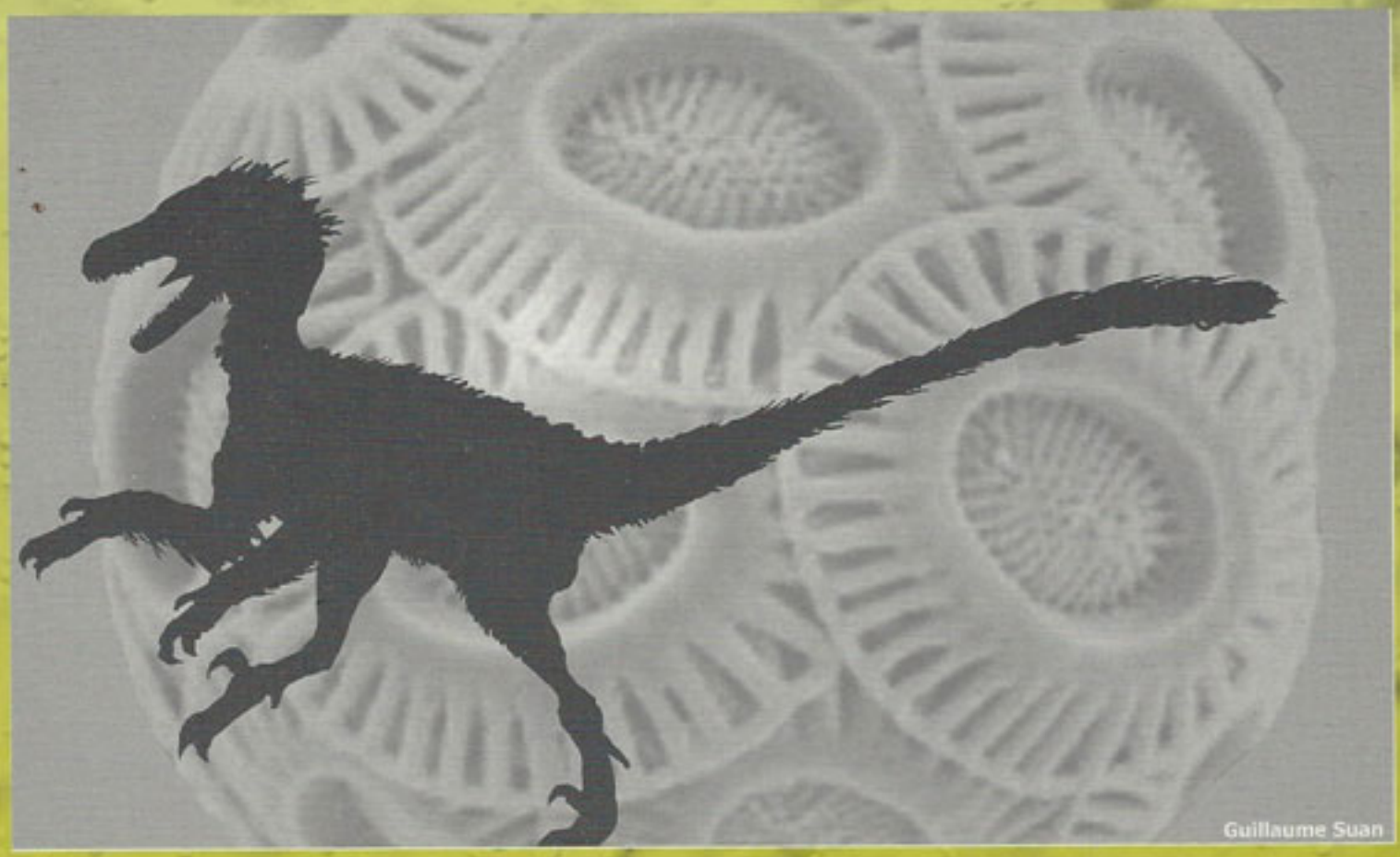
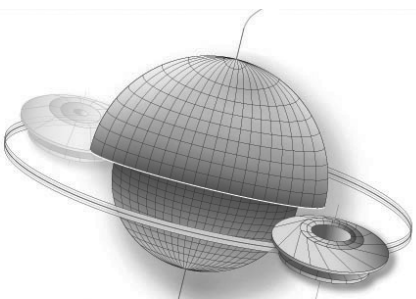
INA12 abstracts
Lyon, France

september 2008



ISSN 1210-8049 Printed by Cambridge University Press, UK



Lyon, 2008

12th INA conference, September 7-13th

INA12 Program

Sunday, Sept. 7th	**17:00 - 21:00**	**Icebreaker party**
Monday, Sept. 8th	**9:00 - 9:30**	**Welcome conference** Speakers: Profs Francis ALBAREDE (ENS Lyon), Germain GILLET (University of Lyon1), Pierre HANTZPERGUE (UFR Earth Sciences), Christophe LECUYER (UMR 5125 PaleoEnvironments & PaleobioSphere)

