei Liu
Tongji University, State Key Laboratory of Marine Geology, Shanghai, 200092; lzhifei@tongji.edu.cn

There are many carbonate layers within the upper Miocene and Pliocene cores at IODP Site U1433, located on the southwest subbasin (SWSB) of the South China Sea (SCS) at a water depth of 4379m. In our study of the calcium carbonate content and calcareous nannofossil assemblages of the late Miocene samples from the core, we were able to provide additional evidence for a turbidity current genesis of the carbonate layers that was suggested by the on-board scientists. The carbonates were deposited by a rapid transportation process that resulted in the sorting of various carbonate particles in the individual layers. The clay sediments were useful for biostratigraphy and paleoenvironment studies.

We also revised the calcareous nannofossil biostratigraphy using the clay samples and constructed an age model for the late Miocene from about 10 to 5.3Ma. The results show that the components of the carbonate turbidites changed during the late Miocene, which probably reflects a change in the source area. We suggest that the source sediments of the carbonate turbidites were periplatform ooze mixed with neritic and pelagic carbonate particles. Changing water conditions and climate can cause alternation of periplatform ooze components because neritic and pelagic productivity have inverse responses. This situation is confirmed by our study of nannofossil assemblages in the clays. We suggest that the upper water conditions of the SWSB and southern SCS were similar during the late Miocene and changed from strongly stratified conditions to well mixed conditions and thus to increased pelagic productivity. Furthermore, subsidence can decrease the size of the platform and decrease the neritic production. Consequently, we suggest that the upper Miocene carbonate layers were transported by turbidity currents from a slope area whose sediments were a mixture of neritic and pelagic components.

This research was supported by the National Natural Science Foundation of China (No: 41530964, 91428309).

References

Li, C.-F., Lin, J. & Expedition 349 Scientists. 2015. Expedition 349 summary. *In* C.-F. Li, J. Lin, D.K. Kulhanek & the Expedition Scientists. *Proceedings of the International Ocean Discovery Program* 349.

Wang, P. & Li, Q. (Eds) 2009. *The South China Sea: paleoceanography and sedimentology*. Springer, Berlin: 506pp.

Middle Pleistocene transition mechanisms and calcareous nannofossils at ODP Site 1209 (NW Pacific Ocean)

Claudia Lupi
Università degli Studi di Pavia, Dipartimento di Scienze della Terra e dell'Ambiente, Pavia, Italy; claudia.lupi@unipv.it

Manuela Bordiga
Uppsala University, Department of Earth Sciences, Uppsala, Sweden; bordiga.manuela@gmail.com

Roberto Sacchi
Università degli Studi di Pavia, Dipartimento di Scienze della Terra e dell'Ambiente, Pavia, Italy; roberto.sacchi@unipv.it

Miriam Cobianchi
Università degli Studi di Pavia, Dipartimento di Scienze della Terra e dell'Ambiente, Pavia, Italy; miriam@unipv.it

The middle Pleistocene transition (MPT; 1.25–0.65Myr; Raymo *et al*., 2004; Clark *et al*., 2006) represents an important reorganization of the climate that switched from a 41kyr periodicity to a quasi-periodic 100kyr cycle. Despite decades of studies, a solution to the mechanisms driving this revolution is still unclear, and more studies are needed.

The high resolution and good preservation of the sedimentary record recovered at Ocean Drilling Program (ODP) Site 1209 offered the opportunity to investigate the climate and oceanographic evolution of the NW Pacific Ocean during this key time interval. The study of calcareous nannofossil content in 212 samples during the last 1.3Myr revealed a complex distribution of the assemblages through time. We performed a permutational multivariate analysis of variance (PERMANOVA) on the nannofossil dataset to investigate whether the temporal distribution of samples depends on: (1) specific age of each sample, (2) climate phases (i.e., glacial or interglacial), or (3) MPT interval (pre/during/post-MPT). With PERMANOVA, we formulated and tested these three alternative distribution models and determined that dependence on the MPT effect explained 28% of total variance. Moreover, the canonical analysis revealed that, while the first component regulating the sample distribution could be dependent on the climate system, the second one could be represented by the intrinsic property of the assemblages.

References

Clark, P.U., Archer, D., Pollard, D., Blum, J.D., Rial, J.A., Brovkin, V., Mix, A.C., Pisias, N.G. & Roy, M. 2006. The middle Pleistocene transition: characteristics, mechanisms, and implications for long-term changes in atmospheric pCO_2. *Quaternary Science Reviews*, **25**: 3150–3184.

Raymo M.E., Oppo, D.W., Flower, B.P., Hodell, D.A., McManus, J.F., Venz, K.A., Kleiven, K.F. & McIntyre, K. 2004. Stability of North Atlantic water masses in face of pronounced climate variability during the Pleistocene. *Paleoceanography*, **19**(2). DOI: 10.1029/2003PA000921.

Evidence of the Faraoni Oceanic Anoxic Event in the Zagros Basin, West of Iran

Azam Mahanipour

Assistant Professor, Department of Geology, Faculty of Science, Shahid Bahonar University of Kerman, Kerman, Iran; A_mahanipour@uk.ac.ir

Katayon Barmakizadeh

[2]Master of Science, Department of Geology, Faculty of Science, Shahid Bahonar University of Kerman, Kerman, Iran; katayoon.barmakizadeh@gmail.com

The latest Hauterivian Faraoni Oceanic Anoxic Event is associated with environmental changes, some perturbations in the carbon cycle, biotic changes and deposition of organic rich sediments (e.g., Baudin *et al*., 2006; Föllmi *et al*., 2012). This event is reported from Italy, the southern Swiss Alps, the Vocontian Basin in France, Spain, Portugal, Morocco and the North Sea area (Mutterlose & Ruffell, 1999; Bersezio *et al*., 2002; Baudin, 2005; Company *et al*., 2005; Tremolada *et al*., 2009). In the present study, we use calcareous nannofossils to investigate sediments of the upper Hauterivian interval from the Garau Formation in the Zagros Basin (West of Iran). The main aim of this work is to identify the Faraoni Oceanic Anoxic Event by using calcareous nannofossils.

The studied interval mainly consists of grey to green marls, marly limestones, black shales and limestones. According to the Roth (1978) zonation, emended by Bralower *et al*. (1995), the NC5a, NC5b and NC5c subzones are recorded at the Upper Hauterivian sediments of the studied interval. An increasing trend in the number of *Micrantholithus* spp. and *Nannoconus* spp. has been observed from NC5a to the middle part of NC5b. Then, a decreasing trend in the abundance of both groups is recorded simultaneously with the LO of *Lithraphidites bollii* in marly-shaly layers, which can be the sign of the Faraoni event in similar studies in other parts of the world (e.g., Tremolada *et al*., 2009). Again, a peak in *Micrantholithus* spp. abundance, along with an increasing trend in the number of *Nannoconus* spp. has been observed. From the middle part of NC5b to the lower part of NC5c, an increasing trend in the number of eutrophic taxa and a decreasing trend in the number oligotrophic taxa have been recorded. Simultaneously, an increasing trend in the number of warm water taxa and a decreasing trend in the number of cool water taxa have been observed.

References

Baudin, F. 2005. A Late Hauterivian short-lived anoxic event in the Mediterranean Tethys: the 'Faraoni Event'. *Comptes Rendus Geoscience*, **337**(16): 1532–1540.

Baudin, F., Busnardo, R., Beltran, C., de Rafelis, M., Renard, M., Charollais, J. & Clavel, B., 2006. Enregistrement de l'événement anoxique Faraoni (Hauterivien supérieur) dans le domaine ultrahelvétique. *Revue de Paléobiologie*, **25**, 525–535.

Bersezio, R., Erba, E., Gorza, M. & Riva, A. 2002. Berriasian–Aptian black shales of the Maiolica formation (Lombardian Basin, Southern Alps, Northern Italy): local to global events. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **180**: 253–275.

Bralower, T.J., Leckie, R.M., Sliter, W.V. & Thierstein, H.R. 1995. An integrated Cretaceous microfossil biostratigraphy. *SEPM Special Publications*, **54**: 65–79.

Company, M., Aguado, R., Sandoval, J., Tavera, J.M., de Cisneros, C.J. & Vera, J.A. 2005. Biotic changes linked to a minor anoxic event (Faraoni Level, latest Hauterivian, Early Cretaceous). *Palaeogeography, Palaeoclimatology, Palaeoecology*, **224**(1): 186–199.

Föllmi, K.B., Bôle, M., Jammet, N., Froidevaux, P., Godet, A., Bodin, S., Adatte, T., Matera, V., Fleitmann, D. & Spangenberg, J.E. 2012. Bridging the Faraoni and Selli oceanic anoxic events: late Hauterivian to early Aptian dysaerobic to anaerobic phases in the Tethys. *Climate of the Past*, **8**: 171–189.

Mutterlose, J. & Ruffell, A. 1999. Milankovitch-scale palaeoclimate changes in pale–dark bedding rhythms from the Early Cretaceous (Hauterivian and Barremian) of eastern England and northern Germany. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **154**(3): 133–160.

Roth, P.H. 1978. Cretaceous nannoplankton biostratigraphy and oceanography of the northwestern Atlantic ocean. *Initial Reports of the DSDP*, **44**: 731–759.

Tremolada, F., Erba, E., de Bernardi, B. and Cecca, F. 2009. Calcareous nannofossil fluctuations during the late Hauterivian in the Cismon core (Venetian Alps, northeastern Italy) and in selected sections of the Umbria-Marche Basin (central Italy): paleoceanographic implications of the Faraoni Level. *Cretaceous Research*, **30**: 505–514.

The first record of the mid-Barremian Oceanic Anoxic Event in the Zagros Basin: evidence from calcareous nannofossils

Azam Mahanipour

Assistant Professor, Department of Geology, Faculty of Science, Shahid Bahonar University of Kerman, Kerman, Iran; A_mahanipour@uk.ac.ir

Maryam Eftekhari

Master of Science, Department of Geology, Faculty of Science, Shahid Bahonar University of Kerman, Kerman, Iran; maryameftekharii@yahoo.com

One of the Mid-Cretaceous Oceanic Anoxic Events is the mid-Barremian Oceanic Anoxic Event, which is recorded from different basins along the northern proto-central Atlantic margins and the Tethys Ocean (Godet *et al*., 2006; Malkoč & Mutterlose, 2010; Yilmaz *et al*., 2012; Huck *et al*., 2013). This event is associated with major changes in the ocean-climate system, such as warming, eutrophication and $\delta^{13}C$ excursions (e.g., Coccioni *et al*., 2003; Godet *et al*., 2006; Mutterlose *et al*., 2009, 2010; Huck *et al*., 2013; Aguado *et al*., 2014). Sediments of the Barremian interval have been analyzed from the Garau Formation in the Zagros Basin which is part of the Neo-Tethys Ocean (west of Iran). The aim of the present study is to document the presence of the mid-Barremian Event (MBE) based on calcareous nannofossil biostratigraphy and paleoecology.

The studied interval mainly consists of green to gray marls, marly limestones, marly shales, black shales and limestones. According to the index calcareous nannofossils, the NC5 biozone of Roth (1978), emended by Bralower *et al*. (1995), is recorded and divided into NC5C, NC5D and NC5E subzones.

Fluctuations in surface water fertility and temperature can be assessed by analyzing changes in nutrient and temperature indices for calcareous nannofossil. In the present study, species such as *Micrantholithus* spp., *Lithraphidites carniolensis*, *Diazomatolithus lehmanii*, *Cyclagelosphaera margerelii*, *Nannoconus* spp., *Rhagodiscus asper* and *Watznaueria barnesiae* are considered as warm water taxa and *Biscutum constans*, *Helenea chiastia* and *Zeugrhabdotus embergeri* are regarded as cool water taxa. An increasing trend in the number of warm water taxa can be observed in NC5D that can be a signal of the mid-Barremian warming event. An increasing trend in the number of eutrophic taxa is also recorded from the middle part of NC5D, which can also be a sign of the MBE, similar to other parts of the world, e.g., southern Spain (Aguado *et al*., 2014).

References

Aguado, R., de Gea, G.A. & O'Dogherty, L. 2014. Integrated biostratigraphy (calcareous nannofossils, planktonic foraminifera, and radiolarians) of an uppermost Barremian–lower Aptian pelagic succession in the Subbetic Basin (southern Spain). *Cretaceous Research*, **51**: 153–173.

Bralower, T.J., Leckie, R.M., Sliter, W.V. & Thierstein, H.R. 1995. An integrated Cretaceous microfossil biostratigraphy. *SEPM Special Publications*, **54**: 65–79.

Coccioni, R., Galeotti, S. & Sprovieri, M. 2003. The Mid-Barremian Event (MBE): the prelude to the OAE1a. *American Geophysical Union*, Fall Meeting, Abstracts.

Godet, A., Bodin, S., Föllmi, K.B., Vermeulen, J., Gardin, S., Fiet, N., Adatte, T., Berner, Z., Stüben, D. & Van de Schootbrugge, B. 2006. Evolution of the marine stable carbon-isotope record during the early Cretaceous: a focus on the late Hauterivian and Barremian in the Tethyan realm. *Earth and Planetary Science Letters*, **242**: 254–271.

Huck, S., Heimhofer, U., Immenhauser, A. & Weissert, H. 2013. Carbon-isotope stratigraphy of Early Cretaceous (Urgonian) shoal-water deposits: Diachronous changes in carbonate-platform production in the north-western Tethys. *Sedimentary Geology*, **290**: 157–174.

Malkoč, M. & Mutterlose, J. 2010. The early Barremian warm pulse and the late Barremian cooling: a high-resolution geochemical record of the Boreal Realm. *Palaios*, **25**(1): 14–23.

Mutterlose, J., Malkoc, M., Schouten, S., Damsté, J.S.S. & Forster, A. 2010. TEX 86 and stable $\delta^{18}O$ paleothermometry of early Cretaceous sediments: implications for belemnite ecology and paleotemperature proxy application. *Earth and Planetary Science Letters*, 298: 286–298.

Mutterlose, J., Pauly, S. & Steuber, T. 2009. Temperature controlled deposition of early Cretaceous (Barremian–early Aptian) black shales in an epicontinental sea. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **273**: 330–345.

Roth, P.H. 1978. Cretaceous nannoplankton biostratigraphy and oceanography of the northwestern Atlantic ocean. *Initial Reports of the DSDP*, **44**: 731–759.

Yilmaz, I.O., Altiner, D., Tekin, U.K. & U Ocakoglu, F. 2012. The first record of the "Mid-Barremian" Oceanic Anoxic Event and the Late Hauterivian platform drowning of the Bilecik platform, Sakarya Zone, western Turkey. *Cretaceous Research*, **38**: 16–39.

Extant *Stephanocha speculum* from the Ross Sea: abundance, morphologies, and double skeletons

Elisa Malinverno

Università degli Studi di Milano-Bicocca, Dipartimento di Scienze dell'Ambiente e della Terra, 20126 Milano, Italy; elisa.malinverno@unimib.it

Extant silicoflagellate populations were analyzed with light and scanning electron microscopes from water samples collected with a CTD Rosette in the photic zone of the western Ross Sea during the twentieth Italian oceanographic expedition on board the R/V *Italica* (January-February 2005).

Silicoflagellates were exclusively represented by *Stephanocha speculum* (Ehrenberg) McCartney and Jordan 2015. They showed highest concentrations (up to 20×10^3 cells l^{-1}) in the upper 50m, which roughly corresponds to the thermocline depth, and after this concentrations rapidly decreased with depth. Integrated abundances were highest in the offshore region and decreased towards the coast with a slight increase at coastal stations.

Several morphologies of *Stephanocha speculum* were observed and counted, following the morphotypes described by Van der Spoel *et al*. (1973) and Malinverno (2010). The most common morphologies were represented by 6-sided skeletons with a large apical ring and fully coronatid ornamentation. Additional morphologies included 5-7-8-sided forms, variable apical ring width, a bipartite apical ring, and aberrant forms with a deformed apical ring, open basal ring, and forked spines. Double skeletons, which represent the division phase with two individuals still attached at the abapical surface (McCartney *et al*., 2014), were abundant at shallow water depths. Pairs were mainly represented by identical individuals, with some exceptions (Figure 1) that confirm the strong intraspecific variability of this species.

References

Malinverno, E. 2010. Extant morphotypes of *Distephanus speculum* (Silicoflagellata) from the Australian sector of the Southern Ocean: Morphology, morphometry and biogeography. *Marine Micropaleontology*, **77**: 154–174.

McCartney, K., Witkowski, J., Jordan, R., Daugbjerg, N., Malinverno, E., van Wezel, R., Kano, H., Abe, K., Scott, F., Schweizer, M., Young, J., Hallegraeff, G. & Shiozawa, A. 2014. Fine structure of silicoflagellate double skeletons. *Marine Micropaleontology*, **113**: 10–19.

Van der Spoel, S., Hallegraeff, G.M. & Van Soest, R.W.M. 1973. Notes on variations of diatoms and silicoflagellates in the South Atlantic Ocean. *Netherlands Journal of Sea Research* **6**(4): 518–541.

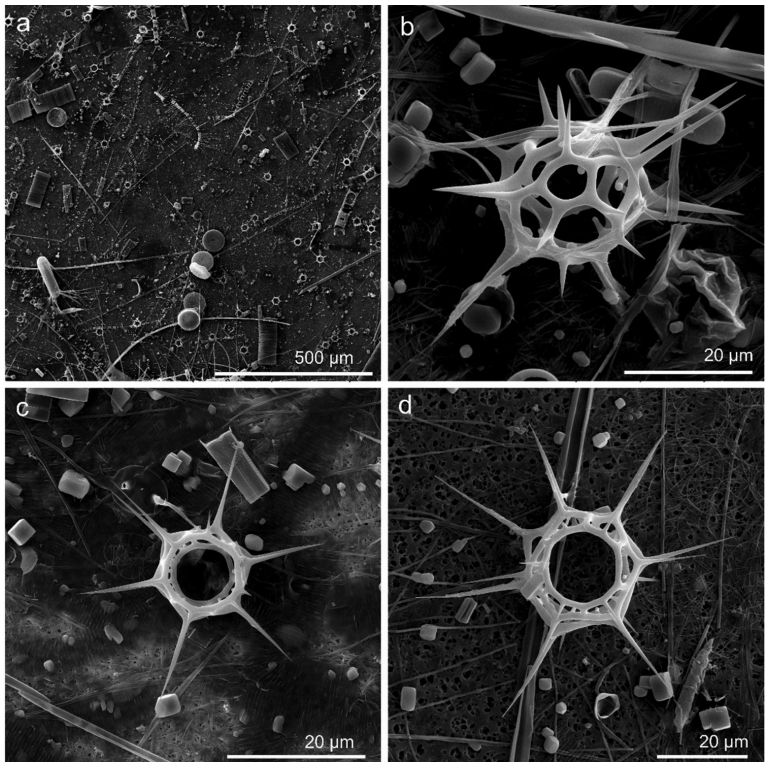


Figure 1: a) Several specimens of *S. speculum* as collected on the filter; b) 6-sided double skeleton (lateral view); c) double skeleton (apical axis view): two specimens with different apical ring width; d) double skeleton (apical axis view): 6-sided and 7-sided specimens

Integrated biostratigraphy and geochronology of sedimentary successions in the East Pisco Basin that crop out on the western side of the Ica River Valley (Ocucaje, Peru)

Elisa Malinverno
Università degli Studi di Milano-Bicocca, Dipartimento di Scienze dell'Ambiente e della Terra, 20126 Milano, Italy; elisa.malinverno@unimib.it

Giulia Bosio
Università degli Studi di Milano-Bicocca, Dipartimento di Scienze dell'Ambiente e della Terra, 20126 Milano, Italy; g.bosio@campus.unimib.it

Karen Gariboldi
Università degli Studi di Pisa, Dipartimento di Scienze della Terra, 56126 Pisa, Italy; karen.gariboldi@for.unipi.it

Anna Gioncada
Università degli Studi di Pisa, Dipartimento di Scienze della Terra, 56126 Pisa, Italy; anna.gioncada@unipi.it

Claudio Di Celma
Università di Camerino, Scuola di Scienze e Tecnologie, Camerino, Italy; claudio.dicelma@unicam.it

Igor M. Villa
Università degli Studi di Milano-Bicocca, Dipartimento di Scienze dell'Ambiente e della Terra, 20126 Milano, Italy; igor.villa@unimib.it

Mario Urbina
Museo de Historia Natural-UNMSM, Departamento de Paleontologia de Vertebrados, Lima, Peru; mariourbina01@hotmail.com

Giovanni Bianucci
Università degli Studi di Pisa, Dipartimento di Scienze della Terra, 56126 Pisa, Italy; giovanni.bianucci@unipi.it

Fossil marine vertebrates are abundant and well preserved in the sedimentary succession in the East Pisco Basin that Dunbar *et al*. (1990) and DeVries (1998) divided into four unconformity-bounded units: the middle-upper Eocene Paracas Formation, the uppermost Eocene-lower Oligocene Otuma Formation, the uppermost Oligocene-lower Miocene Chilcatay Formation, and the upper Miocene-Pliocene Pisco Formation.

During the Italian PRIN project, accurate field mapping (Di Celma *et al*., 2016a and b, 2017) and detailed measurement of outcrop sections enabled the collection of sediment and volcanic ash samples for biostratigraphic and Ar-Ar dating (Gariboldi *et al*., in press).

Calcareous nannofossils now constrain the Eocene section to Zones NP18-20 with the FO of *Isthmolithus recurvus* occurring at mid-section, which is consistent with the rare silicoflagellates, including *Naviculopsis foliacea*, that are present. Silicoflagellates assigned the base of the Chilcatay Formation to the early Miocene, so upper Oligocene deposits are missing in the study area. The lower lithogenic portion is assigned to the silicoflagellate *Naviculopsis ponticula* Zone (19–18Ma), which is consistent with the presence of *Discoaster druggii* among the rare calcareous nannofossils, the diatom *Raphidodiscus marylandicus* (LO at ~16.7Ma), and Ar-Ar dating of 18.80 ± 0.06Ma. The upper diatomaceous portion is assigned to the silicoflagellate *Cannopilus schulzii* Subzone (18–13.5Ma) of the *Corbisema triacantha* Zone, and the diatoms *Coscinodiscus lewisianus* and *Cestodiscus pulchellus* confirm an upper age of >14Ma. The scarce calcareous nannofossils are represented by long-ranging Oligocene-Miocene species, and *Helicosphaera carteri* (FO at ~23Ma) is the youngest species present. Ar-Ar dating of an ash layer close to the section top provided an age of 17.99 ± 0.10Ma (Di Celma *et al*., 2017). The overlying Pisco Formation has been recently subdivided into three unconformity-bounded depositional sequences (P0, P1, and P2, from oldest to youngest; Di Celma *et al*., 2017) and constrained by diatoms and Ar-Ar dating (Gariboldi *et al*., in press) to <17Ma, 9.5–8.5Ma, and 8.5–6.71Ma, respectively. No calcareous nannofossils and rare silicoflagellates were observed in the diatomaceous Pisco Formation.

References

DeVries T.J. 1998. Oligocene deposition and Cenozoic sequence boundaries in the Pisco Basin (Peru). *Journal of South American Earth Sciences*, **11**: 217–231.

Di Celma, C., Malinverno, E., Bosio, G., Collareta, A., Gariboldi, K., Gioncada, A., Molli, G., Basso, D., Varas-Malca, R.M.,

Pierantoni, P.P., Villa, I.M., Lambert, O., Landini, W., Sarti, G., Cantalamessa, G., Urbina, M. & Bianucci, G. 2017. Sequence stratigraphy and paleontology of the upper Miocene Pisco Formation along the western side of the lower Ica River Valley (Ica Desert, Peru). *Rivista Italiana di Paleontologia e Stratigrafia*, **123**(2): 255–274.

Di Celma, C., Malinverno, E., Cantalamessa, G., Gioncada, A., Bosio, G., Villa, I.M., Gariboldi, K., Rustichelli, A., Pierantoni, P.P., Landini, W., Tinelli, C., Collareta, A. & Bianucci, G. 2016b. Stratigraphic framework of the late Miocene Pisco Formation at Cerro Los Quesos (Ica Desert, Peru). *Journal of Maps*, **12**(6): 1020–1028.