Author(s)	Title	Session	Presentation	Scheduled time	Breaks	Workshops / Events
Luc Beaufort	Effect of ocean carbonate chemistry on Isochrysidales calcification: studies from present and past oceans	Coccolithophores in a high CO_2 world: Responses and Related Ecological Changes	Talk	Day 1 - 9:30		
Gerald Langer, Ian Probert, Björn Rost, Patrizia Ziveri	Effects of ocean acidification on the calcification of coccolithophores – Evidence from experimental studies	Coccolithophores in a high CO_2 world: Responses and Related Ecological Changes	Talk	Day 1 - 9:45		
Jorijntje Henderiks, Amos Winter, Malte Elbrächter, Anja van der Plas, Rainer Feistel	Environmental control on size and genotype of *Emiliania huxleyi*	Coccolithophores in a high CO_2 world: Responses and Related Ecological Changes	Talk	Day 1 - 10:00		
Maria Triantaphyllou, Margarita Dimiza, Eva Krasakopoulou, Elisa Malinverno, Valia Avgoustidi, Valia Lianou	Seasonal control on *Emiliania huxleyi* coccolith calcification in the Aegean Sea (E Mediterranean)	Coccolithophores in a high CO_2 world: Responses and Related Ecological Changes	Talk	Day 1 - 10:15	Coffee break 10:30 - 11:00	
Patrizia Ziveri, Gerald Langer, Ian Probert, Jeremy Young	Adaptation of coccolith calcification to sea-water carbonate chemistry	Coccolithophores in a high CO_2 world: Responses and Related Ecological Changes	Talk	Day 1 - 11:00		
R.E.M. Rickaby, P.R. Halloran, I.R. Hall, E. Colmenero-Hidalgo, J. Henderiks	Multi-species coccolithophore response to an anthropogenically-modified ocean	Coccolithophores in a high CO_2 world: Responses and Related Ecological Changes	Talk	Day 1 - 11:15		
Mascha Dedert, Heather Stoll, Jeremy Young, Patrizia Ziveri	Productivity of calcareous nannoplankton during hyperthermal events: results from Sr/Ca ratios and biometry	Coccolithophores in a high CO_2 world: Responses and Related Ecological Changes	Talk	Day 1 - 11:30		
Elisabetta Erba, Cinzia Bottini	Dwarf coccoliths at the onset of Cretaceous Oceanic Anoxic Events 1a and 2: an example of calcareous nannoplankton sensitivity to excess CO_2?	Coccolithophores in a high CO_2 world: Responses and Related Ecological Changes	Talk	Day 1 - 11:45		
Paul Bown, Tom Dunkley Jones	Calcareous nannoplankton evolution and the Paleocene/Eocene thermal maximum event	Coccolithophores in a high CO_2 world: Responses and Related Ecological Changes	Talk	Day 1 - 12:00		
Jackie Lees, Paul Bown, Jeremy Young, Stuart Robinson, Ken MacLeod, Darren Gröcke, Fab Minoletti	Changes in photic-zone habitats through the equatorial Atlantic Palaeocene/Eocene Thermal Maximum: contributions from species-specific nannofossil geochemistry	Coccolithophores in a high CO_2 world: Responses and Related Ecological Changes	Talk	Day 1 - 12:15	Lunch 12:30 - 14:00	
		Coccolithophores in a high CO_2 world: Responses and Related Ecological Changes	Discussion 14:00 - 14:15			
Sandra Herrmann, Gretta Bartoli, Andrew Weller, Hans R. Thierstein	Response of coccolith size to paleoceanographic changes during the Pliocene at Site 999A, southern Caribbean Sea	Paleoceanography	Talk	Day 1 - 14:15		
Baptiste Suchéras-Marx, Emanuela Mattioli, Bernard Pittet, Gilles Escarguel, Guillaume Suan	How did orbital cycles influence coccolith size fluctuations? An example from the Early Pliensbachian (Early Jurassic) of Peniche (Portugal)	Paleoceanography	Talk	Day 1 - 14:30		
Guillaume Suan, Emanuela Mattioli, Bernard Pittet	Changes in size distribution of the Early Jurassic nannofossil *Schizosphaerella* sp.: a new proxy for paleoenvironmental reconstructions?	Paleoceanography	Talk	Day 1 - 14:45		
Cristina Emanuela Casellato, Gloria Andreini, Elisabetta Erba, Guido Parisi	Calcareous nannofossil and calpionellid calcification events across the Tithonian–Berriasian time-interval and low-latitude paleoceanographic implications	Carbonate production and fluxes	Talk	Day 1 - 15:00		
Mara Cortés, Francisco Urcádiz-Cázares, Jörg Bollmann, F. Aguirre-Bahena, Norman Silverberg	Calcareous nannoplankton composition and flux in response to the passage of Hurricanes Ignacio and Marty in the SW Gulf of California	Carbonate production and fluxes	Talk	Day 1 - 15:15		
Gatsby-Emperatriz López-Otálvaro, José-Abel Flores, Francisco Javier Sierro, Alan C. Mix	Variability of the coccolith-derived carbonate at ODP Site 1242 in the eastern tropical Pacific during the middle and late Pleistocene	Carbonate production and fluxes	Talk	Day 1 - 15:30		
Mariem Saavedra-Pellitero, José-Abel Flores, Francisco Javier Sierro	Evolution of the coccolithophore assemblages during the Last Deglaciation in ODP Site 1233 (SE Pacific Ocean)	Carbonate production and fluxes	Talk	Day 1 - 15:45		
		Carbonate production and fluxes	Discussion 16:00 - 16:15		Coffee break 16:15 - 16:45	Reception from the Mayor of Villeurbanne 18:30
Angela Fraguas, Nicola Perilli, María José Comas-Rengifo	Biostratigraphy of late Sinemurian-Pliensbachian calcareous nannofossils in northern Spain (Basque-Cantabrian Basin)	Developments in Biostratigraphy	Talk	Day 2 - 8:45		
Eva Halásová	Calcareous nannofossil study of a possible West Carpathian regional stratotype profile of the Jurassic/Cretaceous boundary (the Brodno section, near Zilina)	Developments in Biostratigraphy	Talk	Day 2 - 9:00		