Di Celma, C., Malinverno, E., Gariboldi, K., Gioncada, A., Rustichelli, A., Pierantoni, P.P., Landini, W., Bosio, G., Tinelli, C. & Bianucci, G. 2016a. Stratigraphic framework of the late Miocene to Pliocene Pisco Formation at Cerro Colorado (Ica Desert, Peru). *Journal of Maps*, **12**(3): 515–529.

Dunbar, R.B., Marty, R.C. & Baker, P.A. 1990. Cenozoic marine sedimentation in the Sechura and Pisco Basins, Peru. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **77**: 235–261.

Gariboldi, K., Bosio, G., Malinverno, E., Gioncada, A., Di Celma, C., Villa, I.M., Urbina, M. & Bianucci, G. In press. Biostratigraphy, geochronology and sedimentation rates of the upper Miocene Pisco Formation at two important marine vertebrate fossil-bearing sites of southern Peru. *Newsletters on Stratigraphy*.

Time series of silicoflagellates and ebridians in the eastern Mediterranean and Black Seas

Elisa Malinverno

University of Milano-Bicocca, Dipartimento di Scienze dell'Ambiente e della Terra, Milan, Italy; elisa.malinverno@unimib.it

Boris Theofanis Karatsolis

National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; bkaratsolis@gmail.com

Maria V. Triantaphyllou

National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; mtriant@geol.uoa.gr

Federica Cerino

OGS Istituto Nazionale di Oceanografia e di Geofisica Sperimentale, Sezione di Oceanografia, Trieste, Italy; fcerino@inogs.it

Silicoflagellates and ebridians represent a minor component of siliceous plankton in the oceans but are known to be very sensitive to environmental factors that control species' distribution and the occurrence of peculiar morphological characters.

Here, we show the seasonal and interannual variability in abundance and assemblage composition of silicoflagellates and ebridians. Samples were collected from monthly water sampling in the Gulf of Trieste (northern Adriatic Sea, L-TER C1 stations 45°42′2″N, 13°42′36″E, from May 2011 to February 2013) and fluxes from sediment traps at a mooring station offshore Crete (35°30′N, 23°40′E from June 2005 to May 2006; Malinverno *et al.*, 2009), a mooring station in the pelagic Ionian Sea (35°13′N, 21°30′E from September 1999 to May 2000), and a mooring station in the Black Sea (42° 58′00″N, 29°29′00″E from October 2007 to September 2008; (Triantaphyllou *et al*., 2014)).

Among silicoflagellates, *Dictyocha stapedia* Haeckel 1887 is the most abundant species in both coastal (Gulf of Trieste, off Crete) and pelagic (Ionian Sea) settings, followed by *D. aculeata* (Lemmermann) Dumitrica 1973, where *Stephanocha speculum* (Ehrenberg) McCartney and Jordan 2015 is rare. The latter is, in contrast, the dominant species in the Black Sea throughout the year. *Octactis pulchra* Schiller 1925 is seasonally abundant in the coastal North Adriatic and in the Black Sea but is absent from the Ionian Sea. Ebridians are absent from the pelagic Ionian Sea but are seasonally significant in the coastal northern Adriatic and in the Black Sea, with *Ebria tripartita* showing its maxima in winter-spring and *Hermesinum adriaticum* in summer.

Observations and preliminary morphometric analyses revealed a wide size spectrum for *D. stapedia* and significant variations in the morphological characters of *S. speculum*, as already observed in populations from the northern Aegean Sea under the influence of low-salinity Black Sea water (Malinverno *et al*., 2016).

References

Malinverno, E., Karatsolis, B.T., Dimiza, M.D., Lagaria, A., Psarra, S. & Triantaphyllou, M.V. 2016. Extant silicoflagellates from the Northeast Aegean (eastern Mediterranean Sea): Morphologies and double skeletons. *Revue de Micropaléontologie*, **59**: 253–265.

Malinverno, E., Triantaphyllou, M.V, Stavrakakis, S., Ziveri, P. & Lykousis, V. 2009. Seasonal and spatial variability of coccolithophore export production at the south-western margin of Crete (eastern Mediterranean). *Marine Micropaleontology*, **71**: 131–147.

Triantaphyllou, M.V., Malinverno, E., Dimiza, M.D., Gogou, A., Athanasiou, A., Skampa, E., Tselenti, D., Thanassoura, E., Birli, A., Stavrakaki, I., Stavrakakis, S., Corselli, C. & Lykousis, V. 2014. Coccolithophore biogeographic trends and export production in the Eastern Mediterranean and Black Seas. *Journal of Nannoplankton Research*, **34**: 97–98.

Late Holocene events in the Sibuyan Sea, Philippines, based on calcareous nannofossils, granulometry, and sediment geochemistry

Dorothy Joyce Marquez
University of the Philippines, National Institute of Geological Sciences, Diliman, Quezon City, Philippines, 1101; ddmarquez@up.edu.ph

Alyssa M. Peleo-Alampay
University of the Philippines, National Institute of Geological Sciences, Diliman, Quezon City, Philippines, 1101; ampeleoalampay@up.edu.ph

Zhifei Liu
Tongji University, State Key Laboratory of Marine Geology, Shanghai 200092, China; lzhifei@tongji.edu.cn

This study compares core sediments from the northern (Cores GC4A and MC4-2) and southern (Core GC3A) sub-basins of the Sibuyan Sea that were collected during PhilEx Magellan expedition onboard the RV *Melville*. Relative and absolute nannofossil abundances were calculated from raw counts and then correlated with grain size data that was measured using laser particle size analysis and major oxide percentages and elemental ratios that were measured by X-ray fluorescence spectrometry.

The nannofossil assemblage was comprised mainly of *Gephyrocapsa oceanica* and *Florisphaera profunda*. The total nannofossil abundance was generally higher in the northern sub-basin. The lower nannofossil abundance in the southern sub-basin may be due to higher terrigenous input as evidenced by higher $\%Al_2O_3$, $\%Fe_2O_3$, $\%SiO_2$, and %MgO. In the northern sub-basin, total nannofossil and *G. oceanica* abundances were inversely correlated with $\%Al_2O_3$, $\%Fe_2O_3$, and $\%SiO_2$. The precipitation and run-off proxy, %Ti, followed the trend of these three major oxides, a further indication that increased rainfall and subsequent increase in terrigenous input resulted in lower nannoplankton productivity during these periods.

%Major oxide and %Ti decreased in both basins from 500–600cal YBP to 300–400cal YBP to 200–300cal YBP, which coincides with known insolation anomalies within the Little Ice Age (LIA, 200–600cal YBP). Furthermore, the southern sub-basin also revealed an abrupt decrease in grain size from 500–600cal YBP to 200–300cal YBP to 100–200cal YBP, and finally to 50–100cal YBP. Ni/Co, a bottom-water oxygenation proxy, revealed that the southern basin was always oxygenated and that the northern basin was anoxic from the LIA (~300cal YBP) to present. On the other hand, the northern basin shifted from being dysoxic to oxic during the Medieval Warm Period (MWP, ~700–1000cal YBP).

Possible local events may have occurred during the intervals 1,200–1,400cal YBP, 1,600–1,800cal YBP, and 2,100–2,300cal YBP as shown by abrupt shifts in calcareous nannofossil abundance, grain size, % major oxides, and %Ti and Ni/Co. These variations in productivity, sedimentation, and oxygenation were influenced by changes in monsoon strength through time.

Productivity and North Atlantic subpolar dynamics at orbital-to-millennial scales during middle Pleistocene Marine Isotope Stages 19-11

Marta Martínez-Sánchez

Universidad de Salamanca, Departamento de Geología, 370008 Salamanca, Spain; marta.martinez@usal.es

José-A. Flores

Universidad de Salamanca, Departamento de Geologia, Facultad de Ciencias, 37008 Salamanca, Spain; flores@usal.es

Francisco J. Sierro

Universidad de Salamanca, Departamento de Geología, Facultad de Ciencias, 37008 Salamanca, Spain; sierro@usal.es

Montserrat Alonso-García

Universidad de Salamanca, Departamento de Geología, 37008 Salamanca, Spain; Instituto Portugues do Mar e da Atmosfera (IPMA), 1495-006 Lisboa, and Universidade do Algarve, Centro de Ciências do Mar (CCMAR), 8005-139 Faro, Portugal; montserrat.alonso@ipma.pt

Quantitative coccolithophore analyses were performed on sediments from IODP Site U1314, located in the subpolar North Atlantic, in order to reconstruct sea surface water conditions throughout Marine Isotope Stages (MIS) 19c to 11c. The data were compared to available paleoenvironmental proxies from the same site, as well as other nearby North Atlantic records that support the coccolithophore signature at glacial-interglacial and millennial scales. Total coccolithophore absolute abundance increased during interglacials and interstadials but abruptly dropped during the colder glacial and stadial phases, indicating clear changes in productivity.

Coccolithophore interglacial assemblages indicated low productivity during early MIS 11, late MIS 13a, MIS 15b, and some intervals in MIS 17. We attributed these intervals of lower productivity to a reduced influence of the Irminger Current over the study area.

At MIS 18, 16, 12b and 12a, the coccolithophore absolute abundances were close to zero, and the distinctive increase in cold-water proxies from other studies marked the presence of polar waters in the area at a time when iceberg melting was significantly enhanced.

Millennial-scale abrupt changes in productivity are related to ice-rafting events and the subsequent interstadials. During the stadial phase, productivity values were low, which is concomitant with increases in the polar foraminifera, indicating the presence of cold and low salinity water in the region. In contrast during the interstadial, productivity rose rapidly following the sea surface temperature shift.

Calcareous nannofossils from the Upper Triassic-Lower Jurassic of Lurestan (Iran): preliminary data

Mariarosaria Martino
Università degli Studi di Napoli, Dipartimento di Scienze della Terra, 80138 Naples, Italy; mariarosaria.martino@unina.it

Cinzia Bottini
Università degli Studi di Milano, Dipartimento di Scienze della Terra, 20133 Milano, Italy; cinzia.bottini@unimi.it

Elisabetta Erba
Università degli Studi di Milano, Dipartimento di Scienze della Terra, 20133 Milan, Italy; elisabetta.erba@unimi.it

Davoud Morsalnejad
National Iranian Oil Company (Nioc), Tehran, Iran; morsalnejad@gmail.com

Mariano Parente
Università degli Studi di Napoli, Dipartimento di Scienze della Terra, 80138 Naples, Italy; maparent@unina.it

In the Zagros fold and thrust belt of Iran, Upper Triassic-Lower Jurassic rocks are widely exposed only in north Lurestan, which is close to the Iran-Iraq border. Biostratigraphic data for this interval are very poor, and correlations with other areas of the Arabian Plate are mainly based on lithostratigraphy. Consequently, sequence stratigraphic interpretations that attempt to extend the standard chrono-sequence stratigraphy of the Arabian Plate (Sharland *et al*., 2004) to this region are highly uncertain and speculative. One of the main uncertainties is the position of the Triassic-Jurassic boundary, which is either placed at the boundary between the Baluti Shale and the Sarki Formation or within the lowermost part of the Sarki Formation (i.e., Aqrawi *et al*., 2010).

In this work, we present the first data on the calcareous nannoplankton distribution in the Baluti Shale and the Sarki Formation. The studied samples came from a key section exposed northwest of the village of Dudan. According to our data, the upper part of the Baluti Shale is of Late Triassic (Rhaetian) age. Thus, the Triassic-Jurassic boundary is located within the Sarki Formation at a level bracketed by the last occurrence of Late Triassic nannofossils, including *Prinsiosphaera triassica* Jafar, and the first occurrence of *Schizosphaerella punctulata* Deflandre & Dangeard. This sequence of nannofossil bioevents is consistent with those recently documented in the Southern Alps by Bottini *et al*. (2016).

References

Aqrawi, A.A.M, Goff, J.C., Horbury, A.D. & Sadooni, F.N. 2010. *The Petroleum Geology of Iraq*. Scientific Press Ltd, Beaconsville, U.K.: 424pp.

Bottini, C., Jadoul, F., Rigo, M., Zaffani, M., Artoni, C. & Erba, E. 2016. Calcareous nannofossils at the Triassic/Jurassic boundary: stratigraphic and paleoceanographic characterization. *Rivista Italiana di Paleontologia e Stratagrafia*, **122**(3): 141–164.

Sharland, P.R., Casey, D.M. & Davies, R.B. 2004. Arabian Plate Sequence Stratigraphy - revision to SP2. *Geoarabia*, **371**: 199–214.

Dating paleontological collections that contain poorly documented specimens

Isabel Matias

Museu de Geologia de Barcelona-MCNB, Dpt. de Palaeontologia, 08003 Barcelona, Spain; mmatias@xtec.cat

Jaume Gallemí

Museu de Geologia de Barcelona-MCNB, Dpt. de Palaeontologia, 08003 Barcelona, Spain; jgallemi@bcn.cat

Natural History Museums often have specimens in their paleontological collections, sometimes even holotypes, whose biostratigraphy, for various reasons, is not always well established. Either the fossil site has disappeared, the precise location is not accurately known, the age is just presumed or attributed but not justified, or specimens are only given a chronostratigraphic stage or preferable, a geological level or formation. These facts may present serious difficulties for specialists undertaking systematic, phylogenetic, and/or biostratigraphic studies.

Calcareous nannofossils are currently demonstrating their usefulness in solving such difficulties by combining their value as biostratigraphic markers and the small amount of sample needed for their study. To date, ten samples of sediment associated with Mesozoic (Jurassic and Cretaceous) fossil echinoids belonging to the Museu de Geologia de Barcelona, Museo Paleontológico de Elche (both in Spain), and Université Claude Bernard-Lyon 1 (France) have been analyzed. A smear slide was prepared from each sample, and a minimum of 300 coccoliths was counted. A number of additional transects were made to check for rare occurrences of biostratigraphic markers. Zones NJT 15b, NJT 17a, and NJT 17b of Castellato (2010) and Zones UC5 and UC7 of Burnett (1998) were recognized. The results allowed us to give precise dates to the samples, thus increasing the interest of the museums' paleontology departments for continuing this type of study.

References

Burnett, J.A. 1998. Upper Cretaceous. *In:* P.R. Bown (Ed.). *Calcareous Nannofossil Biostratigraphy*. British Micropalaeontolical Society Publication Series. Chapman and Hall/Kluwer Academic Publishers, London: 132–199.

Casellato, C.E. 2010. Calcareous nannofossil biostratigraphy of Upper Callovian-Lower Berriasian successions from Southern Alps, North Italy. *Rivista Italiana di Paleontologia e Stratigrafia,* **116**: 357–404.

Calcareous nannoplankton in a changing paleoworld, a tale of size variations

Emanuela Mattioli

Université de Lyon, Université Claude Bernard Lyon 1, ENS de Lyon, CNRS, UMR 5276 LGL-TPE, F-69622 Villeurbanne, France; emanuela.mattioli@univ-lyon1.fr

Barbara Gollain

Université de Lyon, Université Claude Bernard Lyon 1, ENS de Lyon, CNRS UMR 5276 LGL-TPE, F-69622 Villeurbanne, France; barbara.gollain@gmail.com

Annachiara Bartolini

Muséum National d'Histoire Naturelle Paris, UMR 7207 CNRS - CR2P, France; annachiara.bartolini@mnhn.fr

In modern oceans, the size structure of marine phytoplankton communities greatly affects food web structure and organic/inorganic carbon export into the ocean interior. This last mechanism plays a fundamental role in the transfer of carbon from the surface oceanic reservoir to the carbonate sediments that belong to the lithospheric reservoir. Yet evolutionary patterns through time in the size structure of calcareous nannoplankton have been poorly investigated, especially in the Mesozoic.

Of the fossil coccolithophorids, *Watznaueria barnesiae* (the most abundant coccolith taxon in Cretaceous rocks) shows a peculiar size pattern in the interval Valanginian-Aptian. In this study, a trend of increasing size (1μm) followed by steady size values was observed in the Vocontian Basin, as well as in other localities (Bornemann & Mutterlose, 2006; Erba *et al*., 2010). This trend appears to be mainly evolutionarily driven, although a transient perturbation in the size trend was observed during the Valanginian Weissert event.

Climatically induced changes in oceanic mixing may have altered nutrient availability in the euphotic zone and driven evolutionary shifts in the size of calcareous nannoplankton through geological time. Evolutionary patterns in the size distribution of calcareous nannoplankton can thus be a useful complement to geochemical or sedimentological proxies for interpreting the effects of climate change on marine ecosystems.

References

Bornemann, A. & Mutterlose, J. 2006. Size analyses of the coccolith species *Biscutum constans* and *Watznaueria barnesiae* from the Late Albian "Niveau Breistroffer" (SE France): taxonomic and palaeoecological implications. *Geobios*, **39**(5): 599–615.

Erba, E., Bottini, C., Weissert, H. & Keller, C.E. 2010. Calcareous nannoplankton response to surface-water acidification around Oceanic Anoxic Event 1a. *Science*, **329**: 428–432.

Seasonal succession of coccolithophores during a long-term monitoring in the Kiel Fjord (SW Baltic Sea)

K.J. Sebastian Meier
Kiel University, Institute for Geosciences, Kiel, Germany; smeier@gpi.uni-kiel.de

Hanno Kinkel
GEOMAR Helmholtz Centre for Ocean Research, Kiel, Germany; hkinkel@geomar.de

Coccolithophores were long thought to play a minor role in the phytoplankton community in the Baltic Sea (Tyrrell *et al*., 2008). However, their first observations date as far back as 1905–1906, when large populations of *Emiliania huxleyi* were recorded as a major component of the phytoplankton succession in the Kieler Förde off Laboe (Lohmann, 1908). Subsequent studies failed to report any coccolithophores, despite intensive monitoring by various projects (e.g., Smetacek *et al*., 1985). This may have three reasons: (1) the fixation of samples with Lugol's solution dissolved the coccoliths, (2) monthly sampling intervals may not have been suitable to discover the sometimes very short-lived appearances of specific species, or (3) the primarily lightly calcifying coccolithophores have been overlooked and actually are present in the Baltic Sea (Thomsen, 2016).

Since 2009, we conducted weekly to monthly phytoplankton monitoring in the inner Kiel Fjord and since July 2014, in the western Kiel Bight (Meier *et al*., 2014a). Coccolithophores were a consistent member of the phytoplankton community, with their earliest occurrence in June, usually peaking in late summer/autumn, and declining over winter until they disappeared in March. Their occurrence and timing was similar to that found 100 years ago. The assemblage was dominated by *E. huxleyi*, which forms blooms of up to 3×10^6 cells/l. There was a repeated seasonal succession of *E. huxleyi* Type A during summer/autumn and an overcalcified Type A during the winter. The gradual increase in calcification was demonstrated by a continuous decrease in the ratio between inner tube area and distal shield area, which correlated best with temperature. Similar seasonal successions are known from the Bay of Biscay (Daniels *et al*., 2012), the Gulf of Lions (Meier *et al*., 2014b), and the Aegean Sea (Triantaphyllou *et al*., 2010), and may be useful for seasonality reconstructions or even for temperature estimates in paleoclimate studies.

References

Daniels, C.J., Tyrrell, T. Poulton, A.J. & Pettit, L. 2012. The influence of lithogenic material on particulate inorganic carbon measurements of coccolithophores in the Bay of Biscay. *Limnology and Oceanography*, **57**:145–153.

Lohmann, H. 1908. Untersuchungen zur Feststellung des vollständigen Gehaltes des Meeres an Plankton. *Wissenschaftliche Meeresuntersuchungen, Abteilung Kiel,* Neue Folge, **10**: 132–270.

Meier, K.J.S., Beaufort, L. Heussner, S. & Ziveri, P. 2014b. The role of ocean acidification in *Emiliania huxleyi* coccolith thinning in the Mediterranean Sea. *Biogeosciences*, **11**: 2857–2869.

Meier, K.J.S., Kinkel, H. & Young. J.R. 2014a. A note on calcareous nannoplankton from the Kieler Förde (Baltic Sea). *Journal of Nannoplankton Research*, **33**: 29–37.

Smetacek, V. 1985. The annual cycle of Kiel Bight plankton: a long-term analysis. *Estuaries*, **8**: 145–157.

Thomsen, H.A. 2016. Baltic Sea coccolithophores - an overview of insights into their taxonomy and ecology from the last 40 years. *Journal of Nannoplankton Research*, **36**: 97–119.

Triantaphyllou, M.V., Dimiza, M.D., Krasakopoulou, E., Malinverno, E., Lianou, V. & Souvermezoglou, E. 2010. Seasonal control on *Emiliania huxleyi* coccolith morphology and calcification in the Aegean Sea (Eastern Mediterranean). *Geobios* **43**, 99–110.

Tyrrell, T., Schneider, B., Charalampopoulou, A. & Riebesell, U. 2008. Coccolithophores and calcite saturation state in the Baltic and Black Seas. *Biogeosciences,* **5**(2): 485–494.

Calcareous nannofossil biochronology and paleoecology of onshore and offshore Miocene Colombian sequences

Alejandra Mejía-Molina

Universidad de Salamanca, Departamento de Geología, 37008 Salamanca, España; Instituto Colombiano del Petróleo-ICP-ECOPETROL, Piedecuesta, Santander, Colombia; Yachay Tech University, Urcuquí, Ecuador; amejia@yachaytech.edu.ec; alejandra@usal.es

José-A. Flores

Universidad de Salamanca, Departamento de Geologia, Facultad de Ciencias, 37008 Salamanca, Spain; flores@usal.es

Francisco J. Sierro

Universidad de Salamanca, Departamento de Geología, Facultad de Ciencias, Salamanca, Spain; sierro@usal.es

A high-resolution stratigraphic and biochronologic study was carried out on Neogene sedimentary sequences from multiple onshore sections in Colombia and offshore cores drilled in the Caribbean Sea (ODP Site 999). In the sequences studied, calcareous nannofossil horizons were identified using the biochronology proposed by Berggren *et al*. (1985), Raffi & Flores (1995), and Raffi *et al*. (2006).

Exceptionally high abundances of *Sphenolithus heteromorphus* and *Sphenolithus abies* were recorded in the sections. Both species became the dominant components of the nannofossil assemblage in what are called SDI (*Sphenolithus* dominance intervals) (Mejía-Molina *et al*., 2010). In northern Colombia and the Caribbean Sea, these dominance intervals occurred in both shallow-water and open-marine paleoenvironments and may be useful for regional correlations (Figure 1).

References

Berggren W.A., Kent D.V., Swisher C.C. & Aubry M.P. 1985. A revised Cenozoic geochronology and chronostratigraphy. *In*: W. Berggren, D. Kent, M. Aubry & J. Hardenbol (Eds). *Geochronology, Time Scales and Global Stratigraphic Correlation*. Society for Sedimentary Geology Special Publications, **54** 129–212.

Mejía-Molina, A., Flores, J.-A., Torres Torres, V. & Sierro, F.J. 2010. Distribution of calcareous nannofossils in Upper Eocene-Upper Miocene deposits from Northern Colombia and the Caribbean Sea. *Revista Española de Micropaleontología*, **42**(3): 279–300.

Raffi, I., Backman, J., Fornaciari, E., Palike, H., Rio, D., Lourens, L. & Hilgen, F. 2006. A review of calcareous nannofossil astrobiochronology encompassing the past 25 million years. *Quaternary Science Reviews*, **25**: 3113–3137.

Raffi, I. & Flores, J.-A. 1995. Pleistocene through Miocene calcareous nannofossils from eastern equatorial Pacific Ocean. *Proceedings of the Ocean Drilling Program, Scientific Results*, **138**: 233–286.

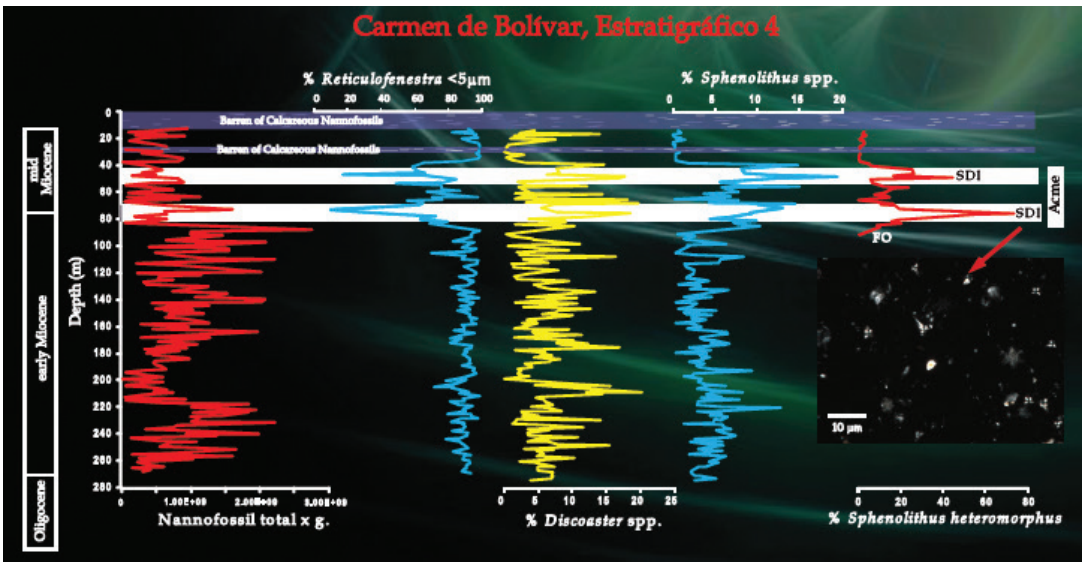


Figure 1: Percentages of *Reticulofenestra* <5µm, *Discoaster* spp., *Sphenolithus* spp., *Sphenolithus abies*, *Sphenolithus heteromorphus*, and total nannofossils per gram in the Carmen de Bolívar, Estratigráfico 4. White bars correspond to calcareous nannofossil barren intervals. FO, first occurrence; SDI, *Sphenolithus* dominance interval

The Pliensbachian-Toarcian boundary event (Early Jurassic): new paleoenvironmental interpretations based on calcareous nannofossil data

Alessandro Menini

Université de Lyon, Université Claude Bernard Lyon 1, ENS de Lyon, CNRS, UMR 5276 LGL-TPE, F-69622 Villeurbanne, France; alessandro.menini@univ-lyon1.fr

Emanuela Mattioli

Université de Lyon, Université Claude Bernard Lyon 1, ENS de Lyon, CNRS, UMR 5276 LGL-TPE, F-69622 Villeurbanne, France; emanuela.mattioli@univ-lyon1.fr

Guillaume Suan

Université de Lyon, Université Claude Bernard Lyon 1, ENS de Lyon, CNRS, UMR 5276 LGL-TPE, F-69622 Villeurbanne, France; guillaume.suan@univ-lyon1.fr

Bernard Pittet

Université de Lyon, Université Claude Bernard Lyon 1, ENS de Lyon, CNRS, UMR 5276 LGL-TPE, F-69622 Villeurbanne, France; bernard.pittet@univ-lyon1.fr

Many investigations that deal with Early Jurassic calcareous nannofossils have focused on their response to the Toarcian anoxic event (T-OAE). However, studies performed on carbon and oxygen isotopes point to a significant perturbation before the T-OAE, namely at the Pliensbachian-Toarcian boundary (Pl/Toa). Here, we present a high-resolution study from two sections: La Almunia de Doña Godina in central Spain and Anse St. Nicolas in western France. These two sections are located at a key position to investigate the boundary between the northern and the southern margin of the western Tethys Ocean. The two sites, which contain no apparent discontinuities, are ideal for documenting the Pl/Toa. This contrasts significantly with most known localities, which show a large hiatus in this interval. The new data were compared to others from the literature and to the new boundary stratotype in Peniche (Portugal). The investigation of relative abundances and nannofossil fluxes showed both differences and similarities. The late Pliensbachian and early Toarcian were times when many species of calcareous nannofossils first appeared. The first occurrences of *Biscutum intermedium* and *Zeugrhabdotus erectus* are well documented at both sites across the Pl/Toa. Although the two localities were paleogeographically close during the Early Jurassic, differences in the nannofossil assemblages, such as a high abundance of *Bussonius* at Anse St. Nicolas and high proportions of *Mitrolithus jansae* at La Almunia, suggest that the paleoenvironments were quite different. We conclude that the Pl/Toa event represented the onset of profound paleoenvironmental perturbations that culminated with the T-OAE.

Late Cretaceous deposits from Zakynthos Island (Preapulian Zone, Ionian Sea, western Greece): evidence from calcareous nannofossil dating and microfacies analysis

Ioulietta Mikellidou
RPS Energy, Woking, GU21 6DH, UK; mikellidoui@rpsgroup.com

Maria V. Triantaphyllou
National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimiopolis 157 84, Athens, Greece; mtriant@geol.uoa.gr

Stefano Patruno
Petroleum Geo-Services (PGS), Weybridge, Surrey, KT13 0NY, UK; stefano.patruno@gmail.com

Fotini Pomoni-Papaioannou
National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimiopolis 157 84, Athens, Greece; fpomoni@geol.uoa.gr

Vasilios Karakitsios
National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimiopolis 157 84, Athens, Greece; vkarak@geol.uoa.gr

The Ionian Islands are situated on the western Hellenic Arc, part of the most active plate margins in the Mediterranean Sea. The westerly-verging Hellenides fold-and-thrust belt in this area comprises the deformed Mesozoic-Cenozoic succession of the Ionian Zone, which thrusts over the time-equivalent slope unit of the Preapulian Zone. The basal front of this tectonic contact outcrops along the eastern edges of Kefalonia and Zakynthos Islands.

The purpose of this study was to investigate both the nannoflora assemblages and microfacies of Zakynthos carbonate deposits and attempt to determine whether the transition between the Apulian Platform (Italy) and the Ionian Basin (Greece) is uninterrupted under the Ionian Sea and subsequently exposed on the island.

Most of the samples proved to be barren of nannofossils, perhaps due to an intense diagenetic and tectonic history. However, a section on Zakynthos Island (Lithakia-Agalas) was both continuous and relatively prolific for nannofossils, and the strata form a north-east dipping monocline that spans the transition from the edge of the Apulian Platform (westernmost edges) and the pre-Apulian slope facies. Microfacies analyses pointed to a more proximal depositional setting, becoming increasingly shallower towards the west, where platform margin facies occurred. Calcareous nannofossil assemblages were dominated by *Watznaueria barnesiae*, *Quadrum gartneri*, and *Retecapsa crenulata*. Campanian-Maastrichtian markers, such as *Reinhardtites levis*, *Quadrum trifidum*, and *Broinsonia parca*, occur in the central and eastern part of the island, indicating a Campanian-Maastrichtian age.

The only other sampled sections that contained nannofossils were in the north of Zakynthos Island, around the village of Orthonies. Here, a typical slope succession contained poor nannofossil assemblages. This succession is no older than the Turonian, as suggested by the occurrence of *Micula staurophora*, and the oldest part of the section is no younger than early Campanian, as indicated by *Lithastrinus grillii*.

The absence of representative nannoflora of Coniacian and Santonian ages may suggest a potential hiatus, which was possibly caused by faulting towards the western edge of the section.

Size changes of calcareous nannofossils during the Weissert Event (Early Cretaceous)

Carla Möller

Ruhr-Universität Bochum, 44780 Bochum, Germany; carla.moeller@rub.de

André Bornemann

Bundesanstalt für Geowissenschaften und Rohstoffe, 30655 Hannover, Germany; Andre.Bornemann@bgr.de

Jörg Mutterlose

Ruhr-Universität Bochum, 44801 Bochum, Germany; joerg.mutterlose@rub.de

Recent biometric studies have observed size reductions in certain calcareous nannofossil species that can be linked to global environmental perturbations in the Cretaceous. Dwarfism has specifically been ascribed to the mid-Cretaceous (~125–90Ma) oceanic anoxic event (OAE) 1a and OAE2 (Erba *et al.*, 2010; Lübke & Mutterlose, 2016; Faucher *et al.*, 2017). Possible causes for these size reductions, which were found in the current study, include light attenuation due to increased continental weathering and runoff, and input of toxic trace metals to the oceans from submarine volcanism.

Our biometric analyses of selected nannofossil taxa in samples from northern Germany and the western Atlantic revealed an average size reduction of *Biscutum constans* coccoliths throughout the late Valanginian (~136–133Ma) that parallels the Weissert Event. This event is marked by a 1.5‰ positive carbon isotope excursion and coincided with volcanic activity in the Paraná-Etendeka continental flood basalt province. A humid climate in the late Valanginian, probably linked to volcanic CO_2 outgassing, caused increased weathering and the transport of large amounts of detrital material into ocean basins. This supports a scenario of light attenuation in the surface waters that gave the smaller varieties of *B. constans*, which were adapted to lower light availability, an advantage over the larger forms that thrived in the clear waters of open-ocean settings (Lübke *et al.*, 2015).

References

Erba, E., Bottini, C., Weissert, H.J. & Keller, C.E. 2010. Calcareous nannoplankton response to surface-water acidification around Oceanic Anoxic Event 1a. *Science*, **329**: 428–432.

Faucher, G., Erba, E., Bottini, C. & Gambacorta, G. 2017. Calcareous nannoplankton response to the latest Cenomanian Oceanic Anoxic Event 2 perturbation, *Rivista Italiana di Paleontologia e Stratigrafia*, **123**(1): 159–176.

Lübke, N. & Mutterlose, J. 2016. The impact of OAE 1a on marine biota deciphered by size variations of coccoliths. *Cretaceous Research*, **61**: 169–179.

Lübke, N., Mutterlose, J. & Bottini, C. 2015. Size variations of coccoliths in Cretaceous oceans — a result of preservation, genetics and ecology?. *Marine Micropaleontology*, **117**: 25–39.

A nannofossil and geochemical investigation into the top Tor hardground, a reservoir barrier/baffle in the Danish Sector of the North Sea

Sarah D. Möller
Geological Survey of Denmark and Greenland (GEUS), Stratigraphy Department, DK 1350, Copenhagen K, Denmark; sdm@geus.dk

Jon Ineson
Geological Survey of Denmark and Greenland (GEUS), Stratigraphy Department, DK 1350, Copenhagen K, Denmark; ji@geus.dk

Emma Sheldon
Geological Survey of Denmark and Greenland (GEUS), Stratigraphy Department, DK 1350, Copenhagen K, Denmark; es@geus.dk

In the Danish sector of the North Sea, the Maastrichtian Tor Formation and overlying Danian Ekofisk Formation hydrocarbon reservoirs are separated by an upper Maastrichtian hardground barrier/baffle and an inferred hiatus at the base of the Danian. In order to characterize this barrier/baffle, detailed nannofossil biostratigraphic and stable isotope analyses were carried out on a core from a well in the Halfdan Field.

Previous nannofossil analyses revealed that the uppermost Maastrichtian Tor Formation chalk, which could be dated as UC20dBP, was separated from the Ekofisk Formation chalk, which was dated as NNTp2E-F, by a 'mixed interval' that contained both Maastrichtian and Danian nannofossils and encompassed the hardground level. The extensively burrowed ca. 1-m-thick hardground interval was the focus of the current study, and high-resolution sampling was undertaken for nannofossils and $\delta^{13}C$ and $\delta^{18}O$ stable isotope analyses from within the multi-tiered network of *Thalassinoides* burrows.

Detailed study of the burrow fill revealed earliest Danian (NNTp1A) chalk in the deepest burrows, with younger chalk dated as NNTp2 (undifferentiated) and NNTp2D in succeeding burrows, thus confirming the presence of earliest Danian chalk that previously was thought to be absent in this area.

In the upper part of the mixed interval, isotope signatures for the host Tor chalk and the burrow fills differ significantly. This is probably due to early submarine cementation of the host chalks in contrast to late diagenesis in the porous burrow fills. Low $\delta^{13}C$ values in the burrow fills are probably due to metabolic processes within the active burrow systems and the input of light carbon from earliest Danian sediments and from late diagenetic fluids.

This study illustrates the complex history of this barrier/baffle and demonstrates that although the burrow systems remained open for much of the hiatal period, there was local preservation of earliest Danian sediments. This composite burrow infill subsequently acted as a bypass route for fluids through the hardground level.

The effect of a frontal zone on the spatial distribution of extant coccolithophores around the Madeira Archipelago (northeast Atlantic)

Áurea Narciso

CIIMAR-Madeira and OOM - Oceanic Observatory of Madeira, Edifício Madeira Tecnopolo, 9020-105 Funchal, Madeira, Portugal; aurea.narciso@ciimarmadeira.org

Rui Caldeira

CIIMAR-Madeira and OOM - Oceanic Observatory of Madeira, Edifício Madeira Tecnopolo, 9020-105 Funchal, Madeira, Portugal; rui.caldeira@ciimarmadeira.org

Mona Hoppenrath

German Centre for Marine Biodiversity Research (DZMB), Senckenberg am Meer, Wilhelmshaven, Germany; mhoppenrath@senckenber.de

Mário Cachão

Universidade de Lisboa, Instituto Dom Luiz, Faculdade de Ciências, 1749-016 Lisboa, Portugal; Sociedade de História Natural, Torres Vedras, Portugal; mcachao@fc.ul.pt

Manfred Kaufmann

CIIMAR-Madeira and OOM - Oceanic Observatory of Madeira, Edifício Madeira Tecnopolo, 9020-105 Funchal, Madeira, Portugal; University of Madeira, Faculty of Life Sciences, Marine Biology Station of Funchal, 9000-107 Funchal, Portugal; CIIMAR, University of Porto, 4450-208 Matosinhos, Portugal; mkbiomar@staff.uma.pt

The current study aims to identify and quantify the extant coccolithophore communities in the vicinity of the Madeira Islands, which are considered to be "pre-seamount" stages, in order to address whether and how these islands affect the abundance, composition, and distribution of these communities. One hundred and forty-two samples were collected for coccolithophore analysis during the research cruise POS466 of RV *Poseidon* (March 2014) as part of project MAPS (Madeira Archipelago Pre-Seamount Stages). Seawater samples were obtained from depths between 10 and 150m at 37 stations around the Madeira Archipelago. A total of 30 distinct taxa, 4 genera, 23 species, and 3 varieties were recognized using a polarizing light microscope. Total cell densities ranged between 12×10^3 and 112×10^3 cell/l, and *Emiliania huxleyi* was the dominant species. Of the 30 identified taxa, only ten reached significant cell densities of more than 500 coccospheres per litre: *Algirosphaera robusta*, *Calcidiscus leptoporus*, *Calciosolenia* ssp., *Coronosphaera mediterranea*, *Emiliania huxleyi*, *Gephyrocapsa ericsonii*, *Gephyrocapsa oceanica*, *Michaelsarsia* spp., *Syracosphaera* spp., and *Umbilicosphaera* spp. The highest total cell densities were observed between Madeira and Porto Santo Islands, more precisely between the north of Ponta de São Lourenço and the south coast of Porto Santo, and the lowest coccolithophore densities were observed off the southwest coast of Madeira Island. No specific patterns were detected for the vertical distribution of the species, probably due to the well-mixed upper layer. The spatial differences may be explained by the appearance of a frontal zone between Madeira and Porto Santo Islands that has different seawater temperature signatures.

This study provides essential information for understanding the influence of seamounts and islands on phytoplankton communities and their dynamics, particularly along the Madeira hotspot track, as well as the evolution of planktonic ecosystems associated with the geomorphologic evolution of the islands.

Distribution of living coccolithophores in the marginal and inland seas in the Philippine Archipelago

Jaan Ruy Conrad P. Nogot
University of the Philippines, National Institute of Geological Sciences, Diliman, Quezon City, Philippines, 1101; jrcnogot@gmail.com

Alyssa M. Peleo-Alampay
University of the Philippines, National Institute of Geological Sciences, Diliman, Quezon City, Philippines, 1101; ampeleoalampay@up.edu.ph

Dorothy Joyce Marquez
University of the Philippines, National Institute of Geological Sciences, Diliman, Quezon City, Philippines, 1101; ddmarquez@up.edu.ph

Allan Gil S. Fernando
University of the Philippines, National Institute of Geological Sciences, Diliman, Quezon City, Philippines, 1101; agsfernando@yahoo.com, asfernando@up.edu.ph

Forty-six coccolithophore species, including 10 variants and one species described for the first time, were identified from 61 water samples that were collected from various marginal and inland seas of the Philippines. Coccolithophore abundance in the marginal and inland seas, including coastal waters, is remarkably low (<1000 coccolithophores/l). Generally, coccolithophores in this region were subordinate to diatoms in the phytoplankton population. The present study reveals hydrographic controls on the distribution of coccolithophores within the inland seas of the Philippines. The more abundant and diverse coccolithophore communities in the inland seas were often recognized off areas less affected by monsoon-enhanced jets, but in proximity to a cyclonic eddy (upwelling feature). *Gephyrocapsa oceanica* dominated the surface assemblage, especially in inland seas, whereas *Discosphaera tubifera* and *Umbellosphaera irregularis* dominated the offshore surface assemblage in the Philippine Sea. The flora in the deep chlorophyll maximum (DCM) in nearshore stations was primarily composed of *Florisphaera profunda*, although *Oolithotus antillarum* was found to flourish within the Mindanao Eddy in the Philippine Sea. Coccolithophores with dissolved features occurred frequently throughout the study area.

A seafloor observatory for the Kolumbo volcano: an informed modelling system

Paraskevi Nomikou

National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; evinom@geol.uoa.gr

Submarine hydrothermal systems that are located along active volcanic ridges and arcs are highly dynamic. Their restless state and puzzling evolution require state-of-the-art, long-term, and continuous in situ observation in order to perform the high-resolution monitoring that can ascertain their part in the evolution of ocean chemistry and volcanic change over time. Shallow-water hydrothermal systems in the subduction-related submarine arc volcanoes, like those along the active Hellenic Volcanic Arc in the Aegean Sea, are of particular interest because of their vicinity to highly populated/touristic areas (e.g., Santorini Island). There currently is limited knowledge of this type of hydrothermal activity, which is a source of volcanic heat, toxic metals/minerals, and greenhouse gases such as CO_2, that can be a serious risk for marine biota, including pelagic calcifiers (e.g., coccolithophores). Currently, there is no strategy for monitoring and identifying the sudden and potentially disastrous changes that often accompany these activities.

To confront these challenges, it is essential to establish a hybrid seafloor and water column observatory with fixed seafloor monitoring platforms that contain innovative sensors, an integrated onboard hybrid glider, and hover-capable autonomous underwater vehicles (AUV) that will enable large-scale/high-resolution visualization of spatial and temporal hydrothermal variability. The Kolumbo submarine volcano, located 7km NE of Santorini, and its hydrothermal vents at 500m bsl are known to discharge pure gaseous CO_2 and fluids at 220°C and could serve as a natural laboratory. The vents are enriched in critical metals (e.g., antimony) and support a thriving microbial activity, the speciation and diversity of which have not been fully evaluated. Such a shallow observatory will shed light on the processes that control local hydrothermal activity and the linkages to mantle processes, the crust, the oceans, and dark ecosystem function. This seafloor observatory will act as a proof of concept towards developing effective strategies for hazard mitigation in underwater volcanic systems worldwide.

Changes in calcareous nannoplankton assemblages across the Eocene–Oligocene transition in the Hungarian Paleogene Basin (Central Paratethys)

Anita Nyerges

Eötvös Loránd University, Department of Physical and Applied Geology, Budapest H-1117, Hungary; MTA-MTM-ELTE Research Group for Paleontology, H-1431 Budapest, Hungary; anyerges@caesar.elte.hu

Ádám T. Kocsis

Universität Erlangen-Nürnberg, GeoZentrum Nordbayern, Department of Geography and Geosciences, 91054 Erlangen, Germany; MTA-MTM-ELTE Research Group for Paleontology, H-1431 Budapest, Hungary; adamkocsis@caesar.elte.hu

József Pálfy

Eötvös Loránd University, Department of Physical and Applied Geology, Budapest H-1117, Hungary; MTA-MTM-ELTE Research Group for Paleontology, H-1431 Budapest, Hungary; palfy@elte.hu

The Eocene-Oligocene transition (EOT), the last major greenhouse-icehouse climate state shift in Earth history, ended the warm, ice-free early Paleogene world and ushered in Antarctic glaciation. The Paratethys was an unique epicontinental seaway that existed from ~34–12Ma in an area that was affected by the ongoing Alpine orogeny. This study focused on the Hungarian Paleogene Basin within the Central Paratethys in order to characterize the effect of the global cooling event on the calcareous nannoplankton, reconstruct the paleoenvironmental evolution of the region across the EOT, and compare it with the global trends.

Closely spaced samples were collected from the Cserépváralja-1 drillcore between 440.8 and 383.5m and were studied using paleontological and statistical analyses. Calcareous nannoplankton biostratigraphy focused on documenting Zone NP21, which includes the Eocene-Oligocene boundary. Hierarchical cluster analysis made it possible to distinguish five successive assemblages in the studied core section. Phases of calcareous nannoplankton community evolution were compared with recently published trends in $\delta^{18}O$ and $\delta^{13}C$ isotope values and foraminiferal changes. The lowest assemblage is dominated by taxa with a preference for oligotrophic and warm surface waters. The next assemblage is marked by a nannoplankton turnover and signals a phase of eutrophication and incipient cooling. Nannoplankton abundance drops to a minimum in the third phase, which represented the coldest climate within the EOT. A gradual rebound of nannoplankton abundance occurred in the fourth phase, when ameliorated environmental conditions occurred that are postulated to have been influenced by regional climate change related to the uplifting of the Alps. The youngest assemblage includes mainly euryhaline taxa, which could tolerate an increase in the rate of freshwater and terrestrial influx.

These stepwise changes in calcareous nannoplankton assemblages are comparable to global trends, which suggests that in addition to a regional overprint controlled by the ongoing Alpine orogeny, environmental and biotic evolution across the EOT in the Central Paratethys was affected by global climate shifts that were triggered by Antarctic glaciation.

Calcareous nannoplankton and stable oxygen isotopes as proxies for paleoenvironmental reconstructions of the Albian–Cenomanian succession in the Mount Carmel Region (northwestern Israel)

Maria Ovechkina

Geological Survey of Israel, Jerusalem, Israel; University of KwaZulu-Natal, School of Agricultural, Earth and Environmental Sciences, Durban, South Africa; A.A. Borissiak Paleontological Institute, RAS, Moscow, Russia; mariao@gsi.gov.il

This study is based on calcareous nannoplankton from Borehole CT8 (32.79°N, 34.98°E) in the NW Mount Carmel area. The continuous sequence (225m) is composed of the following formations: Yagur (dolomite limestone), Isfiye (dolomitized chalk, tuffaceous layer, and micritic carbonates), Bet Oren (indurated chalks), and Arqan (chalks with chert nodules). The zonation of Bralower *et al*. (1995) was used for the Albian (NC zones), and that of Burnett (1998) was used for the Cenomanian (UC zones). The following calcareous nannoplankton zones and subzones were recognized: Subzone NC9b (late Albian), Zone UC0 (late Albian-early Cenomanian), Zone UC1 (early Cenomanian), Zone UC2 (early–middle Cenomanian), and Zone UC3 (middle–late Cenomanian).

For the quantitative analysis, 300 calcareous nannoplankton specimens were counted in traverses across 80 samples. In Borehole CT8, 56 bulk sediment samples from were analyzed for $\delta^{18}O$. The productivity index (PI) was calculated as following: [(*Zeugrhabdotus* spp. + *Biscutum constans* + *Discorhabdus ignotus*) / (*Zeugrhabdotus* spp. + *B. constans* + *D. ignotus*) + *Watznaueria barnesae*] × 100, where *Zeugrhabdotus* spp., *B. constans*, and *D. ignotus* are considered high productivity indicators, and *W. barnesae* is a low productivity indicator (e.g., Gale *et al*., 2000; Erba, 2004).

The upper Albian-Cenomanian sediments were deposited in an outer shelf environment. A significantly low Shannon diversity index and evenness and species richness in the assemblage indicated unstable environmental conditions with low fertility. The entire succession was deposited in quite warm (~25–32.5°C), open-marine, oligotrophic conditions with a poor nutrient supply. Five paleoecological phases were recognized through quantitative analysis of the calcareous nannoplankton, the PI, and $\delta^{18}O$ values. Warming/cooling events of various scales and fluctuations in eutrophication/oligotrophication have been detected in each phase.

The project is supported by the Ministry of National Infrastructures, Energy, and Water Resources (Israel).

References

Bralower, T.J., Leckie, R.M., Sliter, W.V. & Thierstein, H.R. 1995. An integrated Cretaceous timescale. *In*: W.A. Berggren, D.V. Kent, M.-P. Aubry & J. Hardenbol (Eds). *Geochronology Time Scales and Global Stratigraphic Correlation*. Society of Economic Paleontologists and Mineralogists, Special Publication, **54**: 65–79.