James Bergen	Campanian nannofossil biostratigraphy from Mississippi (Gulf of Mexico) and correlations to north-west Europe, south-west France and Tunisia	Developments in Biostratigraphy	Talk	Day 2 - 9:15	
Emma Sheldon	Campanian–Maastrichtian nannofossil biostratigraphy of the Boreal Realm (Danish Basin chalks)	Developments in Biostratigraphy	Talk	Day 2 - 9:30	
Mihaela Melinte-Dobrinescu, Marcos Lamolda, Ana-Voica Bojar	Calcareous nannofossil extinction pattern across the Cretaceous/Tertiary boundary in the Tethyan Realm	Developments in Biostratigraphy	Talk	Day 2 - 9:45	Coffee break 10:00 - 10:30
Fatemeh Hadavi	Calcareous nannofossil biostratigraphy of the Gurpi Formation in the Kangan Anticline	Developments in Biostratigraphy	Talk	Day 2 - 10:30	
Carmen Mariana Chira, Ramona Balc, Alin Igritan, Florin Florea	Cretaceous and Paleogene calcareous nannofossils from northern Moldavia (Sucevita–Putna area, Romania) and the Cretaceous/Paleogene	Developments in Biostratigraphy	Talk	Day 2 - 10:45	
Eric de Kaenel, James Bergen	Middle Miocene lineages in the calcareous nannofossil genus *Discoaster*	Developments in Biostratigraphy	Talk	Day 2 - 11:00	
Larisa Golovina	Biostratigraphic study of Middle and Upper Miocene nannofossils from eastern Paratethys (Tamanskii Peninsula and northern Ciscaucasia)	Developments in Biostratigraphy	Talk	Day 2 - 11:15	
Akmal Marzouk	Nannofossil biostratigraphy of Miocene sections in two wells from the Gulf of Suez, Egypt	Developments in Biostratigraphy	Talk	Day 2 - 11:30	
Agata Di Stefano, Gioconda Sturiale	New tools for detecting the Miocene/Pliocene boundary in the Mediterranean region by means of calcareous nannofossils	Developments in Biostratigraphy	Talk	Day 2 - 11:45	
		Developments in Biostratigraphy	Discussion 12:00 - 12:15		Lunch 12:15 - 13:45
Atsuko Kijima, Richard Jordan	Coccolithophorid distribution in Palauan lagoons	Paleoceanography	Talk	Day 2 - 13:45	
Martine Couapel, Luc Beaufort	Coccolithophore spatial distribution from an extremely oligotrophic gyre to an intense upwelling in the subtropical South Pacific	Paleoceanography	Talk	Day 2 - 14:00	
Chuanlian Liu, Shiying Zhang, Haiyan Jin	Coccolith evidence of upper ocean water variations for the past 1.53Myr in the Western Pacific Warm Pool	Paleoceanography	Talk	Day 2 - 14:15	
Sergio Bonomo, F. Azzaro, T. Bahri, G. Basilone, A. Bonanno, G. Buscaino, A. Cuttitta, E. Di Stefano, O. Drebeka, A. Incarbona, M. Leonardi, A. Marini, F. Massa , S. Mazzola, B. Patti, M. Talha, G. Tranchida, S. Zgozi	First data on oceanography, phytoplankton density and nutrient distribution of the western Libyan sea area (August 2006)	Paleoceanography	Talk	Day 2 - 14:30	
José-Abel Flores, Francisco Sierro, Elena Colmenero-Hidalgo, José Gravalosa, Miquel Canals, Jaume Frigola, Joan Grimalt, Serge Berné, Bernard Dennielou	Coccolithophore response to abrupt and short-term climate changes in the Gulf of Lions (western Mediterranean) for the last 25 000 years	Paleoceanography	Talk	Day 2 - 14:45	
Débora Simón-Baile, Patrizia Ziveri, Heather Stoll, Jose-Abel Flores, Francisco Javier Sierro	The last 20kyr reconstruction of the western Mediterranean Sea and north-western African margin from coccolith chemistry	Paleoceanography	Talk	Day 2 - 15:00	
Áurea Narciso, José-Abel Flores, Mário Cachão, Francisco Javier Sierro, Elena Colmenero-Hidalgo, Andrea Piva, Alessandra Asioli	Sea-surface dynamics and coccolithophore behaviour during sapropel deposition of Marine Isotope Stages 7, 6 and 5 in the western Adriatic Sea	Paleoceanography	Talk	Day 2 - 15:15	
		Paleoceanography	Discussion 15:30 - 15:45		
Francesca Lozar, Simona Cavagna, Pierangelo Clari, Francesco Dela Pierre, Edoardo Martinetto, Donata Violanti, Andrea Irace, Stefania Trenkwalder	Insight into calcareous nannofossil palaeoecology at the beginning of the Messinian Salinity Crisis in the classical section of Alba (NW Italy)	Paleoceanography	Talk	Day 2 - 15:45	
Milos Bartol	Badenian calcareous nannoplankton from NE Slovenia (Mura depression, western central Paratethys): paleogeography and paleoecology	Paleoceanography	Talk	Day 2 - 16:00	
Christian Linnert, Jörg Mutterlose	Evidence of increasing surface-water oligotrophy during the Campanian-Maastrichtian boundary interval: calcareous nannofossil assemblages of DSDP Hole 390A (Blake Nose)	Paleoceanography	Talk	Day 2 - 16:15	
Letizia Reggiani, Emanuela Mattioli	Lower Jurassic (Domerian) calcareous nannoplankton biogeography in the western Mediterranean area	Paleoceanography	Talk	Day 2 - 16:30	Coffee break 16:45 - 17:15 Conference Dinner 19:30 at the Basserie George
Babette Boeckel, Karl-Heinz Baumann, Elke Freytag, Markus Geisen	Evolutionary trends of selected coccolithophore species in the North Atlantic during the Pliocene to Pleistocene	Coccolithophore Eco-Physio-Genomics, Evolution	Talk	Day 3 - 9:00	
Colin Brownlee, Abul Chrachri, Glenn Wheeler, Alison Taylor	Coccolithophore calcification: cellular mechanisms and constraints	Coccolithophore Eco-Physio-Genomics, Evolution	Talk	Day 3 - 9:15	