Burnett, J.A. 1998. Upper Cretaceous. *In:* P.R. Bown (Ed). *Calcareous Nannofossil Biostratigraphy*. British Micropalaeontolical Society Publication Series. Chapman and Hall/Kluwer Academic Publishers, London: 132–199.

Erba, E. 2004. Calcareous nannofossils and Mesozoic oceanic anoxic events. *Marine Micropaleontology*, **52**: 85–106.

Gale, A.S., Smith, A.B., Monks, N.E.A., Young, J.A., Howard, A., Wray, D.S. & Huggett, J.M. 2000. Marine biodiversity through the Late Cenomanian-Early Turonian: palaeoceanographic controls and sequence stratigraphic biases. Journal of the Geological Society of London, **157**: 745–757.

Calcareous nannoplankton biostratigraphy of the early–middle Eocene of the central Negev (Southern Israel)

Maria Ovechkina

Geological Survey of Israel, Jerusalem, Israel; University of KwaZulu-Natal, School of Agricultural, Earth and Environmental Sciences, Durban, South Africa; A.A. Borissiak Paleontological Institute, RAS, Moscow, Russia; mariao@gsi.gov.il

Yoav Avni

Geological Survey of Israel, Jerusalem, Israel; yavni@gsi.gov.il

During the Eocene, most of the Negev experienced a primarily pelagic depositional environment. Extensive Eocene outcrops consist mainly of pelagic chalks with occasional cherts and limestones, which were deposited off-shelf in the southern Tethys. Lithologic, stratigraphic, and biostratigraphic studies have been undertaken in this region for over half a century (i.e., Benjamini, 1979; Weinbaum-Hefetz & Benjamini, 2011), but the Negev is the most stratigraphically complicated area in Israel, and existing geological maps are in dire need of updating.

Using the zonation of Martini (1971), a biostratigraphic analysis was conducted on lower–middle Eocene pelagic deposits that crop out in the synclinal Ein Zik (30.79°N, 34.85°E) and Hod Akev (30.83°N, 34.83°E) sections, which are located between the north Negev anticlines and the Ramon anticline.

Going upsection, the Takiye Formation (grey marls), the Mor Formation (chalky deposits with silica layers and chert nodules), and the Nizzana Formation (chalk and limestone intercalations) are exposed. The Hod Akev section is located near the syncline axis, and its thickness reaches 151m. The Ein Zik section is closer to the anticline, and the thickness of the deposits is reduced (95m).

In the Hod Akev section, the Takiye Formation and the lower part of the Mor Formation are in early Eocene Zone NP11. The middle part of the Mor Formation is in early Eocene Zone NP12, and its upper part is in early Eocene Zone NP13. The uppermost part of the Mor Formation and the Nizzana Formation belong to middle Eocene Subzones NP14a and NP14b. In the Ein Zik section, the Takiye Formation and the lowest part of the Mor Formation are in Zone NP11. The lower part of the Mor Formation belongs to Zone NP12, and its upper part and the lower part of the Nizzana Formation to Zone NP13. The middle part of the Nizzana Formation belongs to Zone NP14a and its upper part to Zone NP14b.

References

Benjamini, C. 1979. Facies relationships of the Avedat Group (Eocene) in the northern Negev, Israel. *Israeli Journal of Earth Science*, **28**: 47–69.

Martini, E. 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. *In*: A. Faranacci (Ed). *Proceedings of the Second Planktonic Conference Roma 1970.* Edizioni Tecnoscienza, Rome, **2**: 739–785.

Weinbaum-Hefetz, M. & Benjamini, C. 2011. Calcareous nannofossil assemblage changes from early to middle Eocene in the Levant margin of the Tethys, central Israel. *Journal of Micropalaeontology*, **30**(2): 129–139.

Early Eocene calcareous nannofossils of the Punta Torcida Formation, Austral Basin, Patagonia: biostratigraphy and paleoceanography

Juan P. Pérez Panera

CONICET/Y-TEC, Avenida del Petróleo Argentino s/n CP: 1923, Buenos Aires, Argentina; juan.p.panera@ypftecnologia.com

C. Daniel Cuciniello

Y-TEC, Avenida del Petróleo Argentino s/n CP: 1923, Buenos Aires, Argentina; carlos.cuciniello@ypftecnologia.com

Érika Bedoya Agudelo

CONICET – CADIC. Avenida Malvinas Argentinas s/n, CP: 9410 Ushuaia, Tierra del Fuego, Argentina; erikal.bedoya@gmail.com

Eduardo B. Olivero

CONICET – CADIC. Avenida Malvinas Argentinas s/n, CP: 9410 Ushuaia, Tierra del Fuego, Argentina; emolivero@gmail.com

Calcareous nannofossil assemblages from a 105m-thick partial section at the type locality of the Punta Torcida Formation, Austral Basin are presented. The section consists of dark gray siltstones that are interbedded with thin gray sandstones. According to the planktonic foraminiferal and radiolarian record, the Torcida has an early Eocene age (planktonic foraminifera Zones E5-E7: 49–52.2Ma), and the micropaleontological assemblage records the ETM-3 (Eocene thermal maximum)(Malumián & Jannou, 2010; Jannou, 2012; Malumián *et al*., 2014). There were high relative abundances of the genera *Toweius*, *Reticulofenestra*, and *Pontosphaera* in the organic rich siltstones. This, in association with diatoms, radiolarians, and planktonic foraminifera, suggests eutrophic sea surface waters and an outer shelf paleoenvironment. The lower part of the profile (samples 742-1 to 742-3) yielded an assemblage dominated by *Toweius* spp., *Chiasmolithus bidens*, and the holococcolith *Lanternithus simplex*, which assigned it to Zone NP11. Sample 742-2 had a relatively higher species richness and abundance and together with the presence of *Discoaster kuepperi*, *Sphenolithus moriformis*, and *Sphenolithus orphanknollensis* might reflect the ETM-2 paleoclimatic event (Fig. 1). In the middle part of the section (samples 742-4 to 744-3), assemblages were assigned to Zone NP12, which contained the first appearance of the genus *Reticulofenestra*. This agrees with the older appearance of the genus in the southern high latitudes (Schneider *et al*., 2011; Shepherd & Kulhanek, 2016). The younger samples in this section yielded a high relative abundance of *Discoaster kuepperi*, and this sudden reappearance is interpreted as the ETM-3 (Agnini *et al*., 2006; 2014). In the upper part (samples 744-4 to 744-7), nannofossil assemblages were assigned to Zone NP13, and *Reticulofenestra* spp. thrived to the detriment of *Toweius* spp. This nannofossil event has been observed worldwide (Schneider *et al*., 2011) and coincides with a climatic cooling trend after the early Eocene climatic optimum (EECO).

References

Agnini, C., Fornaciari, E., Raffi, I., Catanzariti, R., Pälike, H., Backman, J. & Rio, D. 2014. Biozonation and biochronology of Paleogene calcareous nannofossils from low and middle latitudes. *Newsletters on Stratigraphy*, **47**:131–18.

Agnini, C., Muttoni, G., Kent, D.V. & Rio, D. 2006. Eocene biostratigraphy and magnetic stratigraphy from Possagno, Italy: The calcareous nannofossil response to climate variability. *Earth and Planetary Science Letters,* **241**: 815–830.

Jannou, G. 2012. Early Eocene radiolarians from the Tierra del Fuego, Magallanes Basin, Argentina. Proceedings of the 13th INTERRAD. Cádiz, 2012. *Radiolaria Newsletter*, **28**: 163–167.

Malumián, N. & Jannou, G. 2010. Los Andes Fueguinos: el registro micropaleontológico de los mayors acontecimientos paleooceanográficos australes del Campaniano al Mioceno. *Andean Geology*, **37**(2): 345–374.

Malumián, N., Náñez, C. & Jannou, G. 2014. The age of the Punta Torcida Formation, Eocene, Magallanes Basin, Argentina: the genera *Planorotalites* and *Igorina* (Planktonic Foraminifera). 19° Congreso Geológico Argentino, Córdoba, 2014. *Actas*, **1**: 30–31.

Schneider, L., Bralower, T.J. & Kump, L.R. 2011. Response of nannoplankton to early Eocene ocean destratification. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **310**: 152–162.

Shepherd, C.L. & Kulhanek, D.K. 2016. Eocene nannofossil biostratigraphy of the mid-Waipara River section, Canterbury Basin, New Zealand. *Journal of Nannoplankton Research*, **36**(1): 33–59.

Sample	Meters	Preservation	Fields of View	Biozone (Martini, 1971)	*Chiasmolithus* sp. (ring fragments)	*Chiasmolithus solitus*	*Toweius occultatus*	*Toweius callosus*	*Coccolithus pelagicus*	*Reticulofenestra minuta*	*Pontosphaera pectinata*	*Reticulofenestra hampdenensis*	Fragments of *Cervisiella* sp.	*Chiasmolithus bidens*	*Toweius rotundus*	*Reticulofenestra daviesii*	*Neococcolithes protenus*	*Toweius pertusus*	*Sphenolithus moriformis*	*Zygrhablithus bijugatus*	*Chiasmolithus nitidus*	*Chiasmolithus grandis*	*Calcidiscus bicircus*	*Cyclicargolithus parvus*	*Lanternithus simplex*	*Sphenolithus moriformis*	*Reticulofenestra lockeri*	*Reticulofenestra filewiczii*	*Reticulofenestra dictyoda*	*Pontosphaera pulcheroides*	*Pontosphaera duocava*	*Pontosphaera plana*	*Reticulofenestra bisecta*	*Jakubowskia leoniae*	*Discoaster kuepperi*	*Cruciplacolithus latipons*	*Cruciplacolithus* sp.	*Prinsius martinii*	*Markalius inversus*	*Fasciculithus tympaniformis*	*Thoracosphaera heimii*	*Prinsius bisulcus*	*Hornibrookina australis*	*Markalius walvisensis*	*Sphenolithus orphanknollensis*	*Watznaueria britannica* (reworked)	*Watznaueria barnesae* (reworked)	Abundance (A)	Richness (S)
744-7	104	P	360	NP13	F	F	R	R	F	R																																						F	6
744-6	95	P	360		R						R	R																																				R	3
744-5	86	G	300		F	R	F	C	F	C	C		F	C	C	F	F	F	F	F	R	F	R																									A	18
744-4	77	G	120		C	F		F	C	F	F	C	F	F	F	C	F			F		R		F	C	F	C	F	F	F	R	F	F	E														A	25
744-3	67,5	G	120	NP12	F			R	C			F	R	C	F		F			F					F						F	F			C	F	F	R	R							R		A	17
744-2	59,2	M	600		R				F				R	R	R	F	R			R																												F	8
744-1	50	M	360		F		R	F	F				R	F	R		R							R	R												R	R										C	12
742-6	47,5	P	600							F			R																																			F	2
742-5	37,5	P	360		F		R	R	R					R	R										F						R								R								R	F	9
742-4	27	N/A	300																																													N/A	0
742-3	17,5	M	400	NP11	F			F	F				R	F	F	F	R	F		R			R	R	F													R		R							R	F	15
742-2	7,5	M	500		C		R	F	F				R	R	C	R	R	R	R					R	F										R			R		R	R	F	R	R	R			C	21
742-1	0	P	600										F		R																																	F	2

Abundance

R	Rare
F	Few
C	Common
A	Abundant
VA	Very Abundant

Preservation

P	Poor
M	Moderate
G	Good
N/A	Not Applicable
	Barren

Toweius/*Reticulofenestra* turnover

ETM-3

ETM-2

Figure 1: Calcareous nannofossil distribution chart for the Punta Torcida Formation at Cabo Campo del Medio – Punta Torcida and EECO and *Toweius*/*Reticulofenestra* turnover record

Calcareous nannofossil biostratigraphy of the Qom Formation in central Iran

Mohammad Parandavar

Ferdowsi University of Mashhad, Department of Geology, Mashhad, Khorasan Razavi, Iran; parandavar.m@mail.um.ac.ir

Fatemeh Hadavi

Ferdowsi University of Mashhad, Department of Geology, Mashhad, Khorasan Razavi, Iran; fhadavi@um.ac.ir; hadavi231@yahoo.com

The Qom Formation has an extensive distribution in northern to central Iran, and it is comprised of thick successions of marine marlstones, limestones, gypsum, and siliciclastics. This formation, which is composed of six lithostratigraphic units (members a to f), is important for oil and gas exploration. The purpose of this study was to identify the calcareous nannofossils in this formation in the Navab and Shurab sections of central Iran. Nannofossil assemblages were well preserved and had high abundances and diversities. According to this study, the age of the Qom Formation in both sections is Chattian to Burdigalian/Langhian in age, which is equal to Zones NP25 and NN4/NN5 of Martini (1971), Zone CNO6 of Agnini *et al.* (2014), and Zone CNM6-7 of Backman *et al.* (2012).

References

Agnini, C., Fornaciari, E., Raffi, I., Catanzariti, R., Pälike, H., Backman, J. & Rio, D. 2014. Biozonation and biochronology of Paleogene calcareous nannofossils from low and middle latitudes. *Newsletters on Stratigraphy*, **47**:131–18.

Backman, J., Raffi, I., Rio, D., Fornaciari, E., & Pälike, H. 2012. Biozonation and biochronology of Miocene through Pleistocene calcareous nannofossils from low and middle latitudes. *Newsletters on Stratigraphy*, **45:** 221–224.

Martini, E. 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. *In*: A. Faranacci (Ed). *Proceedings of the Second Planktonic Conference Roma 1970.* Edizioni Tecnoscienza, Rome, **2**: 739–785.

Is *Emiliania huxleyi* expanding its presence in polar waters? Evidence from multi-year observations

Shramik M. Patil
ESSO-National Centre for Antarctic and Ocean Research, Vasco-da-Gama, Goa 403804, India; shramikantsci@gmail.com

Rahul Mohan
ESSO-National Centre for Antarctic and Ocean Research, Vasco-da-Gama, Goa 403804, India; rahulmohan@ncaor.gov.in

Sahina Gazi
ESSO-National Centre for Antarctic and Ocean Research, Vasco-da-Gama, Goa-403804, India; sahina@ncaor.gov.in

Suhas S. Shetye
National Institute of Oceanography, Dona Paula, Goa 403004, India; suhasshetye@gmail.com

Syed A. Jafar
Flat 5-B, Whispering Meadows, Haralur Road, Bangalore 560102, India; syeda_jafar@yahoo.com

Coccolithophores, one of the most abundant eukaryotic phytoplankton in the oceans that almost always possess calcite scales, play a pivotal role in the oceanic biological pump. Increasing levels of atmospheric carbon dioxide lead to the lowering of oceanic pH, which affects calcifiers and therefore the calcification ability of coccolithophores, including the abundant and widespread species *Emiliania huxleyi*. Recent investigations in southern polar waters indicate an expansion of *E. huxleyi* in the extreme southern latitudes. Our investigation in the southern Indian Ocean sector also showed evidence of a poleward expansion of *E. huxleyi*. Any change in *E. huxleyi* abundance relative to the non-calcifiers (i.e., diatoms) could affect the biogeochemical cycling of carbon and climatic feedback.

We tested the poleward expansion hypothesis of *E. huxleyi* with the use of our six-year cruise data and samples collected during austral summers of 2009–2016. Our findings show that: (1) *Emiliania huxleyi* does not show consistent year by year poleward expansion throughout the austral summer period, (2) the uneven poleward expansion suggests influence from intra-seasonal biogeochemical changes, (3) the decline in the abundance of non-calcifiers (i.e., diatoms) during late summer (low light and low SiO_4) and the increase in grazing by heterotrophs could affect the latitudinal expansion of coccolithophores, (4) *E. huxleyi* is climatically sensitive, and any changes in the environmental conditions are reflected in its morphological variations, and (5) *E. huxleyi* does show overcalcification in polar waters south of 55°S by replacing calcium with magnesium to form magnesium calcite. Coccolithophores probably overcalcify because magnesium calcite is more soluble in acidified water than any other forms of calcite, and thus this extra calcite allows them to exist in the extreme southern latitude waters, which in turn affects the pCO_2 in those surface waters.

Calcareous nannofossils and foraminifera from the surface sediments of the Gulf of Tonkin, South China Sea

Alyssa Peleo-Alampay
University of the Philippines, National Institute of Geological Sciences, Diliman, Quezon City, Philippines, 1101; ampanigs@yahoo.com

Dorothy Joyce Marquez
University of the Philippines, National Institute of Geological Sciences, Diliman, Quezon City, Philippines, 1101; ddmarquez@up.edu.ph

Martin Wiesner
University of Hamburg, Institute of Biogeochemistry and Marine Chemistry, Hamburg, Germany; martin.wiesner@zmaw.de

Allan Gil S. Fernando
University of the Philippines, National Institute of Geological Sciences, Diliman, Quezon City, Philippines, 1101; agsfernando@yahoo.com, asfernando@up.edu.ph

Leopoldo de Silva, Jr.
University of the Philippines, National Institute of Geological Sciences, Diliman, Quezon City, Philippines, 1101; desilva_son@yahoo.com

This study presents calcareous nannofossil and foraminiferal data that were collected from surface sediment samples from the Gulf of Tonkin in the South China Sea. The Gulf of Tonkin is considered to be one of the most productive in the region due to the large rivers that feed into it, monsoons, tidal fronts, and dust. Calcareous nannofossil and foraminiferal total abundances were highest towards the entrance of the Gulf. Greater nannofossil and planktonic foraminiferal abundances were present in muddy sediments. *Gephyrocapsa oceanica* dominated the nannofossil assemblage. *Florisphaera profunda* was found mainly near the mouth of the Gulf, which leads to the more open waters of the South China Sea. The effect of fluvial sedimentation from the Red River into the Gulf of Tonkin was also apparent in the distribution and dominance of certain species. *Globigerinoides ruber*, *G. sacculifer*, and *Globorotalia menardii* were the dominant planktonic foraminifera throughout the sampled stations, and the results from this study validated their preference for warm waters. These taxa exhibited opportunism in these low diversity assemblages. The benthic foraminifera *Cibicides subhaedingeri* was found in almost all of the stations, which indicates its tolerance for the variable sub-environments in a restricted basin. Calcareous nannofossils and foraminifera are effective indicators of relative variations in salinity, ventilation of surface waters, and temperature even in restricted marine environments, such as the Gulf of Tonkin.

Combining physiological modeling at the cellular scale and in situ biogeochemical data to investigate the deep niche of *Emiliania huxleyi* in the South Pacific Gyre

Laura Perrin
Université Pierre et Marie Curie-CNRS-IRD-MNHN, LOCEAN-IPSL, 75252 Paris, France; lpelod@locean-ipsl.upmc.fr

Ian Probert
Station Biologique de Roscoff, 29680 Roscoff, France; probert@sb-roscoff.fr

Gerald Langer
The Marine Biological Association of the United Kingdom, Plymouth PL1 2PB, UK; gerlan@mba.ac.uk

Luc Beaufort
Aix-Marseille University, CNRS, IRD, Col. France; CEREGE, Aix en Provence, France; beaufort@cerege.fr

Giovanni Aloisi
Université Pierre et Marie Curie-CNRS-IRD-MNHN, LOCEAN, 75252 Paris, France; galod@locean-ipsl.upmc.fr

The distribution of *Emiliania huxleyi* from subarctic to subequatorial regions and from eutrophic to oligotrophic waters makes it the most widely studied coccolithophore species. However, its physiologic response under key environmental conditions, such as the co-limitation of light and nutrients, remains poorly investigated in the laboratory and in the field in coccolithophores deep niches in oceanic gyres. We conducted laboratory culture and numerical modeling experiments in order to understand the controls on the physiology of *Emiliania huxleyi* in low-nutrient and low-light conditions with the aim of gaining a better understanding of the deep ecological niche of coccolithophores in the South Pacific Gyre.

We carried out batch culture experiments to test the co-limitation of nutrients (nitrate and phosphate) and light with an *E. huxleyi* strain that was isolated from the BIOSOPE transect (South Pacific Gyre). A simple physiological model that was based on the Droop theory was applied to the culture experiments in order to constrain the key physiological parameters of *E. huxleyi* that are usually obtained in more costly and time-consuming chemostat experiments. Our approach provided a rapid, simpler procedure to estimate these fundamental parameters. Evidence of this capacity to grow in different environments can be found in the deep niche reported in the South Pacific Gyre during the BIOSOPE cruise. This coccolithophore niche, which is characterized by a strong community of Isochrysidales, such as *E. huxleyi*, *Gephyrocapsa* spp., and *Reticulofenestra* spp., was investigated by combining physiological parameters and in situ biogeochemical data. The modeled spatial distribution of growth rate matches the in situ observed abundance of *Emiliania huxleyi* cells. We highlighted nitrate and light as the two forcing environmental parameters that control growth in the niche, and we are now working on the potential estimation of the calcification rate of *Emiliania huxleyi* in this niche.

A new morphometric approach to coccolith morphometry: reassessing *Coccolithus pelagicus s.l.* data from the Holocene

Gonçalo A. Prista

Universidade de Lisboa, Instituto Dom Luiz, Faculdade de Ciências, 1749-016 Lisboa, Portugal; Sociedade de História Natural, Torres Vedras, Portugal; gaprista@fc.ul.pt

Áurea Narciso

CIIMAR-Madeira and OOM - Oceanic Observatory of Madeira, Edifício Madeira Tecnopolo, 9020-105 Funchal, Madeira, Portugal; aurea.narciso@ciimarmadeira.org

Mário A. Cachão

Universidade de Lisboa, Instituto Dom Luiz, Faculdade de Ciências, 1749-016 Lisboa, Portugal; Sociedade de História Natural, Torres Vedras, Portugal; mcachao@fc.ul.pt

The measurement of coccolith morphological parameters (coccolith morphometry) is based on the fact that heterococcoliths are produced intracellularly, and their final proportions are set prior to being extruded (e.g., Westbroek *et al*., 1984). Thus, their dimensions may be considered as an intrinsic property of a particular species or ecophenotype. This method has already been used to address questions of taxonomy, biostratigraphy, and paleoecology for several calcareous nannofossils (e.g., Samtleben 1980; Young 1990; Baumann 1995; Narciso *et al*., 2006).

Morphological plasticity corresponds to changes in morphology that are ecologically significant under two conditions: (1) must impact fitness to certain environmental conditions and (2) must differ across environmental conditions for some ecological reason (Travis, 1994). Thus, a species such as *Coccolithus pelagicus s.l.* may have different morphotypes (e.g., different coccolith sizes) in response to different (paleo)environmental conditions. In fact, the work of Parente *et al*. (2004) and Narciso *et al*. (2006) confirmed previous assumptions (e.g., Cachão & Moita, 2000) that different morphotypes exist in different environments. Micropaleontologists have proposed that phenotypic variations have genotypic counterparts, and genetic studies have now separated these morphotypes into two different species (Sáez *et al*., 2003) that probably evolved due to the physical separation of the morphotypes/subspecies: *C. pelagicus* ssp. *pelagicus* (smaller – subpolar waters) and *C. pelagicus* ssp. *braarudii*, (intermediate – upwelling regions). A third morphotype/subspecies, *C. pelagicus* ssp. *azurinos*, was defined from surface sediments (Parente *et al*., 2004) but has not been found since then in the water column off the Azores.

In this work, a new statistical approach to coccolithophore morphometry is presented that is based on theoretical models and previous size data sets for *C. pelagicus s.l.* Additional paleoenvironmental and paleoecological information are expected to be obtained from measurements with of 0.μm resolution.

The new method brings greater accuracy to the definition of morphotype size limits and suggests new behavior patterns for the intermediate morphotype, *C. pelagicus braarudii*, which responds to nutrient availability and upwelling systems.

This publication is supported by FCT project UID/GEO/50019/2013 - Instituto Dom Luiz.

References

Baumann, K.H. 1995. Morphometry of Quaternary *Coccolithus pelagicus* coccoliths from Northern North Atlantic and its paleoceanographical significance. *In*: J.A. Flores & F.J. Sierro (Eds). *5th INA Conference in Salamanca Proceedings*: 11–21.

Cachão, M. & Moita, M.T. 2000. *Coccolithus pelagicus*, a productivity proxy related to moderate fronts off Western Iberia. *Marine Micropaleontology*, **39**: 131–155.

Narciso, A., Cachão, M. & de Abreu, L. 2006. *Coccolithus pelagicus* subsp. *pelagicus* versus *Coccolithus pelagicus* subsp. *braarudii* (Coccolithophore, Haptophyta): A proxy for surface subarctic Atlantic waters off Iberia during the last 200kyr. Marine Micropaleontology, **59**: 15–34.

Parente, A., Cachão, M., Baumann, K., de Abreu, L. & Ferreira, J. 2004. Morphometry of *Coccolithus pelagicus s.l.* (Coccolithophore, Haptophyta) from offshore Portugal, during the last 200kyr, *Micropaleontology*, **50**: 107–120.

Sáez, A.G., Probert, I., Geisen, M., Quinn, P., Young, J.R. & Medlin, L.K. 2003. Pseudo-cryptic speciation in coccolithophores. *Proceedings of the National Academy of Sciences of the USA*, **100**: 7163–7168.

Samtleben, C. 1980. Die Evolution der Coccolithophoriden - Gattung *Gephyrocapsa* nach Befunden im Atlantik. *Paläontologische Zeitschrift*, **54**: 91–127.

Travis, J. 1994. Evaluating the Adaptive Role of Morphological Plasticity, *In*: P.C. Wainwright & S.M. Reilly (Eds). *Ecological Morphology: Integrative Organismal Biology*. University of Chicago Press, Chicago, 367pp.

Westbroek, P., de Jong, E.W., van der Wal, P., Borman, A.H., de Vrind, J.P.M., Kok, D., de Bruijn, W.C. & Parker, S.B. 1984. Mechanism of Calcification in the Marine Alga *Emiliania huxleyi* [and Discussion]. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, **304**: 435–444.

Young, J. 1990. Size variation of Neogene *Reticulofenestra* coccoliths from Indian Ocean DSDP Cores. *Journal of Micropalaeontology*, **9**: 71–86.

Calcareous nannofossils from Late Cretaceous (Cenomanian-Campanian) shallow-marine deposits in northwest Germany - a record for coastal dynamics

Tobias Püttmann
Ruhr-University Bochum, Institute for Geology, Mineralogy and Geophysics, 44801 Bochum, Germany; Tobias.Puettmann@rub.de

Christian Linnert
Ruhr-University Bochum, Institute for Geology, Mineralogy and Geophysics, 44801 Bochum, Germany; Christian.Linnert@rub.de

Bettina Dölling
Geological Survey North Rhine-Westphalia, 47803 Krefeld, Germany; Bettina.Doelling@gd.nrw.de

Jörg Mutterlose
Ruhr-University Bochum, Institute for Geology, Mineralogy and Geophysics, 44801 Bochum, Germany; Joerg.Mutterlose@rub.de

The early Late Cretaceous was characterized by a warm equable climate and a significant global sea-level rise that caused the flooding of vast continental areas. These oceanographic conditions favored the radiation of calcareous nannofossils, as evidenced by their unique diversity and high abundances in pelagic to hemipelagic environments. Previous studies of Cretaceous calcareous nannofossil biostratigraphy and paleoecology, therefore, focused on material from open ocean chalks and marls. For this study, we analyzed nannofossil assemblages from marginal marine settings in northwest Germany, about 5–15km off the former coastline. A detailed sampling of six recently drilled cores allowed us to study a sequence of glauconitic marls and sand-rich limestones of Cenomanian-early Campanian age for biostratigraphy and nannofossil diversity.

All 330 samples yielded rich and diverse calcareous nannofossil assemblages, which were first used to help establish a detailed biostratigraphic framework. Stable isotope data ($\delta^{13}C$ bulk rock) were then used to calibrate the biostratigraphic findings. The calcareous nannofossil biostratigraphy of the glauconite-rich sediments assigned the studied interval an earliest Cenomanian (nannofossil Zone UC0-1a) to early Campanian age (nannofossil Zone UC14) age. Seven major hiatuses, which were at stratigraphically different levels, were recognized. The accurate dating of these hiatuses resulted in the reconstruction of the dynamic evolution of the former coastline. Our findings allowed us to differentiate between eustatic and epirogenetic induced sea-level fluctuations. In addition to the global eustatic sea-level rise of the Cenomanian-Turonian interval, independent synsedimentary tectonic movements in the Turonian influenced regional sedimentation patterns. The diverse assemblages further improved the paleoecological understanding of calcareous nannofossils.

Millennial scale climate variability during Marine Isotope Stage 19: calcareous nannofossil, alkenone, and planktonic foraminiferal evidence at ODP Site 975 (Balearic Basin)

Ornella Quivelli

Universita degli Studi di Bari Aldo Moro, Dipartimento di Scienze della Terra e Geoambientali, 70125 Bari, Italy; ornella.quivelli@uniba.it

Maria Marino

Universita degli Studi di Bari Aldo Moro, Dipartimento di Scienze della Terra e Geoambientali, 70125 Bari, Italy; maria.marino@uniba.it

Teresa Rodrigues

Instituto Português do Mar e da Atmosfera, Divisão de Geologia e Georecursos Marinhos, 1495-006 Lisboa, Portugal; Universidade do Algarve, Centro de Ciências do Mar (CCMAR), Campus de Gambelas, 8005-139 Faro, Portugal; teresa.rodrigues@ipma.pt

Angela Girone

Universita degli Studi di Bari Aldo Moro, Dipartimento di Scienze della Terra e Geoambientali, 70125 Bari, Italy; angela.girone@uniba.it

Patrizia Maiorano

Universita degli Studi di Bari Aldo Moro, Dipartimento di Scienze della Terra e Geoambientali, 70125 Bari, Italy; patrizia.maiorano@uniba.it

The study of Marine Isotope Stage (MIS) 19 (ca 0.78Ma), the best analogue of MIS 1, is of particular interest for the scientific community because it offers the opportunity to explore the natural length of the current interglacial and the dynamics of glacial inception in the absence of human action. The analogy between MIS 19 and MIS 1 relies especially on the close astronomical configuration of their orbital parameters (Tzedakis *et al*., 2012; Yin & Berger, 2015). Furthermore, it has been suggested that the deglaciation history that is associated with the beginning of MIS 19 (Termination IX) was interrupted by short-term climate phases (Giaccio *et al*., 2015), an analogy with the last deglaciation. Recently, a similar climatic evolution between Termination IX and Termination I has been suggested because of distinct changes in calcareous plankton and pollen assemblages in the marine Montalbano Jonico Section (Maiorano *et al*., 2016) in southern Italy.

In the present study, calcareous nannofossils, biomarkers (alkenones), and planktonic foraminifera were investigated in the Ocean Drilling Program Site 975, located in the western Mediterranean, in order to understand responses to environmental and climate changes that began at the interglacial inception of MIS 19. Biomarkers, in particular, were used to reconstruct sea surface temperature (SST) and primary paleoproductivity, and to track episodes of massive cold freshwater input. The high temporal resolution of our data (about 200–400 years) provided additional evidence that Termination IX was characterized by high climatic variability, a fact that has not been previously identified in other middle Pleistocene glacial-interglacial transitions.

References

Giaccio, B., Regattieri, E., Zanchetta, G., Nomade, S., Renne, P.R., Sprain, C.J., Drysdale, R.N., Tzedakis, P.C., Messina, P., Scardia, G., Sposato, A. & Bassinot, F. 2015. Duration and dynamics of the best orbital analogue to the present interglacial. *Geology*, **43**(7): 603–606.

Maiorano, P., Bertini, A., Capolongo, D., Eramo, G., Gallicchio, S., Girone, A., Pinto, D., Toti, F., Ventruti, G. & Marino, M. 2016. Climate signatures through Marine Isotope Stage 19 in the Montalbano Jonico section (Southern Italy): A land–sea perspective. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **461**: 341–361.

Tzedakis, P.C., Channell, J.E.T., Hodell, D.A., Kleiven, H.F. & Skinner, L.C. 2012. Determining the natural length of the current interglacial. *Natural Geoscience*, **5**: 138–141.

Yin, Q.Z. & Berger, A. 2015. Interglacial analogues of the Holocene and its natural near future. *Quaternary Science Reviews*, **120:** 28–46.

Recurrent *Braarudosphaera* acmes in the mid-Oligocene subtropical South Atlantic Ocean linked to astronomical forcing of the hydrological cycle.

Isabella Raffi
Università degli Studi "G. d'Annunzio" di Chieti–Pescara, 66100 Chieti CH, Italy; isabella.raffi@unich.it

Diederik Liebrand
University of Southampton, Southampton, UK; Diederik.Liebrand@noc.soton.ac.uk

Ángela Fraguas
Universidad Complutense de Madrid, Departamento de Paleontología, Facultad de Ciencias Geológicas, 28040 Madrid, Spain; arfragua@ucm.es

Frederik J. Hilgen
Utrecht University, Utrecht, The Netherlands; F.J.Hilgen@uu.nl

Paul A. Wilson
University of Southampton, Southampton, UK; paul.wilson@noc.soton.ac.uk

Sietske J. Batenburg
University of Oxford, Oxford, UK; sbatenburg@gmail.com

Helen M. Beddow
Utrecht University, Utrecht, The Netherlands; hbeddow@live.co.uk

Anya J. Crocker
University of Southampton, Southampton, UK; anya.crocker@noc.soton.ac.uk

Claire E. Huck
University of Southampton, Southampton, UK; C.E.Huck@soton.ac.uk

Lucas J. Lourens
Utrecht University, Utrecht, The Netherlands; l.j.lourens@uu.nl

Steven M. Bohaty
University of Southampton, Southampton, UK; S.Bohaty@noc.soton.ac.uk

Luciana Sabia
Università degli Studi di Napoli "Parthenope", 80133 Naples, Italy; luluci_s@hotmail.com

A continuous record across the "*Braarudosphaera* chalks" was recovered from mid-Oligocene (~30–27Ma) deep-sea sediments in the subtropical South Atlantic Ocean and has been studied in detail. This stratigraphic section from ODP Site 1264 (Walvis Ridge) documents a succession of several chalky layers that consist almost completely of *Braarudosphaera bigelowii*, which indicates a basin-wide open-ocean acme for this calcareous nannofossil. Sediment cores with multiple *Braarudosphaera*-enriched layers have previously been recovered at drill-sites throughout the South Atlantic Ocean, such as Oligocene sections on the Rio Grande Rise and off the coast of Africa. This peculiar presence of *B. bigelowii*, a nannofossil taxon known to have shallow-water and low-salinity preferences in the modern ocean, suggests that unusual paleoceanographic conditions caused this mid-Oligocene biogeographical anomaly. Our study was concerned with unraveling the causes of the recurrences and the timing and durations of the acmes. We identified seven acme intervals of variable intensity in the *B. bigelowii*/pentaliths abundance record, and some, but not all, of these intervals correspond to prominent chalk layers. Through astronomical tuning, we found a correspondence between the longest lasting acme and a strong minimum in the ~2.4-Myr eccentricity cycle at ~28.5Ma, and between four of the seven acmes and a 405-kyr eccentricity maxima. This remarkable and complex astronomical pacing of the *Braarudosphaera* blooms suggests that the aberrant oceanographic conditions that enabled *B. bigelowii* to outcompete other nannoplankton probably occurred in response to astronomically forced changes of the global mid-Oligocene hydrological cycle.

Coccolithophore distribution in the western Black Sea during early summer 2016

Alexandra Ravani
National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; alexandrarvn@gmail.com

Boris Theofanis Karatsolis
National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; bkaratsolis@gmail.com

Margarita D. Dimiza
National and Kapodistrian University of Athens, Faculty of Geology & Geoenvironment, Panepistimioupolis 157 84, Athens, Greece; mdimiza@geol.uoa.gr

Maria V. Triantaphyllou
National and Kapodistrian University of Athens, Faculty of Geology & Geoenvironment, Panepistimioupolis 157 84, Athens, Greece; mtriant@geol.uoa.gr

Elisa Malinverno
Università degli Studi di Milano-Bicocca, Dipartimento di Scienze dell'Ambiente e della Terra, 20126 Milano, Italy; elisa.malinverno@unimib.it

Anna Lagaria
Hellenic Centre for Marine Research, Institute of Oceanography, 190 13 Anavyssos, Attiki, Greece; lagaria@hcmr.gr

Stella Psarra
Hellenic Centre for Marine Research, Institute of Oceanography, 190 13 Anavyssos, Attiki, Greece; spsarra@hcmr.gr

The Black Sea is the largest semi-enclosed marginal sea and receives drainage from almost one-third of continental Europe. Intensive coccolithophore blooms (*Emiliania huxleyi*, primarily) are typical events for the Black Sea. According to satellite observations, on a temporal scale the most extended bloom occurs in May-June, although differences in intensity and area of coverage have been recorded (e.g., Cokacar *et al*., 2004; Kopelevitch *et al*., 2014; Triantaphyllou *et al*., 2014; Mikaelyan *et al*., 2015). These blooms can be detected by ocean color sensors as a result of light being scattering by the coccolith plates that are detached from cells. The optical signature of coccolithophore blooms on satellite true color images is a very bright patch of water with a milky turquoise color. The Black Sea is an ideal site in which to study the effect of biogeochemical properties on coccolithophore blooms. The main aim of this study was to determine the spatial and vertical distribution patterns of living coccolithophores from the oxic surface zone in the western part of the Black Sea in June 2016. A total of 90 plankton samples from 32 stations were taken from discrete water samples (1 to 50m depths) that were collected from coastal and open sea zones. Coccolithophores showed excessively high cell densities ($\sim 4 \times 10^6$ cells l^{-1}) with an impressive almost monospecific assemblage of *Emiliania huxleyi* lightly calcified morphotypes. In general, cell numbers were usually higher in the surface layer (0–20m), and tended to decrease in abundance below ~20m water depth. In the lower part of the surface zone (~50m water depth), *E. huxleyi* gradually decreased, while *Algirosphaera robusta* occurred in high abundances ($\sim 0.2 \times 10^5$ cells l^{-1}), indicating low light availability below the thermocline. Differences in abundances between coastal and open-sea environments were observed that are primarily associated with major river discharges. However, these differences were less pronounced in chlorophyll-*a* concentrations between coastal and offshore stations. This observation indicates that other groups than coccolithophores (e.g., diatoms) also play an important role. Further examination will elucidate the phytoplankton community structure.

Samples were collected during the BIO-OPT-2016 EUROFLEETS cruise, onboard the R/V *Akademik*.

References

Cokacar, T., Oguz, T. & Kubilay, N. 2004. Satellite-detected early summer coccolithophore blooms and their interannual variability in the Black Sea. *Deep-Sea Research Part I*, **54:** 1017–1031.

Kopelevich, O.V., Burenkov, V.I., Sheberstov, S.V., Vazyulya, S.V., Kravchishina, M., Pautova, L.A., Silkin, V.A., Artemiev, V. & Grigoriev, A. 2014. Satellite monitoring of coccolithophore blooms in the Black Sea from ocean color data. *Remote Sensing of the Environment*, **146:** 113–123.

Mikaelyan, A.S, Pautova, L.A., Chasovnikov, V.K., Mosharov, S.A. & Silkin, V.A. 2015. Alternation of diatoms and coccolithophores in the northeastern Black Sea: a response to nutrient changes. Hydrobiologia, **755**: 89–105.

Triantaphyllou, M.V., Malinverno, E., Dimiza, M.D., Gogou, A., Athanasiou, A., Skampa, E., Tselenti, D., Thanassoura, E., Birli, A., Stavrakaki, I., Stavrakakis, S., Corselli, C. & Lykousis, V. 2014. Coccolithophore biogeographic trends and export production in the Eastern Mediterranean and Black Seas. *Journal of Nannoplankton Research*, **34**: 97–98.

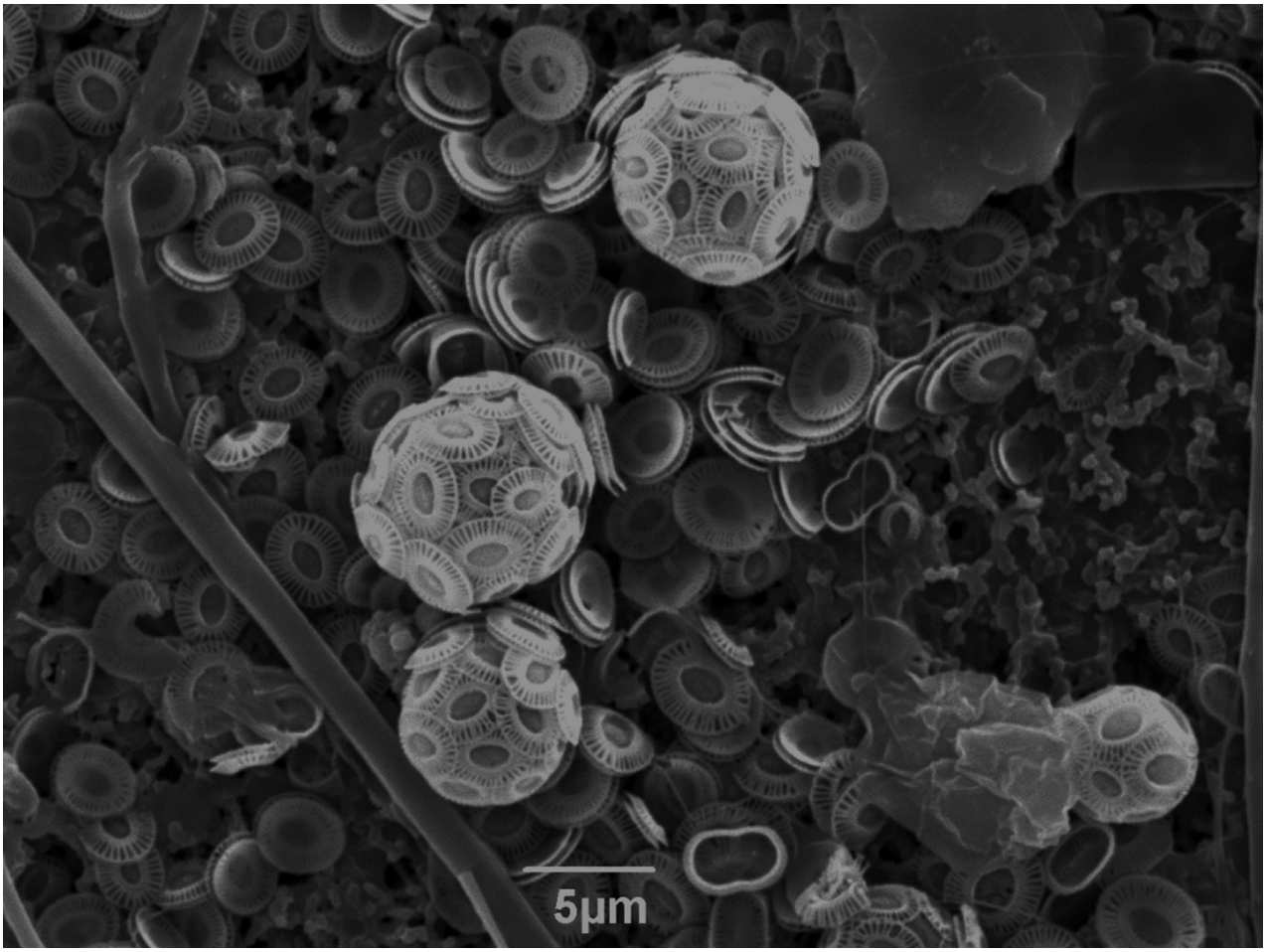


Figure 1: Black Sea waters coccolithophore assemblage

Coccolithophore and diatom distribution across the main pelagic zonal systems of the Southern Ocean

Andrés S. Rigual-Hernández
Universidad de Salamanca, Departamento de Geología, 37008 Salamanca, Spain; arigual@usal.es

Jessica Wilks
Macquarie University, Marine Research Centre, Department of Biological Sciences, North Ryde, NSW 2109, Australia; jessica.wilks@students.mq.edu.au

Tom W. Trull
University of Tasmania, Antarctic Climate and Ecosystems Cooperative Research Centre, Hobart, Tasmania 7001, Australia; CSIRO Oceans and Atmosphere Flagship, Hobart, Tasmania 7001, Australia; Tom.Trull@csiro.au

Francisco J. Sierro
Universidad de Salamanca, Departamento de Geología, Facultad de Ciencias, 37008 Salamanca, Spain; sierro@usal.es

Miguel Ángel Fuertes
Universidad de Salamanca, Departamento de Geología, 37008 Salamanca, Spain; fuertes@usal.es

Stephen G. Bray
Macquarie University, Marine Research Centre, Department of Biological Sciences, North Ryde, NSW 2109, Australia; stephenb4321@gmail.com

Leanne K. Armand
Macquarie University, Marine Research Centre, Department of Biological Sciences, North Ryde, NSW 2109, Australia; leanne.armand@mq.edu.au

Jose-A. Flores
Universidad de Salamanca, Departamento de Geologia, Facultad de Ciencias, 37008 Salamanca, Spain; flores@usal.es

Time series sediment traps were deployed along a transect between Tasmania and Antarctica in order to quantify and characterize the seasonal and inter-annual variability of particle fluxes in the main oceanographic regions of the Southern Ocean: the Subantarctic Zone (SAZ), Polar Frontal Zone (PFZ), and Antarctic Zone (AZ). Additionally, the composition and temporal variability of coccolithophore and diatom sinking assemblages were studied at the three sites. Total mass fluxes were highest in the AZ, followed by the PFZ, and then the SAZ. Bulk chemical composition of the particle fluxes mirrored the composition of the distinct plankton communities in the surface layer. The latitudinal variation of the total coccolith and diatom fluxes was found to be in line with the carbonate and biogenic silica export, respectively. While the carbonate fraction was the main component of the particle fluxes in the SAZ, where coccolithophores are most abundant, the biogenic silica fraction dominated the particle export in the PFZ and AZ, where phytoplankton assemblages are dominated by diatoms. Despite the fact that total mass fluxes were significantly higher in the AZ and PFZ as compared to those of the AZ, particulate organic carbon (POC) export was similar for the annual average at the three sites (~1g m^{-2} yr^{-1}). Our results suggest that the latitudinal variations in the composition and abundance of phytoplankton communities largely influence the efficiency of the biological pump across the zonal systems of the Southern Ocean.

Ocean and monsoonal dynamics of the Japan Sea over the last 450,000 years – a coccolithophore perspective

Mariem Saavedra-Pellitero
University of Bremen, Department of Geosciences, 28334 Bremen, Germany; msaavedr@uni-bremen.de

Karl-Heinz Baumann
University of Bremen, Department of Geosciences, 28334 Bremen, Germany; baumann@uni-bremen.de

The semi-enclosed Japan Sea, located in the northwest margin of the Pacific Ocean, is an ideal region to investigate the interaction between the ocean, climate, and sea-level variability. Integrated Ocean Drilling Program (IODP) Expedition 346 (July 29-September 27, 2013), from Valdez, Alaska to Busan, South Korea, drilled seven sites in the Japan Sea and two sites in the East China Sea.

Site U1427, located at 35°57.9'N, 134°26.1'E in a 330m water depth in the Yamato Basin, was selected for this study. Coccolithophore paleoproductivity was reconstructed for the last 450kyr using coccolithophore assemblages and coccolith absolute numbers. Samples were prepared using a combined technique of dilution and filtering. Following the counting routine, a minimum of 400 whole coccoliths per sample were recognized and classified using a scanning electron microscope at 3000X and 5000X. Coccolith preservation was generally poor to moderate, and the number of coccoliths remained relatively low, except during interglacials, when *Gephyrocapsa oceanica*, *Calcidiscus leptoporus*, and *Helicosphaera carteri* peaked due to influx of the Tsushima Warm Current into the Japan Sea.

Coccolithophore productivity during MIS 11 in the Pacific sector of the Southern Ocean and its impact on the carbon cycle

Mariem Saavedra-Pellitero
University of Bremen, Department of Geosciences, 28334 Bremen, Germany; msaavedr@uni-bremen.de

Karl-Heinz Baumann
University of Bremen, Department of Geosciences, 28334 Bremen, Germany; baumann@uni-bremen.de

Frank Lamy
Alfred-Wegener-Institut, Helmholtz-Zentrum für Polar-und Meeresforschung (AWI), D-27568, Bremerhaven, Germany; Frank.Lamy@awi.de,

Peter Köhler
Alfred-Wegener-Institut, Helmholtz-Zentrum für Polar-und Meeresforschung (AWI), D-27568, Bremerhaven, Germany; pkoehler@awi.de

Johannes Ullermann
Alfred-Wegener-Institut, Helmholtz-Zentrum für Polar-und Meeresforschung (AWI), D-27568, Bremerhaven, Germany; Johannes.Ullermann@awi.de

Proxy-based reconstructions of past changes in the marine biological carbon pumps are still limited, especially in the Southern Ocean. This study provides new insights into productivity variations in the Pacific sector of the Southern Ocean during Marine Isotope Stage 11 (MIS 11; between ca. 424 and 374kyr).