Mário Cachão, Ana Bento, Conceição Freitas, Aurea Narciso	Multivariate Morphon Analysis of *Braarudosphaera bigelowii* during a Holocene interval at Mira (SW Portugal)	Coccolithophore Evolution	Eco-Physio-Genomics, Talk	Day 3 - 9:30			
Lluïsa Cros, Marta Estrada	Ecological implications of the haplo-diploid versatility in coccolithophores	Coccolithophore Evolution	Eco-Physio-Genomics, Talk	Day 3 - 9:45			
Tom Dunkley Jones, Paul Bown, Jeremy Young	New perspectives on the Cenozoic history of the Syracosphaerales	Coccolithophore Evolution	Eco-Physio-Genomics, Talk	Day 3 - 10:00	Coffee break 10:15 - 10:45		
Kyoko Hagino, Yoshihito Takano, Takeo Horiguchi	Pseudocryptic speciation of living *Braarudosphaera bigelowii*	Coccolithophore Evolution	Eco-Physio-Genomics, Talk	Day 3 - 10:45			
Jeremy Young, Dan Franklin, Gill Malin, Alex Poulton, Ian Probert	The role of coccolithophores in dimethylsulphide production and their potential impact on climate	Coccolithophore Evolution	Eco-Physio-Genomics, Talk	Day 3 - 11:00			
Bianca De Bernardi, Elisabetta Erba	Morphologic evolution of *Discoaster multiradiatus* from the Late Paleocene to the Early Eocene: abiotic and biotic causes	Coccolithophore Evolution	Eco-Physio-Genomics, Talk	Day 3 - 11:15			
Sebastian Meier	Thoracospheres: the evolution of calcification in dinoflagellates	Coccolithophore Evolution	Eco-Physio-Genomics, Talk	Day 3 - 11:30			
		Coccolithophore Evolution	Eco-Physio-Genomics, Discussion 11:45 - 12:15				
Jeremy Young	The complex discovery of coccolithophores, from Ehrenberg to Lohmann *via* Sorby, Wallich and Huxley	Historical	Talk	Day 3 - 12:15	Lunch 12:30 - 14:00		
Laura Pea, Chiara Fioroni, Davide Persico, Silvia Palandri, Giuliana Villa	Late Eocene-Late Oligocene nannofossil paleoecology at Site 1090 (Agulhas Ridge, South Atlantic)	Paleoceanography	Talk	Day 3 - 14:00			
Giuliana Villa, Davide Persico, Sherwood Wise, Alessia Gadaleta	Calcareous nannofossil evidence for Marine Isotopic Stage 31 (1Ma) in ANDRILL MIS Core (western Ross Sea, Antarctica)	Paleoceanography	Talk	Day 3 - 14:15			
Channarayapattana Prabhu, Teresa Rodrigues, Jose-Abel Flores, Antje Voelker, Fatima Abrantes	Productivity response to the SST and hydrography change in the Tagus prodelta during the Younger Dryas and the Holocene	Paleoceanography	Talk	Day 3 - 14:30			
Alejandra Mejía-Molina, José-Abel Flores, Francisco Javier Sierro, M. Ángeles Barcena, Francis Grousset, Elsa Jullien	Response of coccolithophores to atmospheric and oceanographic changes during the Holocene African Humid Period in the East Atlantic, NW Africa	Paleoceanography	Talk	Day 3 - 14:45			
Elena Colmenero-Hidalgo, José-Abel Flores, Francisco J. Sierro, M. Ángeles Bárcena, Renata G. Lucchi and the SVAIS project participants	New coccolithophore records from the southern Svalbard margin: Preliminary results on the SVAIS Cruise sediment cores	Paleoceanography	Talk	Day 3 - 15:00			
Sara Marreco, Mário Cachão, Lúcia de Abreu, Vanda Brotas	MIS11 calcareous nannoplankton assemblages off western Iberia (MD01-2443): Paleoecological and paleoceanographic implications	Paleoceanography	Talk	Day 3 - 15:15			
		Paleoceanography	Discussion 15:30 - 16:00		Coffee break 16:00 - 16:30	16:30-19:00	DATABASE (M.-P. Aubry, M. Bonnemaison), Paleogene taxonomy & biostratigraphy (S. Monechi, T. Dunkley Jones), Intercalibration of methodologies (E. Erba)
Bianca De Bernardi, Claudia Agnini	Volume calculation of Paleocene calcareous nannofossils	Carbonate production and fluxes	Poster	Days 1 to 3; 16:30-19:00			
Gatsby-Emperatriz López-Otálvaro, José-Abel Flores, Francisco Javier Sierro	Nutri-thermocline dynamics reconstruction and coccolith carbonate contribution during the middle and late Pleistocene in the eastern equatorial Pacific ODP Site 1241	Carbonate production and fluxes	Poster	Days 1 to 3; 16:30-19:00			s
Karl-Heinz Baumann, Claudia Sprengel, Harald Andruleit	Coccolith fluxes in the North Atlantic: assemblage composition and carbonate supply	Carbonate production and fluxes	Poster	Days 1 to 3; 16:30-19:00			
Nicolas Thibault, Niels Schovsbo, Emma Sheldon, Lars Stemmerik, Finn Surlyk	Campanian–Maastrichtian nannofossil palaeoecology in the Boreal Realm (Stevns-1 well, Danish Basin chalks)	Carbonate production and fluxes	Poster	Days 1 to 3; 16:30-19:00			
Mascha Dedert, Heather Stoll, Jeremy Young, Patrizia Ziveri	Overgrowth on *Discoaster* and *Zygrhablithus* during the PETM: results from Sr/Ca measurements, stable isotopes and SEM analyses	Coccolithophores in a high CO_2 world: Responses and Related Ecological Changes	Poster	Days 1 to 3; 16:30-19:00			
Lia Auliaherliaty, Patrizia Ziveri, Heather M. Stoll	Eastern Mediterranean Sapropel 1 (S1) dynamics from coccolith chemistry	Coccolithophores in a high CO_2 world: Responses and Related Ecological Changes	Poster	Days 1 to 3; 16:30-19:00			
David Bord, Marie-Pierre Aubry	Morphological similarities linking fossil species *E. macellus* to the extant coccolithophorids *Gaarderia* and *Umbellosphaera* Significant implications for the function of coccoliths	Coccolithophore Evolution	Eco-Physio-Genomics, Poster	Days 1 to 3; 16:30-19:00			
Cleber Alves, Eduardo Koutsoukos, Maria Wanderley	Upper Cretaceous to Paleogene of the Dahomey Basin: calcareous nannofossil biostratigraphy	Developments in Biostratigraphy	Poster	Days 1 to 3; 16:30-19:00			

Teodora Blaj, Ian Backman, Isabella Raffi	Late Eocene to Oligocene preservation history and biochronology of calcareous nannofossils from paleo-equatorial Pacific Ocean sediments	Developments in Biostratigraphy	Poster	Days 1 to 3; 16:30-19:00
Margarita Buitrago-Reina, José-Abel Flores, Francisco Sierro, Vladimir Torres Torres	Review of calcareous nannofossil biostratigraphy and biochronology for the upper Miocene-Pliocene at ODP Site 999 (Caribbean Sea)	Developments in Biostratigraphy	Poster	Days 1 to 3; 16:30-19:00
Cristina Casellato, Elisabetta Erba, James Channell, Giovanni Muttoni	New bio-magnetostratigraphy for the Upper Jurassic and lowermost Cretaceous of the Southern Alps (Italy)	Developments in Biostratigraphy	Poster	Days 1 to 3; 16:30-19:00
Carmen Chira, Doru Juravle, Ramona Balc, Alin Igrita, Mirela Popa	The Paleogene/Neogene boundary in northern Moldavia (Moldovita Basin, Romania)	Developments in Biostratigraphy	Poster	Days 1 to 3; 16:30-19:00
Fereshte Farhad, Anoshiravan Kani	Calcareous nannofossils of Turonian-Santonian sediments, Zagros Basin, Iran	Developments in Biostratigraphy	Poster	Days 1 to 3; 16:30-19:00
Chiara Fioroni, Davide Persico, Laura Pea, Silvia Palandri, Giuliana Villa	High-resolution Late Eocene–Late Oligocene biostratigraphy from Site 1090 (Agulhas Ridge, South Atlantic)	Developments in Biostratigraphy	Poster	Days 1 to 3; 16:30-19:00
Azam Mahanipour, Anoshiravan Kani, Naser Raisossadat	Calcareous nannofossil biostratigraphy of the Sarcheshmeh and Sanganeh Formations in the Takal Kuh section, Kopet Dagh Basin (NE Iran)	Developments in Biostratigraphy	Poster	Days 1 to 3; 16:30-19:00
Alejandra Mejía-Molina, José-Abel Flores, Vladimir Torres Torres, Francisco Sierro	Coccolithophore assemblages of the Early-Middle Miocene in the Colombian Caribbean Sea: A correlation between the Arroyo Alférez section and ODP Leg 165, Site 999	Developments in Biostratigraphy	Poster	Days 1 to 3; 16:30-19:00
Simonetta Monechi, Viviana Reale, Gilen Bernaola, Barbara Balestra	New high-resolution calcareous nannofossil biostratigraphy and *Fasciculithus* evolutionary trend across the Danian-Selandian transition at ODP Site 1262, comparison with Zumaia (Spain) and the Qreiya (Egypt) sections	Developments in Biostratigraphy	Poster	Days 1 to 3; 16:30-19:00
Frédéric Ricciardi	Calcareous nannofossils in petroleum exploration: improving correlations using palaeoecological events	Developments in Biostratigraphy	Poster	Days 1 to 3; 16:30-19:00
Olga Rodríguez, Marie-Pierre Aubry	Paleocene calcareous nannofossil analysis of the Qreiya section (Egypt) and Eastern Venezuelan Basin	Developments in Biostratigraphy	Poster	Days 1 to 3; 16:30-19:00
Anatoliy Shumnyk, Sherwood Wise, Jr.	A revised calcareous-nannofossil biostratigraphic framework for the Campanian-Maastrichtian interval recovered by ODP Leg 207 on Demerara Rise, western equatorial Atlantic	Developments in Biostratigraphy	Poster	Days 1 to 3; 16:30-19:00
Seirin Shimabukuro, Armando Cunha	Nannolithofacies: an alternative method, using minerals and calcareous nannofossils, for hydrocarbon reservoir characterization and stratigraphic correlation	Developments in Biostratigraphy	Poster	Days 1 to 3; 16:30-19:00
Kristalina Stoykova	Paleocene-Lower Eocene calcareous nannofossil biostratigraphy of Bulgaria	Developments in Biostratigraphy	Poster	Days 1 to 3; 16:30-19:00
Lilian Svábenická	Diachroneic first occurrence of *Marthasterites furcatus* in the Tethyan foreland basins (outer Western Carpathians)	Developments in Biostratigraphy	Poster	Days 1 to 3; 16:30-19:00
Kristalina Stoykova, Marin Ivanov	Paleocene hyperthermal events evidenced by calcareous nannofossils in Bulgarian sections	Developments in Biostratigraphy	Poster	Days 1 to 3; 16:30-19:00
Svetlana Mizintseva	Reconstruction of the interregional Late Cretaceous sea-level record using nannofossil biostratigraphy	Developments in Biostratigraphy	Poster	Days 1 to 3; 16:30-19:00
Dennis Waga, Aida Andreeva-Grigorovich	Paleocene nannofossils from the Odessa Shelf (south-western Black Sea region)	Developments in Biostratigraphy	Poster	Days 1 to 3; 16:30-19:00
Dennis Waga, Aida Andreeva-Grigorovich	Calcareous nannofossil biostratigraphy of the Buchak and Kiev Formations (Middle Eocene) of the central part of the Ukrainian Shield	Developments in Biostratigraphy	Poster	Days 1 to 3; 16:30-19:00
Felipe Antonio de Lima Toledo, Lucio Riogi Tokutake	Quaternary calcareous nannofossil biostratigraphy and stable isotope stratigraphy (C and O) from the middle slope, northern portion of Campos Basin, Brazil	Developments in Biostratigraphy	Poster	Days 1 to 3; 16:30-19:00
Andrew Bowman, David Watkins, Felix Gradstein	Applying statistical techniques to construct a refined Paleocene-Eocene calcareous nannofossil biozonation	Developments in Biostratigraphy	Poster	Days 1 to 3; 16:30-19:00
Ines Galoviç	Correlation between Paratethys Mediterranean (NN-MNN) calcareous nannoplankton zonations	Developments in Biostratigraphy	Poster	Days 1 to 3; 16:30-19:00
Sjepan Coric, Johann Hohenegger	Quantitative analysis of Middle Miocene calcareous nannofossils from the scientific drilling at Baden-Sooss (Austria, central Paratethys)	Paleoceanography	Poster	Days 1 to 3; 16:30-19:00

Claudia Lupi, Iacopo Trattenero, Nicoletta Mancin, Miriam Cobianchi	Calcareous nannofossil, benthic foraminiferal and geochemical responses to nutrient availability in the SW Pacific Ocean during the Pleistocene	Paleoceanography	Poster	Days 1 to 3; 16:30-19:00
Carmen Álvarez, Lluïsa Cros, Belén Alonso, Belén Alonso, Javier Alcántara-Carrió	The last 20kyr in the Alboran Sea from the coccolithophore record: preliminary results	Paleoceanography	Poster	Days 1 to 3; 16:30-19:00
Barbara Balestra, Adele Bertini, Anne de Vernal, Simonetta Monechi, Viviana Reale	Highly variable Holocene climate from the Laurentian Fan using coccolith and palynomorph proxies	Paleoceanography	Poster	Days 1 to 3; 16:30-19:00
Anne-Marie Ballegeer, José-Abel Flores, Francisco Sierro, Rainer Gersonde	Calcareous nannofossil record of ODP site 1090 (South Atlantic) before and after the Eltanin impact at ~2.5Ma: preliminary results	Paleoceanography	Poster	Days 1 to 3; 16:30-19:00
Adrian Raymund Fernandez, Allan Gil S. Fernando	Distribution of 'minor' calcareous nannofossil species in the surface sediments along the Vietnam upwelling zone: western South China Sea revisited	Paleoceanography	Poster	Days 1 to 3; 16:30-19:00
Allan Gil S. Fernando, Reishi Takashima, Hiroshi Nishi, Hisatake Okada	High-resolution calcareous nannofossil biostratigraphy and chemostratigraphy of the Cenomanian-Turonian boundary in the Vocontian Basin, southeast France	Paleoceanography	Poster	Days 1 to 3; 16:30-19:00
Ekaterina Shcherbinina	Variations in abundance and morphology of *Watznaueria britannica* and *W. barnesiae* coccoliths in the Volgian sediments of the Ivkino section, Russian Platform	Paleoceanography	Poster	Days 1 to 3; 16:30-19:00
Daniele Tiraboschi, Elisabetta Erba	Calcareous nannofossil biostratigraphy (Upper Bajocian–Lower Bathonian) of the Ravin du Bès section (Bas Auran, Subalpine Basin, SE France), evolutionary trends of *Watznaueria barnesiae* and new enigmatic morphotypes of the genus *Rucinolithus*	Paleoceanography	Poster	Days 1 to 3; 16:30-19:00
Alessandro Incarbona, Sergio Bonomo, Enrico Di Stefano, Rodolfo Sprovieri, Nicola Pelosi, Mario Sprovieri	Millennial-scale paleoenvironmental changes in the central Mediterranean during the Last Interglacial: comparison with European and North Atlantic records	Paleoceanography	Poster	Days 1 to 3; 16:30-19:00
Alyssa Peleo-Alampay, Deborah Tangunan	Calcareous nannofossils as paleoproductivityiIndicators in sediments from the southeastern Sulu Sea	Paleoceanography	Poster	Days 1 to 3; 16:30-19:00
Julien Plancq, Stefano Palmerini, Vincent Grossi, Emanuela Mattioli, Bernard Pittet, George Yordanof, François Fourel, Luis Vitor Duarte, François Baudin	Nannofossil and environmental changes across the Sinemurian/Pliensbachian boundary in the Lusitanian Basin (S. Pedro de Moel, Portugal)	Paleoceanography	Poster	Days 1 to 3; 16:30-19:00
Letizia Reggiani, Emanuela Mattioli, Bernard Pittet	Spatial distribution of Pliensbachian (Lower Jurassic) calcareous nannofossils within the Lusitanian Basin (Portugal)	Paleoceanography	Poster	Days 1 to 3; 16:30-19:00
Damien Carcel, Fabienne Giraud, Claude Colombié	Paleoenvironmental changes in a Kimmeridgian platform (western France) revealed by calcareous nannoplankton and ascidian spicule variations	Paleoceanography	Poster	Days 1 to 3; 16:30-19:00
Katharina Stolz, Karl-Heinz Baumann, Till Hanebuth	Variations in surface-water conditions at the NW Iberian margin during the last ~50kyr as revealed by coccoliths	Paleoceanography	Poster	Days 1 to 3; 16:30-19:00
Karl-Heinz Baumann, Helge Meggers	Dynamics of the surface-water masses in the North Atlantic during the last 20 000 years as revealed by coccolith assemblages	Paleoceanography	Poster	Days 1 to 3; 16:30-19:00
Christina Fink, Karl-Heinz Baumann	Geochemical and isotopic signals (Sr/Ca ratios, stable $\delta^{13}C$ and $d^{18}O$ isotopes) in coccolith carbonate of different grain-size fractions in Atlantic sediments	Paleoceanography	Poster	Days 1 to 3; 16:30-19:00
Harald Andruleit	Distinctive new deep-photic coccolithophore taxa from the Java upwelling system (eastern Indian Ocean)	Paleoceanography	Poster	Days 1 to 3; 16:30-19:00
Emma Sheldon	Late Maastrichtian short-term warming events in the Boreal Realm: nannofossil evidence from Denmark	Paleoceanography	Poster	Days 1 to 3; 16:30-19:00