In this study, we present new data that was derived from three sediment cores (PS75/059-2, PS75/76-2, and PS75/079-2) that show glacial/interglacial coccolithophore variability across MIS 11. The cores were retrieved from Polarstern cruise PS75 and were located at water depths between 3613m and 3742m within an area 54.3ºS to 57.5ºS and 125.4ºW to 157.2ºW. Coccolithophore assemblages were dominated by the species *Gephyrocapsa caribbeanica,* followed by small *Gephyrocapsa* spp. Total numbers of coccoliths, coccolith fraction (CF; <20μm-fraction), Sr/Ca data, and temperature-corrected CF Sr/Ca records consistently showed an increase in coccolithophore productivity during Termination V, highest productivity throughout most of MIS 11, and a decrease during late MIS 11 in all the cores. Additionally, we back calculated coccolith calcification rates for the ocean surface and considered its potential contribution to changes in the concentration of atmospheric CO_2.

Calcareous nannofossils from the Manavgat Sub-basin, SW Turkey, reveal the age of lower Pleistocene paleotsunami deposits that overlie a late Pliocene erosional surface

Enis Kemal Sagular
Suleyman Demirel University, Faculty of Engineering, Department of Geological Engineering, 32260 Isparta, Turkey; eniskemal@gmail.com

Gülin Yavuzlar
Suleyman Demirel University, Faculty of Engineering, Department of Geological Engineering, 32260 Isparta, Turkey; gulinyavuzlar@gmail.com

In the Manavgat Sub-basin (southwestern Turkey), which is part of the eastern Mediterranean marginal basin, this study discovered an erosional surface that formed during the late Pliocene regression. This hiatus is overlain by lower Pleistocene paleotsunami deposits that are probably the result of earthquakes below the Mediterranean that caused rapid and short-lived sea flooding of the coastal plain. Sedimentologic and biostratigraphic examination of rock samples from 13 locations provided evidence of this new regressive succession.

The lower Pleistocene paleotsunami zone, which is two to three meters thick, has bimodal-grained clastic sediments that are composed of a muddy matrix with grain components varying from sand to boulder in size. The muddy matrix contains both macrofossils and microfossils reflective of various environmental, sedimentological, and stratigraphic conditions. The sand to boulder components consist of marl, sandstone, conglomerate, and limestone, which are reworked from extrabasin deposits and reef block or boulders that were removed from the intrabasin.

Examination of calcareous nannofossils revealed two distinct sedimentary sequences, one below and one above the paleotsunami deposits. The lower deposits were placed in calcareous nannofossil Zone NN15, and the upper deposit is within Zone NN19. The calcareous nannofossils suggest that the tsunami event/s occurred between 1.81Ma and 1.60Ma (Gelasian-Calabrian transition), which corresponds to the beginning of Zone NN19.

This study was financially supported by TÜBİTAK project: 114Y236.

Timing and paleoceanographic implications of the North Sea 'base Cretaceous unconformity' event at its correlative conformity: a multi-disciplinary core study, North Jens-1 well, Danish Central Graben

Emma Sheldon
Geological Survey of Denmark and Greenland (GEUS), Stratigraphy Department, DK 1350, Copenhagen K, Denmark; es@geus.dk

Karen Dybkjær
Geological Survey of Denmark and Greenland (GEUS), Stratigraphy Department, DK 1350, Copenhagen K, Denmark; kd@geus.dk

Jon Ineson
Geological Survey of Denmark and Greenland (GEUS), Stratigraphy Department, DK 1350, Copenhagen K, Denmark; ji@geus.dk

The so-called 'base Cretaceous unconformity' (BCU) in the North Sea was traditionally considered to be a widespread event with a hiatus at marginal areas, structural highs, and deeper parts of the North Sea Basin. Increased biostratigraphic resolution revealed the existence of complete, often condensed sections on the highs and conformable sequences in the basins. In the earliest Cretaceous basinal settings of the Danish Central Graben, borehole sections through the BCU 'correlative conformity' reveal a shift from dark grey, variably carbonaceous and calcareous, organic-rich claystones of the Farsund Formation to marlstones and chalky limestones of the lowermost Valhall Formation. Though rarely cored in the North Sea, the event was spanned by a 17m thick core in the North Jens-1 well that provided the opportunity for an integrated sedimentological, biostratigraphic, and paleoecological study.

Multidisciplinary biostratigraphic and palynofacies analyses that span the late Ryazanian-early Valanginian reveal a shift in fossil assemblages and palynofacies reflective of a transition from dysoxic bottom conditions and stratified water column, linked to the Farsund Formation, to open-marine conditions and well oxygenated bottom waters associated with the Valhall Formation.

The Farsund Formation nannofossil assemblages included age indicative *Sollasites arcuatus*, *Kokia curvata*, abundant *Watznaueria barnesiae*, and common *Cyclagelosphaera margereli*i. The dinocyst assemblage was dominated by *Canningia compta*, *Sentusidinium* spp., and *Hystrichodinium voigtii* and in the uppermost part by the late Ryazanian marker *Oligosphaeridium diluculum*. Pyritised radiolaria, abundant amorphous organic matter, and common prasinophycean algae indicated a stratified water column in a restricted basin.

The Valhall Formation nannofossil assemblage is dominated by *Watznaueria barnesiae* and includes *Micrantholithus brevis*, *Stradnerlithus silvaradius*, and *Nannoconus kamptneri kamptneri*. The relatively high abundance dinocyst assemblage includes the basal Valanginian marker *Achomosphaera neptunii*. Reduced amorphous organic matter, rare prasinophycean algae, and a relatively rich calcareous benthic foraminifera fauna, dominated by *Lenticulina muensteri*, indicate oxygen-rich bottom waters and mixing of the water column.

Micula prinsii: a latest Maastrichtian marker - its record from low-latitude northeast India, Meghalaya

Abha Singh

Birbal Sahni Institute of Palaeosciences, Lucknow-226007, India; abha.maurya@gmail.com

A significant calcareous nannofossil assemblage was recorded from the latest Maastrichtian at a roadside section near Syndai village, Meghalaya. Twenty-one samples were studied from shales and sandy shales that had some calcareous intervals, but only ten samples were found to be productive. The assemblage recorded from the productive samples was indicative of the *Micula prinsii* Zone. The assemblage was mainly represented by *Arkhangelskiella cymbiformis*, *Braarudosphaera bigelowii*, *Calculites obscurus*, *Chiastozygus litterarius*, *Cretarhabdus conicus*, *Cribrosphaerella ehrenbergii*, *Cyclagelosphaera margerelii*, *Cylindralithus sculptus*, *Eiffellithus sp.*, *Eiffellithus turriseiffelii*, *Microrhabdulus undosus*, *Micula concava*, *M. murus*, *M. praemurus*, *M. premolisilvae*, *M. prinsii*, *M. staurophora*, *M. swastika*, *Prediscosphaera cretacea*, *Quadrum gartneri*, *Radiolithus planus*, *Retecapsa ficula*, *Scrippsiella* test fragments, *Thoracosphaera* spp., *Watznaueria barnesiae,* and *W. ovata*.

Micula prinsii Perch-Nielsen is the latest Maastrichtian marker all over the globe. It has been recorded from both deep-sea sections and shelf areas. It is the most evolved form of the genus *Micula* and became extinct just before the K/T boundary. The *Micula prinsii* Zone occurs from the first occurrence of *Micula prinsii* to the last occurrence of unreworked, non-survivor Cretaceous taxa, and it correlates well with the CC26b Zone of Perch Nielsen and the UC 20d^{TP} Zone of Burnett.

Previous records of calcareous nannofossils from late Maastrichtian and Cretaceous-Tertiary boundary sections indicated a doubtful presence of *Micula prinsii* from Indian sections. There are only two published papers that reported the actual presence of *Micula prinsii* in India. Garg & Jain (1995) recorded this species from the well-known Um Sohryngkew section from Meghalaya, northeast India, and the other record is from the Ariyalur Formation, Vridhhachalam, South India (Rai *et al*., 2013). Therefore, the presence of *Micula prinsii* in latest Cretaceous sections in northeastern India, which were found in this study, is of significant value.

References

Garg, R. & Jain, K.P. 1995. Significance of the terminal Cretaceous calcareous nannofossil marker *Micula prinsii* at the Cretaceous-Tertiary boundary in the Um Sohryngkew section, Meghalaya, India. *Current Science*, **69**(12): 1012–1017.

Rai, J., Malarkodi, N. & Singh, A. 2013. Terminal Maastrichtian age calcareous nannofossils preceding K/T mass extinction from Ariyalur Formation, Vridhhachalam area, South India. *Special Publication Geological Society of India*, **1**: 1–15.

Coccolithophore export fluxes in the NE Mediterranean as revealed from different sediment trap records

Elisavet Skampa
National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; skampaelisavet@gmail.com

Maria V. Triantaphyllou
National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; mtriant@geol.uoa.gr

Margarita D. Dimiza
National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; mdimiza@geol.uoa.gr

Elisa Malinverno
Università degli Studi di Milano-Bicocca, Dipartimento di Scienze dell'Ambiente e della Terra, 20126 Milano, Italy; elisa.malinverno@unimib.it

Odysseas A. Archontikis
National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; odysseas67@windowslive.com

Karl-Heinz Baumann
University of Bremen, Department of Geosciences, 28334 Bremen, Germany; baumann@uni-bremen.de

Constantine Parinos
Hellenic Centre for Marine Research, Institute of Oceanography, 190 13 Anavyssos, Attiki, Greece; ksparinos@hcmr.gr

Spyros Stavrakakis
Hellenic Centre for Marine Research, Institute of Oceanography, 190 13 Anavyssos, Attiki, Greece; stavrak@hcmr.gr

Alexandra Gogou
Hellenic Centre for Marine Research, Institute of Oceanography, 190 13 Anavyssos, Attiki, Greece; agogou@hcmr.gr

Coccolithophore export was investigated in three eastern Mediterranean sediment trap sites: the mesotrophic northern Aegean Sea (500m; October 2014–November 2015), the ultra-oligotrophic southern Aegean/Cretan Sea (1,500m; December 2014–December 2015), and the oligotrophic SE Ionian Sea (2,000m; October 2014–September 2015).

Coccolithophore fluxes (coccospheres m^{-2} day^{-1}) revealed a highly seasonal pattern with a peak during February to March (northern Aegean: max. 8.56×10^6, Ionian Sea: max. 0.81×10^6, Cretan Sea: max. 3.37×10^6). The flux maxima occurred during water column mixing and coincided with an interval of decreased sea surface temperatures (SST). Coccosphere fluxes were dominated (on average) by *Emiliania huxleyi* (75% in the northern Aegean, ~50% in Cretan and Ionian Seas), followed by *Syracosphaera* spp. (14% in the northern Aegean, ~10% in Cretan and Ionian Seas), and *Algirosphaera robusta* (>45% during February in the Ionian Sea). *Umbilicosphaera sibogae* was the most important of the minor species, particularly in the Cretan Sea (13% in average, max. flux 1.01×10^6 coccospheres m^{-2} day^{-1} in March). Northern Aegean total coccosphere flux was considerably higher due to the prominent seasonal peak of *E. huxleyi* (>95% in January).

A comparable seasonal signal in coccosphere fluxes occurred within a previously sampled time series at the same locations. However, a trend towards increasing fluxes (coccospheres m^{-2} day^{-1}) was observed (northern Aegean Sea in 2011: max. 0.29×10^6, Cretan Sea in 2001: max. 0.4×10^6). Overall, the fluxes were strongly dependent on the regeneration of nutrients by winter vertical mixing in the northern Aegean and/or the fertilizing influence of episodic dust input events in the southern Aegean and Ionian Seas (e.g., Triantaphyllou *et al*., 2004; Stavrakakis *et al*., 2013; Dimiza *et al*., 2015).

Using the SEM, a comparative study of trap samples from the SE Ionian and Cretan Seas was made of *E. huxleyi* calcification and the effect on its morphology. Higher relative tube width values (~0.3 in the Cretan Sea, >0.35 in the Ionian) occurred when increased coccolithophore productivity time intervals coincided with SST minima, which matches the seasonal calcification pattern found in the NE Mediterranean (Triantaphyllou *et al*., 2010).

References

Dimiza, M.D., Triantaphyllou, M.V., Malinverno, E., Psarra, S., Karatsolis, B., Mara, P., Lagaria, A. & Gogou, A. 2015. The composition and distribution of living coccolithophores in the Aegean Sea (NE Mediterranean). *Micropaleontology*, **61**: 521–540.

Stavrakakis, S., Gogou, A., Krasakopoulou, E., Karageorgis, A.P., Kontoyiannis, H., Rousakis, G., Velaoras, D., Perivoliotis, L., Kambouri, G., Stavrakaki, I. & Lykousis V. 2013. Downward fluxes of sinking particulate matter in the deep Ionian Sea (NESTOR site), Eastern Mediterranean: seasonal and interannual variability. *Biogeosciences Discussions*, **10**: 591–641.

Triantaphyllou, M.V., Dimiza, M.D., Krasakopoulou, E., Malinverno, E., Lianou, V. & Souvermezoglou, E. 2010. Seasonal control on *Emiliania huxleyi* coccolith morphology and calcification in the Aegean Sea (Eastern Mediterranean). *Geobios*, **43**, 99–110.

Triantaphyllou, M.V., Ziveri, P. & Tselepides, A. 2004. Coccolithophore export production and response to seasonal surface water variability in the oligotrophic Cretan Sea (NE Mediterranean). *Micropaleontology*, **50**: 127–144.

Winter-spring aspect of coccolithophore species diversity in the open waters of the central Adriatic Sea

Sanda Skejić
Institute of Oceanography and Fisheries, 21000 Split, Croatia; sanda@izor.hr

Jasna Arapov
Institute of Oceanography and Fisheries, 21000 Split, Croatia; arapov@izor.hr

Mia Bužančić
Institute of Oceanography and Fisheries, 21000 Split, Croatia; buzancic@izor.hr

Ana Bakrač
Institute of Oceanography and Fisheries, 21000 Split, Croatia; jelacic@izor.hr

Gladan Živana Ninčević
Institute of Oceanography and Fisheries, 21000 Split, Croatia; nincevic@izor.hr

This study presents preliminary results of coccolithophore diversities gained from a winter-spring cruise in 2015-2016 along a transect in the central Adriatic Sea. Coccolithophores in this area were relatively diverse, and a total of 84 morphotypes (58 species) were identified using the scanning electron microscope (SEM). *Emiliania huxleyi,* the most abundant and the most frequently occurring species, and was present in all samples.

During the study period, 10 species occurred in both heterococcolith (HET) and holococcolith (HOL) phases. Among these, four species appeared in a combination HET/HOL phase: *Acanthoica quattrospina*, *Syracosphaera pulchra*, *Syracosphaera molischii*, and *Syracosphaera histrica* (only in spring). Species in the HET phase were dominant in both seasons, while a greater incidence of the HOL phase was recorded during the spring. We noticed that in the spring, the HOL phase of *Coronosphaera mediterranea* and *S. histrica* dominated over their HET phase.

The euphotic layer in early spring showed a higher diversity in comparison to deeper layers (below 50m), while the winter period was not characterized by any regular diversity pattern through its vertical profile. With regard to spatial distribution, diversity decreased toward the northeast (from station 20 to station 24) in both seasons. The average number of species recorded per sample was slightly higher in the spring, and consequently, a higher Shannon diversity index (H'=1.99) was recorded in the spring in comparison to the winter period (H'=1.70). The dominant genus, *Syracosphaera*, was represented by 20 species.

Tithonian–early Berriasian calcareous nannofossil events in Barlya, Bulgaria, and Lókút, Hungary: calibration with magnetostratigraphy and calpionellid biostratigraphy

Kristalina Stoykova
Bulgarian Academy of Sciences, Geological Institute, 1113 Sofia, Bulgaria; stoykova@geology.bas.bg

Jacek Grabowski
Polish Geological Institute – National Research Institute, 00-975 Warszawa, Poland; jacek.grabowski@pgi.gov.pl

Iskra Lakova
Bulgarian Academy of Sciences, Geological Institute, 1113 Sofia, Bulgaria; lakova@geology.bas.bg

We present a high-resolution nannofossil bioevent record through the Tithonian-Berriasian boundary interval at two distant Tethyan sections: Barlya, western Bulgaria and Lókút, northern Hungary. Both sections display a similar sedimentary succession of pelagic limestones. The Barlya section (western Balkan Mountains) exposes a thick and continuous Tithonian to Valanginian carbonate sequence (>100m) (Lakova & Petrova, 2013). However, the upper Tithonian to lower Berriasian part of this section is partially remagnetized and correlation of nannofossil events with magnetic stratigraphy can only be provisional. The Lókút section (Bakony Mountains) represents a ca. 13m-thick succession of early Tithonian to early Berriasian age and is precisely dated with calpionellids and magnetostratigraphy (Grabowski *et al*., 2010).

A comprehensive review of previous and present data on nannofossil and magnetostratigraphy correlation clearly showed two distinct groups of nannofosil taxa: one with rather scattered and diachronous first occurrences (FOs), and the second with a more or less consistent FO record between the different sections. The first group includes *Conusphaera mexicana mexicana*, *Polycostella beckmannii*, *Cyclagelosphaera argoensis*, *Hexalithus noeliae*, and *Nannoconus infans*. These taxa's FOs demonstrate diachroneity in the Tethyan domain and thus cannot be used for precise correlation.

The second group includes *Nannoconus globulus minor*, *Hexalithus geometricus*, *N. globulus globulus*, *N. wintereri*, *Cruciellipsis cuvillieri*, *N. steinmanni minor*, and *N. kamptneri minor*. Overall, their FOs fall within the long M19 chron. The FO of *Hexalithus geometricus* seems to be a fairly consistent bioevent at the middle of the M19n2n subchron and thus of potential use for detailed correlation. The FOs of *N. steinmanni minor* and *N. kamptneri minor*, commonly used for biostratigraphic zonation, were concentrated within the upper part of M19n. It is worth noting that the next two species to evolve in the early Berriasian, *N. steinmanni steinmanni* and *N. kamptneri kamptneri*, showed relatively dispersed FOs within the M19n1r–M17r chrons, which may be due to preservation problems, problematic bio-magnetostratigraphy calibrations, or simple diachroneity.

The investigation was partially financed by the project DNTS Slovakia 01/9-2016 of Bulgarian NSF.

References

Grabowski, J., Haas, J., Márton, E. & Pszczółkowski, A. 2010. Magneto- and biostratigraphy of the Jurassic/Cretaceous boundary in the Lókút section (Transdanubian Range, Hungary). *Studia Geophysica Geodaetica*, **54**(1): 1–26.

Lakova, I. & Petrova, S. 2013. Towards a standard Tithonian to Valanginian calpionellid zonation of the Tethyan Realm. *Acta Geologica Polonica*, **63**(2): 201–221.

Nannofossil evidence for the age and depositional environment during the onset of rifting in the South China Sea and the West Philippine Sea

Xin Su

Chinese Academy of Sciences, South China Sea Institute of Oceanology, Key Laboratory of Ocean and Marginal Sea Geology, Guangzhou 510301, China; Tongji University, State Key Laboratory of Marine Geology, Shanghai 200092, China; xsu@cugb.edu.cn

Denise K. Kulhanek

Integrated Ocean Discovery Program, Texas A&M University, College Station TX 77845, USA; kulhanek@iodp.tamu.edu

Early Oligocene nannofossil samples were examined from four sites [Well BY7-1-1, ODP Site 1148, and IODP Site U1435 in the South China Sea (SCS) and ODP Site 1201 in the West Philippine Sea (WPS)] in order to determine the age and depositional environment during the onset of rifting in the region. Four early Oligocene bioevents were identified for Site U1435, which assigned lithostratigraphic Subunit IB to Oligocene nannofossil Zones NP 21–23, with an ~3.81 My depositional duration (<33.43Ma and >29.62Ma). The presence of the LAD of *Coccolithus formosus* in the basal sediments of Site 1148 assigned an age of <33.4Ma.

The thickness of lower Oligocene Zones NP21–NP24 sequences was found to have varied significantly between basins and within the SCS. The sequence at Site 1148 is ten times thicker than that at Site U1435. A sharp sedimentation hiatus was recognized between 30.00 and 32.02Ma at Site U1435, which may be due to erosion by bottom currents. An age of ~33Ma within early Oligocene nannofossil Zone NP21 was estimated for the onset of rifting of the northern SCS, which is an important time of interaction or transformation between the two marginal seas in the western Pacific, when the WPS ceased rifting and the SCS started rifting.

Nannofossil data indicated that during the initial development of the northern SCS, the depositional environment was shallow seawater from near the shoreline to neritic depths. The differences in the evolution of the basement structure/topography and sedimentary processes between the sites since the onset of rifting is summarized and discussed.

Changes in coccolith weight in the northern South China Sea and their environmental controls

Xiang Su

Chinese Academy of Sciences, South China Sea Institute of Oceanology, Key Laboratory of Ocean and Marginal Sea Geology, Guangzhou 510301, China; Tongji University, State Key Laboratory of Marine Geology, Shanghai 200092, China; suxiang@scsio.ac.cn

Chuanlian Liu

Tongji University, State Key Laboratory of Marine Geology, Shanghai 200092, China; liucl@tongji.edu.cn

Luc Beaufort

Aix-Marseille University, CNRS, IRD, Col. France; CEREGE, Aix en Provence, France; beaufort@cerege.fr

Coccolithophores are one of the most abundant and widespread groups of calcifying plankton and have attracted extensive study in terms of their likely response to ocean acidification. Because of the minuteness of coccoliths, it is difficult to estimate their amount of calcite. Here we applied the SYRACO system (computational image analysis of smear slides) to analyze the morphology and weight of coccoliths produced by the dominant coccolithophore groups. We obtained high-resolution coccolith weight records for *Emiliania huxleyi* and *Gephyrocapsa* spp. from sediment core MD05-2904 in the northern South China Sea over the past 200ka. To compare climatic and environmental variables, the carbonate chemistry parameters, including pH, carbonate content, and bicarbonate content of sea water, were calculated using existing available data. The two sets of coccolith weights showed different patterns over the last 200ka. The weight of *E. huxleyi* correlated with the seawater pH and pCO_2 variations, while the weight of *Gephyrocapsa* spp. was partly negatively related to the seawater pH variations. Both of the two time series showed great changes during the last two glacial terminations, which were characterized by a quick increase in atmospheric CO_2 concentration. Our data revealed that temperature and salinity were not strongly correlated with coccolith weight. Similar to most previous culture studies, the increasing of pCO_2 had a different impact on different coccolithophore species. Coccolithophore calcification is thought to be affected by multiple factors, including nutrient content, insolation, and carbonate chemistry, which have different influences depending upon the period of time.

Pelagic carbonate production across the Cretaceous-Paleogene boundary

Baptiste Suchéras-Marx

Aix-Marseille University, CNRS, IRD, Col. France; CEREGE, Aix en Provence, France; sucheras-marx@cerege.fr

Thomas Marfil

Aix-Marseille University, CNRS, IRD, Col. France; CEREGE, Aix en Provence, France; marfil@osupytheas.fr

Luc Beaufort

Aix-Marseille University, CNRS, IRD, Col. France; CEREGE, Aix en Provence, France; beaufort@cerege.fr

The Cretaceous-Paleogene (K/Pg) boundary is one of the most important mass extinction events during the Phanerozoic. Caused by the volcanism of Deccan Traps and/or the impact of a meteorite, this mass extinction had a disastrous impact on calcareous nannofossil diversity and led to the most important turnover in their evolutionary history. The K/Pg mass extinction also led to an important change in pelagic carbonate production and accumulation, which deeply perturbed the carbonate system. The aim of this study was to quantify nannofossil carbonate accumulation rates before and after the K/Pg boundary in order to understand (1) the impact of the volcanism on calcareous nannofossil size and carbonate production, (2) the impact of the mass extinction event on the pelagic carbonate accumulation rate, and (3) the timing of recovery to stable and efficient pelagic carbonate production and accumulation after the crisis. Ultimately, the aim was to estimate the impact of the K/Pg mass extinction on carbonate and carbon cycles.