Thursday, Sept. 11th, 7:30 Fieldtrip departure
Saturday, Sept. 13th, 14:00 Arrival to Lyon

The last 20kyr in the Alboran Sea from the coccolithophore record: preliminary results

M. Carmen Álvarez, Lluïsa Cros, Belén Alonso, Javier Alcántara-Carrió

We are showing preliminary results from the gravity core ALM6. It was recovered by the R/V "*Garcia del Cid*" of the ICM (Instituto de Ciencias del Mar, Barcelona) during the expedition MAYC-96. The main purpose was to obtain information about the coccolithophorid record of the last 20 ky.

ALM6 is located at the base of slope of the Almeria margin (Alboran Sea, 36.35ºN, 2.61ºW) at a water depth of 1456 m. We studied 41 muddy hemipelagic samples obtained from a 5 cm systematic sampling. The age model was obtained from the AMS-carbon 14 radiocarbon analyses on tests of *Globigerina bulloides*. The calendar ages were obtained using the OxCal v3.10 (Bronk Ramsey, 1995; 2001) calibration program computer. Bottom core was about 20 ky B.P. and the estimated sedimentation rate was about 12 cm/ky. However, sedimentation rate was higher during Pleistocene than Holocene (Bozzano *et al*., in press).

A filtering technique was combined to the technique described in Flores & Sierro (1997) to prepare coccolithophore samples in the laboratory. Observations were made using a SEM (2000x) and counting around 300 coccoliths per sample (Fatela & Taborda, 2003).

The identification and counting of coccoliths revealed that *Emiliania huxleyi* was the dominant species. Other abundant taxa were: *Gephyrocapsa* spp., *Syracosphaera* spp., *Calciosolenia* spp. and *Umbilicosphaera* spp.

The preservation degree was estimated as "good" (Flores *et al*., 2003). It has been possible to observe resistant taxa (*C. leptoporus*) coexisting with other, more easily dissolved coccoliths (small placoliths) in the same sample.

References

Bozzano, G., Alonso, B., Ercilla, G., Estrada, F. & García, M. Late Pleistocene and Holocene depositional facies of the Almeria Turbidite System (Western Mediterranean). *In*: B. Kneller, McCaffrey, O. Martinsen & H. Posamentier (Eds). *External Control on deep water depositional systems: Climate, seal-level and sediment flux*. Geological Society of London (in press).

Bronk Ramsey, C. 1995. Radiocarbon calibration and analysis of stratigraphy: The OxCal program. *Radiocarbon*, **37**(2): 425-430.

Bronk Ramsey, C. 2001. Development of the radiocarbon calibration program OxCal. *Radiocarbon*, **43**(2A): 355-363.

Fatela, F. & Taborda, R. 2003. Confidence limits of species proportions in microfossil assemblages. *Marine Micropaleontology*, **45**: 169-174.

Flores, J.A. & Sierro, F.J. 1997. Revised technique for calculation of calcareous nannofossil accumulation rates. *Micropaleontology*, **43**: 321-324.

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 600 kyr at ODP Site 1089 (Cape Basin, South Atlantic): Paleoceanographic implications. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **196**: 409-426.

Upper Cretaceous to Paleogene of the Dahomey Basin: calcareous nannofossil biostratigraphy

Cleber Fernandes Alves, Eduardo Apostolos Machado Koutsoukos, Maria Dolores Wanderley

The present work aims to identify and correlate the Maastrichtian to middle Eocene calcareous nannofossil assemblages of the southern Dahomey Basin. This is an extensive sedimentary basin located in the Gulf of Guinea, spreading over the central West African margin from Ghana to Togo and Benin to the west, and along southern Nigeria to the east.

Five well-sections (cored well Ilaro-3, Ilaro-1, Araromi and Wasimi, and well Bode Ashe, with ditch-cuttings), and one outcrop section (Shagamu) were selected to be studied. A detailed biostratigraphic framework based on calcareous nannofossils is proposed for the Maastrichtian to middle Eocene of this region.

The calcareous nannofossil study of the selected successions recovered the following bio-chronostratigraphic intervals:
Bode Ashe well: Maastrichtian to middle Eocene, biozones CC26, NP1-NP4, NP6-NP9, NP10, NP11/NP12 and NP13/NP14.
Ilaro-3 well: Eocene, biozones NP12, NP13, NP14 and NP15.
Ilaro-1 well: lower Paleocene to middle Eocene, biozones NP1, NP2-NP4, NP5/NP6, NP7/NP8, NP9 and NP10.
Araromi well: Maastrichtian to lower Eocene, biozones CC26, NP1, NP4, NP5, NP6, NP7/NP8, NP9 and NP10.
Wasimi well: Maastrichtian, biozone CC26.
Shagamu outcrop: upper Paleocene, biozone NP9.

This was a joint project coordinated and carried out by PETROBRAS-CENPES (Rio de Janeiro), the Technische Universität of Berlin (TUB, Germany), and the University of Ilorin (Nigeria). The financial support by the Volkswagen-Stiftung Program of Partnerships is gratefully acknowledged. The present calcareous nannofossil study was sponsored by a doctorate scholarship of the Program of Qualification of Human Resources in Petroleum Geology-PRH-ANP/MCT 18/UFRJ.

Distinctive new deep-photic coccolithophore taxa from the Java upwelling system (eastern Indian Ocean)

Harald Andruleit

Extant coccolithophores have been intensively studied over the past two decades and their taxonomy is probably better established than that of any other phytoplankton group. Nonetheless new taxa continue to be recorded, especially from the deep-photic zone and the number of very distinctive but rare coccolithophores is a curious feature of this extreme habitat (Young & Andruleit, 2006).

Several of such unusual new coccolithophore species were found during examination of samples from the eastern Indian Ocean off SW Indonesia under the influence of the Java upwelling. In this monsoonal influenced area the oceanographic environment exhibits a high variability with a seasonal change from oligotrophic to eutrophic conditions. Today, upwelling seems to recur only for a short time period around September, whereas oligotrophic conditions prevail during most of the year. In the geological record, however, upwelling-indicating species evidently dominate the assemblages (Andruleit *et al*., in press).

Some of the new species described here are rather similar to already known or recently described species. Other species show remarkable new features and are not easily related to already established genera or families. Although the nature of some of the shown specimens is not clear, their morphology, size and structure suggest an origin within the coccolithophores.

A detailed description of the potentially new coccolithophore species will be published in detail elsewhere. Here, selected specimens (Figures 1 to 9) are shown for discussion within the scientific community.

References

Andruleit, H., Lückge, A., Wiedicke-Hombach, M. & Stäger, S. Late Quaternary development of the Java upwelling system (eastern Indian Ocean) as revealed by coccolithophores. *Marine Micropaleontology*, in press.

Young, J.R. & Andruleit, H. 2006. *Navilithus altivelum*: a remarkable new genus and species of deep photic coccolithophores. *Journal of Micropalaeontology*, **25**(2): 141-152.

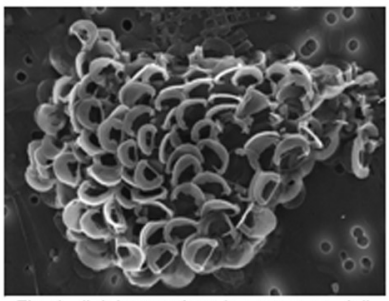


Fig. 1 "Abyssisphaera sp. A"

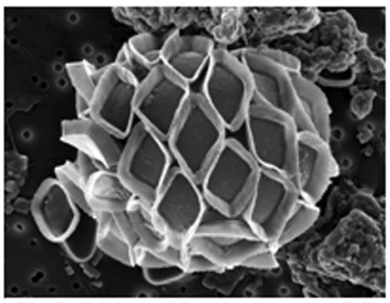


Fig. 2 "Abyssisphaera sp. B"

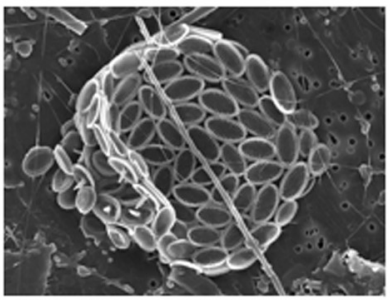


Fig. 3 "Abyssisphaera sp. C"

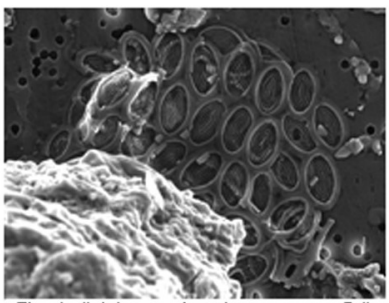


Fig. 4 "Abyssisphaera sp. D"

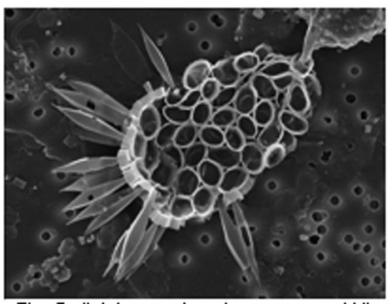


Fig. 5 "Abyssisphaera sp. H"

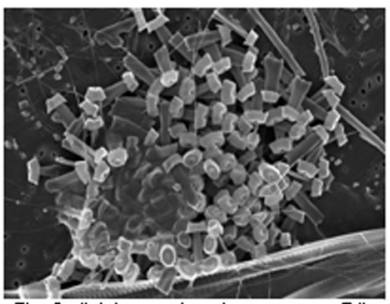


Fig. 6 "Abyssisphaera sp. F"

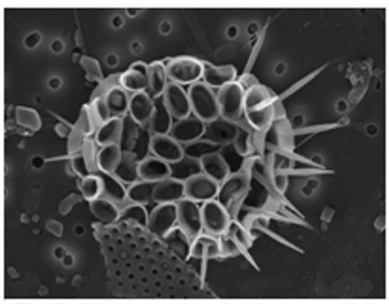


Fig. 7 "Abyssisphaera sp. G"

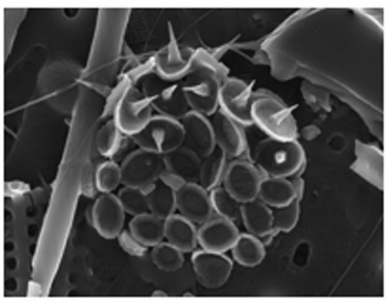


Fig. 8 "Abyssisphaera sp. H"

Fig. 9 Location of the Java-Upwelling

Eastern Mediterranean Sapropel 1 (S1) dynamics from coccolith chemistry

Lia Auliaherliaty, Patrizia Ziveri, Heather M. Stoll

The eastern Mediterranean Sea is an area where occasionally sapropel (organic-rich layer deposited under seafloor anoxic conditions) formation took place. The occurrence of these layers corresponds with the summer insolation maxima of the Northern Hemisphere, which increases the seasonal thermal gradient between ocean and continental regions and thus enhancing the African monsoonal circulation system. The driving mechanism of sapropel deposition is still debatable however, the combination of both anoxia of the bottom-water and enhanced marine productivity, as a response to the climate forcing (Emeis *et al*., 2000) could explain it.

Coccolithophores are a dominant phytoplankton group in the Mediterranean Sea and an important indicator of past conditions in the fossil record. In the eastern Mediterranean, the significant increase of *Florisphaera profunda* during S1 was correlated with a nutrient-rich lower photic zone and stratification of the upper water-column.