Three deep-sea sites were studied: ODP Site 762C from the eastern Indian Ocean, IODP Site 1209 from the northwestern Pacific Ocean, and IODP Site 1267 from the southeastern Atlantic Ocean. These sites have been precisely dated by cyclostratigraphy and biostratigraphy (Husson *et al*., 2011; Westerhold *et al*., 2011; Dinarès-Turell *et al*., 2014) and present continuous sedimentation in the studied interval. We studied approximately 100 samples per site that covered about 3Myr before and 3Myr after the K/Pg boundary. For each sample, the total carbonate content was measured, and its accumulation rate was estimated. We performed biometry on the nannofossils (size and mass) in order to trace the morphometric variability of nannofossils and species specific carbonate accumulation rates through the K/Pg boundary.

References

Dinarès-Turell, J., Westerhold, T., Pujalte, V., Röhl, U. & Kroon, D. 2014. Astronomical calibration of the Danian stage (Early Paleocene) revisited: Settling chronologies of sedimentary records across the Atlantic and Pacific Oceans. *Earth and Planetary Science Letters*, **405**: 119–131.

Husson, D., Galbrun, B., Laskar, J., Hinnov, L.A., Thibault, N., Gardin, S. & Locklair, R.E. 2011. Astronomical calibration of the Maastrichtian (Late Cretaceous). *Earth and Planetary Science Letters*, **305**: 328–340.

Westerhold, T., Röhl, U., Donner, B., McCarren, H.K. & Zachos, J.C. 2011. A complete high-resolution Paleocene benthic stable isotope record for the central Pacific (ODP Site 1209). *Paleoceanography*, **26**: PA2216.

The last 1 million years of discoasters: late Pliocene productivity at IODP Site U1476 (Mozambique Channel)

Deborah N. Tangunan

University of Bremen, MARUM - Center for Marine Environmental Sciences, 28334 Bremen Germany; tangunan@uni-bremen.de

Karl-Heinz Baumann

University of Bremen, Department of Geosciences, 28334 Bremen, Germany; baumann@uni-bremen.de

Luna Brentegani

Queensland University of Technology, Gardens Point Campus, Earth and Environmental Sciences, Brisbane QLD 4000, Australia; luna.brentegani@qut.edu.au

IODP Expedition 361 Scientists

Discoaster is an extinct coccolithophore genus that exhibited a fairly continuous evolutionary development from the first occurrence of its oldest forms during the late Paleocene (~60Ma) to the extinction of the last species by the end of the Pliocene (1.93Ma). Previous works suggested that the inception of bipolar glaciation during the Pliocene led to the successive disappearance of these species. Here, we present initial results from the productivity reconstruction of sediments collected during the IODP Expedition 36, southern African climates at the Mozambique Channel (Site U1476), which focused on the last one million years of the discoasters (2.9 to 1.9Ma). New productivity data were obtained from the abundances and accumulation rates of the last five *Discoaster* species (*Discoaster brouweri*, *D. triradiatus*, *D. pentaradiatus*, *D. surculus*, and *D. tamalis*). The results were then compared to the downcore record of *Florisphaera profunda*, a known and widely used productivity proxy, and to the shipboard geochemical and sedimentological data.

Evidence of tropical Pacific forcing in the western Indian Ocean coccolithophore productivity record

Deborah N. Tangunan
University of Bremen, MARUM - Center for Marine Environmental Sciences, 28334 Bremen Germany; tangunan@uni-bremen.de

Karl-Heinz Baumann
University of Bremen, Department of Geosciences, 28334 Bremen, Germany; baumann@uni-bremen.de

Jürgen Pätzold
University of Bremen, MARUM - Center for Marine Environmental Sciences, 28334 Bremen, Germany; jpaetzold@marum.de

Rudiger Henrich
University of Bremen, Department of Geosciences, 28334 Bremen, Germany; henrich@uni-bremen.de

Michal Kucera
University of Bremen, MARUM - Center for Marine Environmental Sciences, 28334 Bremen Germany; mkucera@marum.de

Ricardo De Pol-Holz
Universidad de Magallanes, GAIA-Antártica, Center for Climate and Resilience Research (CR), 6210427 Punta Arenas, Chile; ricardo.depol@umag.cl

Jeroen Groeneveld
University of Bremen, Department of Geosciences, 28334 Bremen Germany; jgroenev@uni-bremen.de

We present a new coccolithophore productivity reconstruction that covers the last two glacial-interglacial cycles in sediment core GeoB12613-1, which was retrieved from the western tropical Indian Ocean, an area that mainly derives its warm and oligotrophic surface waters from the eastern Indian Ocean. Our results were compared to the record from an upwelling region off the southern tip of Sumatra (SO139-74KL; Andruleit *et al*., 2008), which allowed us to determine the productivity and water-column dynamics between the eastern and the western Indian Ocean regions. *Florisphaera profunda* index and estimated primary productivity (EPP) records from GeoB12613-1 and SO139-74KL show the same long-term trend in paleoproductivity over the studied time period (i.e., strengthening of stratification and reduced productivity towards the Holocene). We observed a similar orbital cyclicity at the precession and also at the obliquity band. Moreover, the strong similarity in the EPP trend at a different period of time and the opposing pattern in the water-column stratification proxy *F. profunda* index suggest the possible existence of an Indian Ocean dipole (IOD) that is analogous to the present day and thus operated on a longer time scale. This is in contrast to the current view of the IOD, which is based only on the Holocene timescales.

References

Andruleit, H., Luckge, A., Wiedicke, M. & Stager, S. 2008. Late Quaternary development of the Java upwelling system (eastern Indian Ocean) as revealed by coccolithophore. *Marine Micropaleontology*, **69**(1): 3–15.

Abundance and size changes in *Schizosphaerella* – relation to climatic and paleoenvironmental change across the Early Jurassic in the Paris Basin

Nicolas Thibault
University of Copenhagen, IGN, Øster Voldgade 10, DK-1350, Copenhagen C., Denmark; nt@ign.ku.dk

Leonie Peti
University of Auckland, School of Environment, PB 92019, Auckland, New Zealand; lpet986@aucklanduni.ac.nz

Abundance and size changes in the calcareous nannofossil genus *Schizosphaerella* were investigated during the Early Jurassic (late Sinemurian to early Toarcian) of the Sancerre-Couy core (Paris Basin). Measurements were compared to variations in $CaCO_3$ content, total organic carbon (TOC) content, and isotopic trends in carbon and oxygen. Our results confirm that *Schizosphaerella* was better adapted to proximal areas than coccoliths, as expressed by the stepwise rise in abundance of *Schizosphaerella* that was followed by a rise in abundance of coccoliths during the major transgression of the Sinemurian. The results show that changes in the size of *Schizosphaerella* were primarily a response to Early Jurassic temperature variations (icehouse and coolhouse versus greenhouse conditions). Large average sizes of *Schizosphaerella* corresponded mainly to the proximal, cool environmental conditions of the upper Sinemurian. Medium average sizes corresponded to more distal conditions and cool surface waters, whereas small average sizes were associated with warm episodes. Biometry statistics also suggest the presence of three main morphotypes and the possibility of an additional fourth morphotype with relatively minor contributions. Changes in the average size of *Schizosphaerella* thus appear to be controlled by changes in the relative abundance of these morphotypes that likely had distinct environmental preferences. These results suggest that *Schizosphaerella* size variations at the Toarcian oceanic anoxic event and preceding environmental perturbations of the Early Jurassic were probably not a physiological response to lower calcification but rather represent changes in abundances of the different ecophenotypes or (sub-) species in response to climate change.

Paleoceanography for the last 772ky in the western South Atlantic by means of calcareous nannofossils

Felipe A.L. Toledo
Oceanographic Institute of the University of São Paulo, LaPAS – South Atlantic Paleoceanography Laboratory, São Paulo, Brazil; ftoledo@usp.br

Juliana P. Quadros
Oceanographic Institute of the University of São Paulo, LaPAS – South Atlantic Paleoceanography Laboratory, São Paulo, Brazil; jupq82@gmail.com

Edmundo Camillo, Jr.
Oceanographic Institute of the University of São Paulo, LaPAS – South Atlantic Paleoceanography Laboratory, São Paulo, Brazil; Edmundocamillo@gmail.com

Karen B. Costa
Oceanographic Institute of the University of São Paulo, LaPAS – South Atlantic Paleoceanography Laboratory, São Paulo, Brazil; karen.costa@usp.br

Changes in paleoceanography and paleoproductivity patterns from MIS 18 to the Holocene were identified by analyzing coccolithophore assemblages from core KF-18, which is located on the Brazilian continental margin. During the Mid-Brunhes Event (MBE) (MIS 15-9), assemblages were characterized by higher nannoplankton abundances, lower diversity, and a bloom of the opportunistic genus *Gephyrocapsa* (mainly *G. caribbeanica*). Variations in coccolithophore abundance have been related to glacial–interglacial cycles, as well as to glacial terminations when the greatest calcium carbonate concentrations occurred, and several species showed higher relative abundance values. Our study suggests that there was an increase in productivity during terminations and increased percentages of *Coccolithus pelagicus* at MIS 8-6. *Coccolithus pelagicus* sharply decreased around 170ky, which was concurrent with abundant occurrences of *Emiliania huxleyi*, *Cyclococcolithus leptoporus*, *Rhabdosphaera* spp., *Syracosphaera* spp., and *Umbilicosphaera* spp. *Coccolithus pelagicus* is regarded as a good indicator of cold and nutrient-rich waters, while *Rhabdosphaera* spp., *Syracosphaera* spp., and *Umbillicosphaera* spp. are more related to warm and oligotrophic environments. These changes in the coccolithophore record may be linked to the displacement of the South Atlantic High (SAH) pressure system. Changes in the relative impact of different water masses are strongly dependent upon the regional wind field, which affects the upper-level circulation mainly through latitudinal displacement of the bifurcation of the South Equatorial Current. In the study area, this displacement impacted the Brazil Current's (BC) strength and the intensity of the upwelling regime. Periods of reduced productivity mainly occurred during a strengthened BC, when the SAH was above the study area, and peak productivity occurred when the atmospheric cell moved northward, which probably intensified the penetration of polar advections and favored the influence of colder, nutrient-rich water.

A review of Cenozoic calcareous nannofossil biostratigraphic studies in the Hellenic territory (Greece): achievements and limitations

Maria V. Triantaphyllou

National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; mtriant@geol.uoa.gr

In the marginal Mediterranean basin, the fragmentation of the geological record, together with a strong diachroneity in zonal boundary events and/or the absence or extreme rareness of primary marker species, does not allow easy application of the standard nannofossil zonations. Therefore, regional zonal schemes were developed (e.g., Theodoridis, 1984; Rio *et al*., 1990; Fornaciari & Rio 1996; Fornaciari *et al*., 1996).

In this study, an extensive dataset was constructed from investigated locations in the Hellenic territory (flysch, mollasic, and post-alpine heavily terrigenous deposits) and available published Cenozoic calcareous nannofossil biostratigraphic results. The aim was to standardize the available data and provide realistic biochronologic estimates, based on the magnetobiochronology of Berggren *et al*. (1995) and the more recent astrobiochronological approaches of Lourens *et al*. (2004), Raffi *et al*. (2006), and Backman *et al*. (2012). In addition, a series of new locations with their unpublished calcareous nannofossil biostratigraphic determinations was incorporated into the biostratigraphic dataset, in order to provide a useful framework for biostratigraphic correlations in the eastern Mediterranean area (e.g., Triantaphyllou, 2013). Thus, a better understanding of the spatiotemporal impact on calcareous nannofossil biostratigraphic assignments from different geological-geotectonic origin deposits in the Hellenic territory was achieved, and the relative limiting factors could be described.

References

Backman, J., Raffi, I., Rio, D., Fornaciari, E., & Pälike, H. 2012. Biozonation and biochronology of Miocene through Pleistocene calcareous nannofossils from low and middle latitudes. *Newsletters on Stratigraphy*, **45**: 221–224.

Berggren W.A., Kent D.V., Swisher C.C. & Aubry M.P. 1985. A revised Cenozoic geochronology and chronostratigraphy. *In*: W. Berggren, D. Kent, M. Aubry & J. Hardenbol (Eds). *Geochronology, Time Scales and Global Stratigraphic Correlation*. Society for Sedimentary Geology Special Publications, **54**: 129–212.

Fornaciari, E. & Rio, D. 1996. Latest Oligocene to early Middle Miocene quantitative Calcareous Nannofossil Biostratigraphy in the Mediterranean region. *Micropaleontology*, **42**(1): 1–36.

Fornaciari, E., Di Stefano, A., Rio, D. & Negri, A. 1996. Middle Miocene quantitative calcareous nannofossil biostratigraphy in the Mediterranean region. *Micropaleontology*, **42**(1): 37–63.

Lourens, L.J., Hilgen, F.J., Shackleton, N.J., Laskar, J. & Wilson, D. 2004. The Neogene Period. *In*: F.M. Gradstein, J.G. Ogg, & A.G. Smith (Eds). *A Geological Time Scale 2004*. Cambridge University Press, Cambridge: 409–440.

Raffi, I., Backman, J., Fornaciari, E., Pälike, H., Rio, D., Lourens, L. & Hilgen, F. 2006. A review of calcareous nannofossil astrobiochronology encompassing the past 25 million years. *Quaternary Science Reviews*, **25**: 3113–3137.

Rio, D., Raffi, I. & Villa, G. 1990. Pliocene-Pleistocene calcareous nannofossil distribution patterns in the Western Mediterranean. *In*: K.A. Kastens, J. Mascle *et al*. *Proceedings of the Ocean Drilling Program, Scientific Results*, **107**: 513–533.

Theodoridis, S. 1984. Calcareous nannofossil biozonation of the Miocene and revision of the helicoliths and discoasters. *Utrecht Micropaleontological Bulletins*, **32**: 1–271.

Triantaphyllou, M.V. 2013. Calcareous nannofossil dating of Ionian and Gavrovo flysch deposits in the External Hellenides Carbonate Platform (Greece): Overview and implications. *Tectonophysics*, **595–596**: 235–249.

Coccolithophore community response along a natural CO_2 gradient off Methana (northeastern Peloponnese peninsula, Aegean Sea)

Maria Triantaphyllou
National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; mtriant@geol.uoa.gr

Karl-Heinz Baumann
University of Bremen, Department of Geosciences, 28334 Bremen, Germany; baumann@uni-bremen.de

Boris Theofanis Karatsolis
National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; bkaratsolis@gmail.com

Margarita D. Dimiza
National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; mdimiza@geol.uoa.gr

Elisavet Skampa
National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens; Greece; skampaelisavet@gmail.com

Nele M. Vollmar
University of Bremen, Department of Geosciences, 28334 Bremen, Germany; nvollmar@uni-bremen.de

Odysseas A. Archontikis
National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; odysseas67@windowslive.com

Paraskevi Nomikou
National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimioupolis, 157 84 Athens, Greece; evinom@geol.uoa.gr

Olga Koukousioura
Aristotle University of Thessaloniki, Department of Geology, Thessaloníki, Greece; okoukous@geo.auth.gr

Ioannis Michailidis
Aristotle University of Thessaloniki, Department of Geology, Thessaloníki, Greece; ismichai@geo.auth.gr

Pierros Patoucheas
Aristotle University of Thessaloniki, Department of Geology, Thessaloníki, Greece; pdpatouc@geo.auth.gr

Anna Katsigera
Harokopio University, Kallithea, 176 71, Athens, Greece; annakatsigera@gmail.com

Stella Psarra
Hellenic Centre for Marine Research, Institute of Oceanography, 19013 Anavyssos, Attiki, Greece; spsarra@hcmr.gr

Methana is located at the eastern Peloponnese peninsula and represents the western end of the Aegean Volcanic Arc. The last eruption on Methana was in 230 BC, but the area is still hydrothermally active with gas emissions of mainly carbon dioxide and smaller amounts of nitrogen, carbon monoxide, and methane (Baggini *et al*., 2014). Data on the macroalgal community of the Methana seep site showed that benthic communities had decreases in

calcifying algal cover and increases in brown algal cover with increasing pCO_2 (Baggini *et al*., 2014).

During September 2011 and 2016, plankton samples were collected to study coccolithophore communities. A natural pH gradient, caused by marine CO_2 seeps off the Methana peninsula, was used as a natural laboratory to assess the effects of long-term ocean acidification on coccolithophores. We observed 69 coccolithophore species of which 34 are holococcolithophores. Nutrient and Chlorophyll-*a* concentrations showed typical oligotrophic summer Aegean Sea conditions. Cell concentrations were a maximum of $\sim 50 \times 10^3$ cells/l, with a high Shannon index of up to 2.8, along a pH gradient from 7.61 to 8.22. Water collected close to the main CO_2 seeps had the highest concentrations of holococcolithophores (max. $\sim 30 \times 10^3$ cells/l, 90% relative abundance), which were much higher than recorded in comparable coastal environments with normal pH values (Dimiza *et al*., 2008). In "normal" water conditions, species such as *Emiliania huxleyi* were more abundant (max. $\sim 7 \times 10^3$ cells/l at 40m depth). Changes in the community structure can possibly be related to increased temperatures, while the overall trend associates low pH values with high cell densities. *Emiliania huxleyi* was present only in low relative abundances. Neither malformed nor corroded coccoliths were documented, in contrast to observations by Ziveri *et al*. (2014) in similar environments. Our preliminary results indicate that in long-term acidified, warm and stratified conditions, the study of the total coccolithophore assemblage may prove useful to recognize intercommunity variability, which favors lightly calcified species such as holococcolithophores.

Financial support for this research has been provided by IKYDA 2016 German-Greek collaboration project.

References

Baggini, C., Salomidi, M., Voutsinas, E., Bray, L., Krasakopoulou, E. & Hall-Spencer, J.M. 2014. Seasonality Affects Macroalgal Community Response to Increases in pCO_2. *Plos One*, **9**: e106520.

Dimiza, M.D., Triantaphyllou, M.V. & Dermitzakis, M.D. 2008. Seasonality and ecology of living coccolithophores in E. Mediterranean coastal environments (Andros Island, Middle Aegean Sea). *Micropaleontology*, **54**: 159–175.

Ziveri, P., Passaro, M., Incarbona, A., Milazzo, M., Rodolfo-Metalpa, R. & Hall-Spencer, J.M. 2014. Decline in Coccolithophore diversity and impact on coccolith morphogenesis along a natural CO_2 gradient. *The Biological Bulletin*, **226**: 282–290.

Semi-automated morphometric system for early Eocene *Naviculopsis* spp. (Silicoflagellata)

Hideto Tsutsui
Yamagata University, Department of Earth and Environmental Sciences, Faculty of Science, Yamagata, Japan; blacksand@mail.goo.ne.jp

Richard W. Jordan
Yamagata University, Department of Earth and Environmental Sciences, Faculty of Science, Yamagata, Japan; sh081@kdw.kj.yamagata-u.ac.jp

A recently published morphometric study of the early Eocene silicoflagellates *Corbisema apiculata* and *C. triacantha*, which are often confused with each other, reached three conclusions: (1*) C. apiculata s.l.* has short radial spines, a large basal ring, and may or may not bear pikes, (2) *C. triacantha s.l.* has long radial spines, a small triangular basal ring, and lacks pikes and, (3) the ratio of radial spine length to basal ring diameter of *C. triacantha* is very similar to those of modern silicoflagellates, e.g., *Stephanocha speculum* (formerly *Distephanus speculum*), *S. medianoctisol*, and Group B in Tsutsui *et al*. 2009 (Tsutsui *et al*., 2017, submitted). The measurement algorithms, database management system, and data formats were transported from the *Corbisema* metric system (Tsutsui & Jordan, 2016) and applied to *Naviculopsis* spp., which were also well preserved in the Mors diatomite from Denmark. The major species in the diatomite was *N. constricta* (although some specimens may belonged to *N.* cf. *biapiculata*). A test run on *N. constricta* showed similar trends to those of modern silicoflagellates. This suggests that early Eocene silicoflagellates produced skeletons in a similar way to their modern counterparts.

References

Tsutsui, H. & Jordan, R.W. 2016. A semi-automatic two-dimensional image system for studying the skeletal design of the silicoflagellate genus *Corbisema* (Dictyochales, Dictyochophyceae). *Journal of Nannoplankton Research*, **26**(2): 139–147.

Tsutsui, H., Jordan, R.W., Nishiwaki, N. & Nishida, S. submitted. Morphometric analysis of early Eocene Corbisema skeletons (Silicoflagellata) in Mors, Denmark. *Journal of Micropalaeontology*.

Tsutsui, H., Takahashi, K., Nishida, S. & Nishiwaki, N. 2009. Intraspecific morphological variation with biometry of *Distephanus speculum* (Silicoflagellata). *Marine Micropaleontology*, **72**: 239–250.

Miocene silicoflagellates from the Paratethys

Yuki Uezato

Yamagata University, Earth Sciences Cluster, Yamagata, Japan; yu.9ocd@icloud.com

Richard W. Jordan

Yamagata University, Yamagata, Japan; sh081@kdw.kj.yamagata-u.ac.jp

The Paratethys, stretching from the Vienna Basin to the Caspian Sea and with connections to the Mediterranean Sea, was fully marine during the Miocene. The western portion, known as the Pannonian Sea, covered an area now centered around Hungary. Outcrops of Paratethyan sediments were studied by diatomists (particularly Josef Pantocsek and Marta Hajós) and included observations on other siliceous microfossil groups (archaeomonads, silicoflagellates, ebridians, and endoskeletal dinoflagellates). However, few detailed studies on silicoflagellates have been made on the samples collected over 100 years ago, which are curated in various diatom collections around the world. In this study, the silicoflagellates were observed, measured, and photographed using a light microscope. Samples of early-middle Miocene age are from Slovakia (Szentpéter, Nagykürtös, Kekkö, and Felsöesztergály), Romania (Borostelek and Bremia), Czech Republic (Brünn), and Hungary (Szakál). End-member morphologies and aberrants have been described as distinct taxa in the past, so it was important to carefully document both of these in order to improve silicoflagellate taxonomy. The highest diversity occurred in the Szentpéter sample, but only one species was found in the Szakál and Borostelek samples, and no silicoflagellates were observed in the Bremia and Kekkö samples. *Distephanopsis crux* and *Stephanocha speculum* were found in most samples, *Bachmannocena* spp. were very common in the Brünn sample, and *Dictyocha fibula* was only observed in the Felsöesztergály sample. Compared with the assemblage data from late Miocene Mediterranean localities, those from the Paratethys are quite distinct.

Stratigraphic variation in abundance, species composition, and morphology of the genus *Umbilicosphaera* (Calcidiscaceae) in the Pliocene–Pleistocene of ODP Site 709C core (western equatorial Indian Ocean)

Masayuki Utsunomiya
Geological Survey of Japan, Research Institute of Geology and Geoinformation, AIST, Tsukuba, Japan; m.utsunomiya@aist.go.jp

Kyoko Hagino
Kochi University, Center for Advanced Marine Core Research, Kochi 783–8502, Japan; hagino@kochi-u.ac.jp

Yuichiro Tanaka
Geological Survey of Japan, Research Institute of Geology and Geoinformation, AIST, Tsukuba, Japan; y-tanaka@aist.go.jp

In order to reveal the evolutionary history of the genus *Umbilicosphaera*, we examined calcareous nannofossil biostratigraphy and the interspecific morphological variation of members of *Umbilicosphaera* through the Pliocene to the Pleistocene in the ODP Site 709C core that was recovered from the western equatorial Indian Ocean. A general biostratigraphic zonation of this core has already been established (e.g., Rio *et al*., 1990). The relative abundance of *Umbilicosphaera* spp. within the total calcareous nannofossil assemblages, except for *Florisphaera* spp., was generally low (<1%) during Subzone NN16/CN12a and upper Subzone NN16/CN12b (Martini, 1971; Okada & Bukry, 1980), but it increased to 7–20% during uppermost Subzone NN16/CN12b, then decreased in Subzone NN17/CN12c. This acme zone was also reported from ODP Site 994 in the western Atlantic (Okada, 2000). We have classified coccoliths of *Umbilicosphaera* into five groups based on morphologic characters: size of central opening, numbers of radial elements on the shield, whether bicyclic or monocyclic, and suture patterns. The stratigraphic and morphologic implications for this lineage will be discussed.

References

Martini, E. 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. *In*: A. Faranacci (Ed). *Proceedings of the Second Planktonic Conference Roma 1970.* Edizioni Tecnoscienza, Rome, **2**: 739–785.

Okada, H. 2000. Neogene and Quaternary calcareous nannofossils from the Blake Ridge, Sites 994, 995 and 997. *In:* C.K. Paull *et al*. (Eds). *Proceedings of the Ocean Drilling Program, Scientific Results*, **164**: 331–341.

Okada, H. & Bukry, D. 1980. Supplementary modification and introduction of code numbers to the low-latitude coccolith biostratigraphic zonation (Bukry, 1973; 1975). *Marine Micropaleontology*, **5**(3): 321–325.

Rio, D., Fornaciari, E. & Raffi, I. 1990. Late Oligocene through Early Pleistocene calcareous nannofossils from western equatorial Indian Ocean (Leg 115). *In:* R.A. Duncan *et al*. (Eds). *Proceedings of the Ocean Drilling Program, Scientific Results*, **115**: 175–235.

Refining Pleistocene-Holocene calcareous nannofossil biostratigraphy of IODP Expedition 349 Site 1433, South China Sea

Mirko Alessandro C. Uy
University of the Philippines, National Institute of Geological Sciences, Diliman, Quezon City, Philippines; amcuy2@up.edu.ph

Alyssa M. Peleo-Alampay
University of the Philippines, National Institute of Geological Sciences, Diliman, Quezon City, Philippines; ampanigs@yahoo.com

IODP Expedition 349 Scientists

The South China Sea (SCS) is an important basin in the western Pacific due to its size, tropical and monsoonal setting, and limited interaction with the Pacific Ocean. IODP Expedition 349 was conducted in order to study the relict seafloor spreading that corresponds to the opening of the SCS. Biostratigraphers on the expedition established an age depth model that used calcareous nannofossils to restrict the age of sediments in the basin, using sediments in the core catchers. The goal of this study was to refine the shipboard calcareous nannofossil biostratigraphy from the Pleistocene to Holocene. Samples were obtained from Sites 1433A and 1433B, where 1433A contains younger sediments. The sampling interval was approximately every 150cm. Preliminary data confirmed and refined four events: (1) the last occurrence (LO) of *Pseudoemiliania lacunosa* at 13H-2W-20cm (113.6 mbsf), (2) the LO of *Gephyrocapsa* sp. 3 at 15H-1W-20cm (133.6 mbsf), (3) the first occurrence (FO) of *Gephyrocapsa* sp. 3, which coincides with that of the shipboard results, at 4R-CC (205 mbsf), and (4) the FO of *Discoaster surculus* at 17R-6W-20cm (337.6 mbsf).

Taxonomic revision of selected Tithonian species based on examination a with mobile mounting technique

Osman Varol

Varol Research, 3300 Sage Road, #8208, Houston, TX 77056, USA; osman@varol.com

Andrew R. Bowman

Statoil Gulf Services LLC, 2107 City West Blvd, Houston, TX 77042 USA; anbow@statoil.com

The stratigraphic ranges of the Tithonian species *Polycostella senaria*, *Hexalithus geometricus*, *Hexalithus strictus*, *Nannoconus compressus*, *Nannoconus erbae*, and *Nannoconus infans* have been reported in several publications as being diachronous. Bralower *et al*. (1989), Casellato (2010), and Bergen et al. (2014) independently analyzed similar sample sets from DSDP Site 534, ultimately producing different and unique stratigraphic ranges of the same species (Figure 5, Bergen *et al.*, 2004).

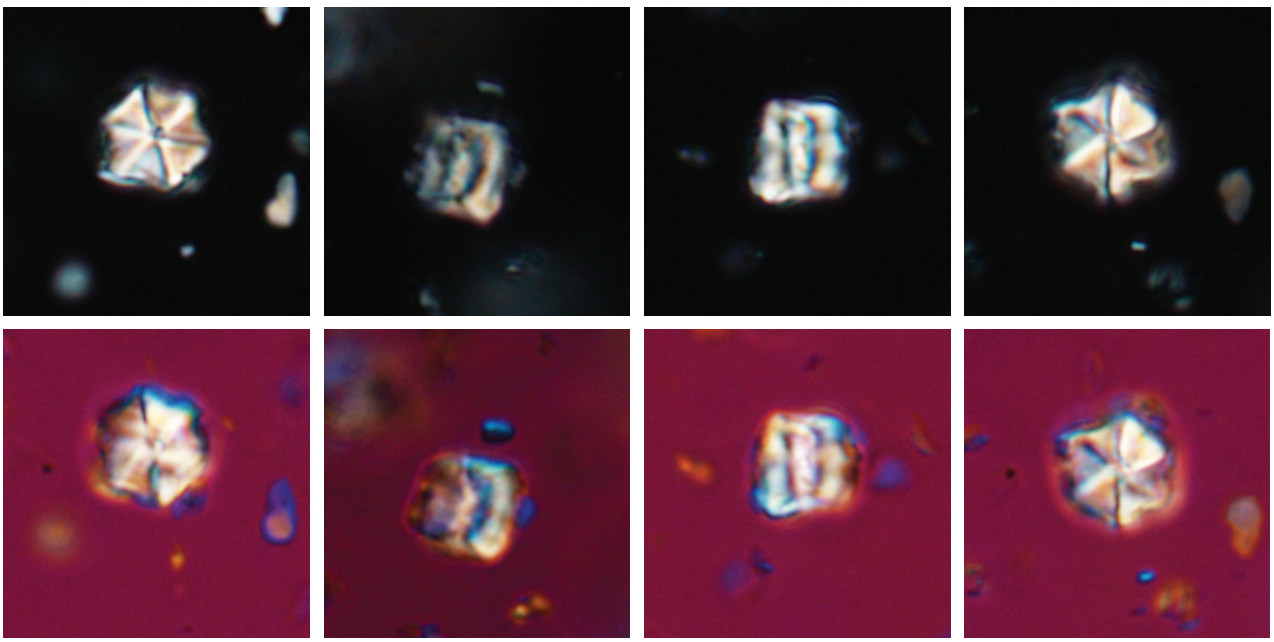
We utilized the mobile mounting technique to investigate the morphologic characteristics of the above species in different views, observed through rotation of the specimens. We demonstrate that the discrepancies in the ranges are primarily caused by the misunderstood taxonomic concepts representing these forms. Using this technique, we mapped the side views of these forms to their associated plan views. The side views/plan views of the following species have also been mapped in this paper: *Conusphaera mexicana*, *Conusphaera rothii*, *Conusphaera mexicana minor*, *Polycostella beckmannii*, *Paleomicula maltica*, and *Acadialithus valentinei*.

References

Bergen, J.A., Boesiger, T.M. & Pospichal, J.J. 2004. Low-latitude Oxfordian to Early Berriasian nannofossil biostratigraphy and its application to the subsurface of Eastern Texas. *In* U. Hammes & J. Gale (Eds). *Geology of the Haynesville Gas Shale in East Texas and West Louisiana, U.S.A.* AAPG Memoir **105**: 69–102.

Bralower, T.J., Monechi, S. & Thierstein, H.R. 1989. Calcareous nannofossil zonation of the Jurassic–Cretaceous boundary interval and correlation with the geomagnetic polarity timescale. *Marine Micropaleontology*, **14**: 153–235.

Casellato, C.E. 2010 Calcareous nannofossil biostratigraphy of Upper Callovian-Lower Berriasian successions from the Southern Alps, North Italy. *Rivista Italiana di Paleontologia e Stratigrafia*, **116**(3): 357–404.



Polycostella senaria [same specimen in mobile mounting]

Calcareous nannofossil biostratigraphy and paleoceanography across the Toarcian Oceanic Anoxic Event cored at Colle di Sogno (Lombardy Basin, northern Italy)

Stefano Visentin
Università degli studi di Milano, Dipartimento di Scienze della Terra, 20133 Milano, Italy; stefano.visentin@unimi.it

Dario Reolon
Università degli studi di Milano, Dipartimento di Scienze della Terra, 20133 Milano, Italy; dario.reolon@studenti.unimi.it

Giulia Faucher
Università degli studi di Milano, Dipartimento di Scienze della Terra, 20133 Milano, Italy; giulia.faucher@unimi.it

Elisabetta Erba
Università degli studi di Milano, Dipartimento di Scienze della Terra, 20133 Milano, Italy; elisabetta.erba@unimi.it

Calcareous nannofossil biostratigraphy was carried out in the upper Pliensbachian-lower Toarcian interval cored at Colle di Sogno (northern Italy). Semiquantitative analyses were performed on ~160 samples across the Domaro Limestone-Sogno Formation boundary that was recovered in two different boreholes (S1 and S3). Geochemistry evidenced the presence of the negative C isotopic excursion across the "fish level" black shale interval representative of the Toarcian Oceanic Anoxic Event (T-OAE).

Main and secondary events of the Tethyan zonation (Mattioli & Erba, 1999) were recognized, allowing the identification of Zones NJT 5 and NJT 6. The T-OAE C isotopic anomaly was constrained by the FO of *Carinolithus superbus* at the onset and the LO of *Mitrolithus jansae* at the end. Our results confirmed that the latter biohorizon is a primary stratigraphic event.

Semiquantitative and morphometric analyses were performed on *Schizosphaerella punctulata* and *M. jansae* to assess potential changes in abundance, size, and/or morphologies relative to the T-OAE. Both taxa displayed a major decrease in abundance at the onset of T-OAE and remained rare through the interval of perturbed conditions. Only *S. punctulata* showed a recovery at the end of the T-OAE, while *M. jansae* barely survived the paleoenvironmental stress and disappeared soon after its termination.

Our results confirm that calcareous nannoplankton were influenced by paleoenvironmental changes associated with the T-OAE when increased nutrient availability, warming, and excess CO_2 led to a dramatic shift in assemblage composition. After a period of prolonged stability and oligotrophy that promoted a diversified calcareous phytoplankton community with abundant k-selected deep- and intermediate-dwellers, meso- to eutrophic conditions occurred that were locally associated with accelerated runoff and favored opportunistic taxa. After the T-OAE, paleoceanographic conditions, at least as far as the photic zone was concerned, only partially and gradually returned to a pre-perturbation state, suggesting that the deepening of the nutricline and re-establishment of stability required a long period after anoxia terminated.

References

Mattioli, E. & Erba, E. 1999. Synthesis of calcareous nannofossil events in the Tethyan Lower and Middle Jurassic successions. *Rivista Italiana di Paleontologia e Stratigrafia,* **105**(3): 343–376.

Modern and past morphology of *Emiliania huxleyi* and its co-occurrence with other Noelaerhabdaceae in the Atlantic Ocean

Nele M. Vollmar
University of Bremen, Department of Geosciences, 28334 Bremen, Germany; nvollmar@uni-bremen.de

Anne Strack
University of Bremen, Department of Geosciences, 28334 Bremen, Germany; annestrack@uni-bremen.de

Karl-Heinz Baumann
University of Bremen, Department of Geosciences, 28334 Bremen, Germany; baumann@uni-bremen.de

Emiliania huxleyi is the most abundant and widespread coccolithophore species in modern oceans. Several studies have shown morphological variations within the coccoliths and coccospheres of this important species that are related to various environmental parameters. However, definitions of morphotypes were often based on restricted regions and might not always be consistent among authors and study sites. Furthermore, even though some of the morphotypes have already been used for paleoceanographic reconstructions, only little is known about the development of these morphotypes through time.

Here, we present new, detailed, and unified morphometric data on *E. huxleyi* morphotypes from plankton and sediment traps in the Atlantic Ocean. Moreover, the evolution of *E. huxleyi* morphotypes, since the first appearance of this species approximately 270ka, was investigated in sediment cores. The findings of our study provided knowledge about the evolution of *E. huxleyi* morphotypes, the modern distribution of its morphotypes in relation to its sister taxa, and a unified and applicable classification scheme for distinguishing the morphotypes of this species.

Investigating the role of calcification in Coccolithophores

Charlotte E. Walker
The Marine Biological Association of the United Kingdom, Plymouth, UK, PL12PB; University of Southampton, National Oceanography Centre, Southampton, UK, SO14 SO14 3ZH; chawal@MBA.ac.uk

Alison R. Taylor
University of North Carolina Wilmington, North Carolina 28403, USA; taylora@uncw.edu

Gerald Langer
The Marine Biological Association of the United Kingdom, Plymouth, UK, PL12PB; gerlan@MBA.ac.uk

Toby Tyrrell
University of Southampton, National Oceanography Centre, Southampton, UK, SO14 SO14 3ZH; Toby.Tyrrell@soton.ac.uk

Colin Brownlee
The Marine Biological Association of the United Kingdom, Plymouth, UK, PL12PB; cbr@MBA.ac.uk

Glen L. Wheeler
The Marine Biological Association of the United Kingdom, Plymouth, UK, PL12PB; glw@MBA.ac.uk

Despite the ecological significance of coccolithophores, the role of calcification remains uncertain, and the cellular mechanisms behind the process remain poorly understood. One of the reasons for this is that studies to date have predominantly focused on *Emiliania huxleyi*, the most globally abundant coccolithophore species. It is well documented that *E. huxleyi* can readily exist in a non-calcified state in laboratory cultures without any significant impact on cell fitness. However, emerging evidence suggests that there are important physiological differences among species and that the mechanisms of calcification in *E. huxleyi* are not typical of all coccolithophores. *Coccolithus braarudii*, a significant contributor to global calcite production, has been highlighted by recent literature as a contrasting species to *E. huxleyi* in terms of its calcification mechanisms. We applied a multifaceted approach to compare the impact of disrupting calcification in *E. huxleyi* and *C. braarudii* in culture experiments. Our findings indicate that there are clear differences between these organisms, which adds to the emerging variation in calcification mechanisms found in the coccolithophores, and these differences have important implications for our understanding of the evolution, ecology, and future response of coccolithophores to changing ocean conditions.

Nannotax: progress and prospects

Jeremy R. Young
University College London, Department of Earth Sciences, London WC1E 6BT, UK; jeremy.young@ucl.ac.uk

Paul R. Bown
University College London, Department of Earth Sciences, London WC1E 6BT, UK; p.bown@ucl.ac.uk

It is now four years since Nannotax3 was launched at the INA14 conference in Reston, VA, USA. Since then, it has become a key reference tool for nannofossil studies and has steadily expanded its scope. Through the efforts of Rich Howe, the catalog side of the system is now nearly comprehensive and contains original descriptions of >4000 taxa. In parallel, the main Cenozoic and Mesozoic databases include descriptions and range data on ca 2700 taxa and are now illustrated by >20,000 images, mostly with full metadata, including images from ca 200 publications. Data on stratigraphic distributions come from both total range summaries, based on literature compilations, and actual records from the Neptune database of occurrence data from DSDP, ODP, and IODP records.

Work over the past 18 months has largely focused on developing the system and applying it to planktonic foraminifera, and is supported by a further round of funding from the UK Natural Environment Research Council and in collaboration with Brian Huber, Bridget Wade, and other planktonic foraminiferal specialists. This work has resulted in many improvements to the editing interface so that it is accessible to user-editors via the internet without need for database skills. It also has resulted in numerous improvements to the presentation of data on the system. In parallel, there has been continuous development of the content.

This talk will both review the progress over the last two years and review the prospects for building on the system in terms of both potential avenues for extending to other groups of microfossils and adding additional functionality and data types to the nannofossil content. A particular focus will be the discussion of tagging and keys to allow searching for taxa using morphological characteristics.

The small *Reticulofenestra* event/*R. pseudoumbilicus* paracme revisited -new data from IODP Expedition 359

Jeremy R. Young
University College London, Department of Earth Sciences, London WC1E 6BT, UK; jeremy.young@ucl.ac.uk

Santi D. Pratiwi
Akita University, Department of Geosciences, Geotechnology and Materials Engineering for Resources, 1-1 Teagata-Gakuencho, Akita 010-8502 Japan; rhabdosphaera@gmail.com

Xiang Su
Chinese Academy of Sciences, South China Sea Institute of Oceanology, Key Laboratory of Marginal Sea Geology, Guangzhou 510301, China suxiang@scsio.ac.cn

At tropical and sub-tropical latitudes within late Miocene Zone NN10, *Reticulofenestra* specimens larger than about 5 microns abruptly disappear from the fossil record at about 8.8Ma. This event was first recognized independently by Young (1990) and Rio *et al.* (1990) and was termed respectively the small *Reticulofenestra* event and the *Reticulofenestra pseudoumbilicus* paracme. The event has since been shown to be essentially global at low latitudes and an excellent biostratigraphic marker, and it was adopted as a marker event in the zonation of Backman *et al.* (2012). It also appears to be the most prominent in a succession of abrupt size reduction events exhibited by reticulofenestrids in the Cenozoic.

IODP expedition 359 drilled the Maldives carbonate system in the western Indian Ocean, which appears to be the region in which the event is best developed, and both Young (1990) and Rio *et al.* (1990) based their studies on material from this area. The event was well developed in an interval with a high sedimentation rate and low reworking at IODP site 1467. This site provides an excellent opportunity to review the pattern of disappearance and compare it to that seen at other events. These data will also be used to review the nature of such events and their potential significance as indicators of environmental change.

References

Backman, J., Raffi, I., Rio, D., Fornaciari, E. & Palike, H. 2012. Biozonation and biochronology of Miocene through Pleistocene calcareous nannofossils from low and middle latitudes. *Newsletters on Stratigraphy*, **45**: 221–244.

Rio, D., Fornaciari, E. & Raffi, I. 1990. Late Oligocene through early Pleistocene calcareous nannofossils from western equatorial Indian Ocean (Leg 115*). Proceedings of the Ocean Drilling Program. Scientific Results*, **115**: 175–235.

Young, J.R. 1990. Size variation of Neogene *Reticulofenestra* coccoliths from Indian Ocean DSDP cores. *Journal of Micropalaeontology*, **9**: 71–86.

Measuring the sinking characteristics of coccoliths: refinement of coccolith separation methods

Hongrui Zhang
Tongji University, Siping Road 1239, Shanghai, China; 103443_rui@tongji.edu.cn

Chuanlian Liu
Tongji University, Siping Road 1239, Shanghai, China; liucl@tongji.edu.cn

Xiaobo Jin
Tongji University, Siping Road 1239, Shanghai, China; 386jinxiaobo@tongji.edu.cn

Xinquan Zhou
Tongji University, Siping Road 1239, Shanghai, China; 54zhouxq@tongji.edu.cn

Clara Bolton
Aix-Marseille University, CNRS, IRD, Col. France; CEREGE, Aix en Provence, France; bolton@cerege.fr

The use of coccoliths in geochemical analyses and paleoenvironmental reconstructions has been hindered by the difficulty in isolating coccoliths as compared to the greater ease in separating the larger sized foraminifera. Two main methods have been developed to concentrate near monospecific assemblages of coccoliths from bulk sediments: one is based on a decanting technique and the other is based on micro filtering. An improved separation technique could offer new perspectives on the study of earth history. Moreover, developments in coccolith oxygen and carbon isotope culturing and modeling studies in recent years have provided more reliable interpretations of coccolith isotope data and therefore increased the need for more purified coccolith fraction samples.

The most widely used and most efficient method, the micro filtering method, relies heavily on the specifications of the microfilter (such as 2μm, 3μm, 5μm, and 8μm) and has difficulty separating coccoliths with similar sizes, such as *Florisphaera profunda* and *Emiliania huxleyi*. Hence, in some studies, both of the microfilter and the sinking or centrifugation method were used for coccolith separation.

The earliest used method in isolating coccoliths, the repetitive sinking/decanting method, is poorly supported by Stokes' Law, which applies only to spherical objects, and the sinking velocities of coccoliths with their complex shapes and surfaces are difficult to calculate. So, it is still worthwhile to be able to refine the sinking/decanting method.

In this study, a new method was developed in order to improve the repetitive settling/decanting method. First, the sinking velocities of different coccoliths were carefully measured through a series of settling experiments. Second, the influence of different vessels used in the sinking experiment was proved to be negligible. Third, a formula for coccolith movement during centrifugation was developed and tested to improve the efficiency of coccolith separation. We now can offer a method that achieves near monospecific assemblages of coccoliths through repeated settling and have compared this to the established settling and filtering methods.

NOTES

NOTES

NOTES FOR CONTRIBUTORS TO THE *JNR*

We publish peer-reviewed scientific articles concerning all aspects of nannoplankton research, and especially encourage papers and notes on new taxa and new techniques. We aim to publish articles within 6–12 months of submission. You will be provided with a free PDF of your article (reprints are not available). Published articles also appear in digital form on the INA website: **http://ina.tmsoc.org/JNR/JNRcontents.htm**. All articles should be submitted to the Editor-in-Chief.

The *JNR* is valid for description of new taxa, as long as these are in accordance with the rules of the current *International Code of Nomenclature (ICN) for algae, fungi and plants*. Articles should be clearly and concisely written in English, with an informative title. The article should contain a short abstract, giving a comprehensive overview of the article, and up to 10 keywords.

INSTRUCTIONS FOR ARTICLE SUBMISSIONS

Initial submission procedures

Submit manuscripts electronically to the Editor-in-Chief in a format that can be annotated by the reviewers, ideally a Word file of the text and a PDF file containing figures/plates/tables. The file names should comprise your surname and date of submission. Use 12-point font and double line-spacing, and number the lines and pages.

The reviewers and Editor-in-Chief will correct minor problems with the English and grammar of non-native speakers, but it is suggested that, if necessary, non-native speakers have their manuscripts checked by a confident English-speaker before submission, to avoid problems with ambiguity in the text.

If the manuscript is accepted for review you will receive a link to your submission folder. Please save this link for future access, as this folder will allow you to view your submission and reviews, upload revisions and view proofs of your article.

Taxonomy: Taxonomic descriptions should follow the latest *JNR* format. Taxonomic lists are not accepted; any taxonomic notes or discussions should be included in a systematics section in the paper. Do refer readers to an up-to-date taxonomic reference, such as Bown (1998) or *Nannotax3*. Note that *Nannotax3* is the official taxonomic resource of the INA and can be accessed at **http://ina.tmsoc.org/Nannotax3/index/html**.

References: References should be in alphabetical order by author, then year, and must follow the *JNR* style (as seen in the most recent issues) using full references, not abbreviations. All (but only) references used in the text must appear in the reference list. You do not need to cite taxon author references. Note that references to *Nannotax3* require a date, as this site changes regularly to accommodate the most recent developments in taxonomy. See **http://tmsoc.org/Nannotax3/ntax-citation.html** for more information and how to reference individual taxa.

Final submission procedure

Files should be uploaded directly into your submission folder. Ensure your file names contain your surname, table/figure/plate number and submission date.

Text: Remove page and line numbers, page breaks, columns, footnotes and headers. Do not embed figures or tables into the text. Do italicize species names and *et al.* Remember to thank your reviewers in the acknowledgements - the review process is essential to furthering our science, and it commonly takes a day of unpaid time to review a manuscript thoroughly.

Figures: Submit as individual TIFF, JPEG, PDF or, if possible, CorelDraw files (500dpi minimum). Figures may be submitted in color for the digital publication, but ensure these figures are clear when printed in black and white. Use of color for printed articles can be discussed with the Editor-in-Chief. Avoid using unusual or multiple fonts (Verdana, Calibri and Helvetica are recommended). Captions must be succinct. Figures may be reduced in size in the *JNR,* so check that font sizes are adequate.

Tables: (Including range-charts) should be submitted in Excel. The *JNR* reserves the right to provide large biostratigraphic charts as appendices in PDF format only. Note that all distribution charts should contain all information, not selected taxa.

Plates: Submit as individual TIFF, JPEG, PDF or, if possible, CorelDraw files (500dpi minimum). A scale-bar must be provided on each plate. Taxon names and sample numbers should appear on the plate, below each image, in 8-point sans-serif font. Figure numbers (not letters) should appear in one comer of each image. Other necessary information can also be added to the plate.

JNR and *Nannotax3*

As general policy, relevant content published in the *JNR* will also be used on the *Nannotax3* website with full referencing. In particular, new taxa and images published in the *JNR* will routinely be incorporated into the *Nannotax3* website. This means your contribution will be used as widely as possible. If you do not wish for your images to be used on the website, please explain this to the Editor-in-Chief when making your final submission.

Journal of Nannoplankton Research
INA16 abstracts
Athens, Greece

page contents

9 771210 804009