To reconstruct the dynamics of S1 formation, we analyzed species-specific coccolith stable isotopes on four deep-sea sediment cores spanning S1 from the eastern Mediterranean, and one from the western Mediterranean. The oxygen isotopes of species-specific coccolith carbonate may infer the oxygen isotope composition of the seawater, which is affected by temperature, evaporation, and precipitation. The $\delta^{13}C$ of the dissolved inorganic carbon (DIC) in seawater is influenced by the production and respiration of organic matter. We also present results on Sr/Ca ratios as a proxy of productivity from two cores.

The fine fraction (<20 μm) record showed a shift of about ~ 0.5 to 2 ‰ in $\delta^{18}O$ and ~1 ‰ in $\delta^{13}C$. The fine fraction carbonate in the Mediterranean Sea is made up of not only several coccolith species (vital effects in $\delta^{18}O$ and $\delta^{13}C$) but possibly also reworked coccolith species and fragments of other unidentified biogenic carbonate. *Emiliania huxleyi* enriched fraction (3-5 μm) showed a negative shift of about ~ 1 ‰ in $\delta^{18}O$ and $\delta^{13}C$. The $\delta^{18}O$ results combined with alkenone temperature reconstructions from the same samples confirmed a large freshwater discharge before sapropel formation. An increase of freshwater input will establish a low-salinity surface layer, thus modifying the thermohaline circulation of the eastern Mediterranean by weakening the Eastern Mediterranean Deep Water formation and promoting a termination of deep water ventilation. This condition might lead to the oxygen depleted zone which caused accumulation and preservation of the organic-carbon-rich sediments. Furthermore, an increase of continental influence may fertilize the basin and lead to relatively high productivity.

A parallel trend of negative shifts in the $\delta^{18}O$ and $\delta^{13}C$ of both fractions mirrored the Sr/Ca ratios which showed an increase of ~ 1.5 mmol/mol for fine fraction and ~ 0.75 mmol/mol for *E. huxleyi* enriched fraction. These results clearly suggested an increase in productivity during S1 in the eastern Mediterranean. Nevertheless, the record in the western basin showed no response to such climate change during S1 time interval.

Reference

Emeis, K.C., Sakamoto, T., Wehausen, R. & Brumsack, H-J. 2000. The sapropel record of the eastern Mediterranean Sea - results of Ocean Drilling Program Leg 160. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **158**: 371-395.

Highly variable Holocene climate from the Laurentian Fan using coccolith and palynomorph proxies

Barbara Balestra, Adele Bertini, Anne de Vernal, Simonetta Monechi, Viviana Reale

Coccolith, dinocyst and pollen analyses from the IMAGES core MD95-2033, collected from the Laurentian Fan (lat: 44˚39.87N, long: 55˚37.21W; water depth 1412m), provide new data set in millennial scale, to assess the magnitude of climatic changes during the Holocene. Today, the area is under the influence of the North Atlantic Current (NAC). North Atlantic circulation, through its heat transport and deepwater formation, is an important contributor in the climate system. Several dramatic reorganizations of the ocean circulation have occurred during the last glacial and interglacial period. During the Holocene period in particular, the surface ocean circulation shows different patterns and the mechanisms behind them are very still much under debate.

In this research, coccolith, dinocyst and pollen diversity and concentrations are used as proxies to trace those surface water circulation changes. In particular, in the coccolith assemblages, the abundances of *Emiliania huxleyi*, *Calcidiscus leptoporus* and *Gephyrocapsa* spp. show millennial-scale oscillations. Dinocyst assemblages are dominated by *Operculodinium centrocarpum* followed by *Spiniferites elongatus*, *Bitectatodinium tepikiense* and *Alexandrium excavatum*. These species show large-amplitude temperature and salinity fluctuations, which indicate major climate and/or hydrographic change, at least on a regional scale. Estimates of sea-surface temperatures, salinity and sea-ice cover, reconstructed using dinocysts, were also performed.

This work provides new data in order to better understand the key processes in Holocene regional cooling and warming of North Atlantic surface waters and the variability of NAC formation.

Calcareous nannofossil record of ODP Site 1090 (South Atlantic) before and after the Eltanin impact at ~2.5Ma: Preliminary results

Anne-Marie Ballegeer, José-Abel Flores, Francisco J. Sierro, Rainer Gersonde

The Eltanin asteroid impact was first discovered as an Ir anomaly in 1981 (Kyte *et al*., 1981). The impact ripped up Eocene, and probably Paleocene, sediments that afterwards were redeposited in a chaotic assemblage (Gersonde *et al*., 1997). Chronostratigraphic data, obtained from a series of 4 piston cores recovered on the R/V *Polarstern* ANTXVII/5a Cruise, place the Eltanin impact at 2.5 Ma (Gersonde *et al*., 2003). It is the only known asteroid in a deep-ocean basin. Recent results estimate that the asteroid was larger than 1 km (Gersonde *et al*., 2003). Up to now, no crater has been found. Glatz *et al*. (2002) claimed to have found a 132 km crater, but this has been rejected later on (Gersonde *et al*., 2003). The impact might have caused mega-tsunamis, probably visible in sediments throughout the Pacific and Southern Ocean shores, which may have had an effect on the climate by ejection of large amounts of saltwater into the atmosphere (Gersonde *et al*., 1997). Disturbance from the impact clearly extends for about 100 km north and east of the Freeden Seamounts. However, with increasing distance to the north and the east, the concentrations of ejecta decrease and thick deposits of disturbed sediments are not present (Gersonde *et al*., 2003).

In the last decade, scientists have tried to obtain a better understanding of the impact and its consequences. Impact deposits have been recovered from 20 sediment cores. Tsunami deposits of 7-10 m thick, found along the coast of N Chili, might be related to this impact (Felton & Crook, 2003). A study of the sediment cores of the Bellinghausen Sea, made by Flores *et al*. (2002), did not reveal significant changes in the calcareous plankton association for the interval immediately after the impact, but relatively slow sedimentation rates and extensive bioturbation may be indicative of paleoenvironmental changes immediately after the impact. During Leg 178, Site 1096 (at 1300 km from the impact site) was examined to find traces of the impact. In this site, no strong evidence was found that could be related to the impact (Kyte, 2001).

The present study is focused on the calcareous nannofossil record of this particular interval (between 3 and 2 Myr) to see whether or not significant changes in the calcareous nannofossil record can be observed and/or related to the Eltanin impact. For this purpose, material of OPD Hole 1090B, recovered during Leg 177, is studied. This core is situated in the Subantarctic zone of the South Atlantic, on the southern flank of the Agulhas Ridge. A well-preserved nannofossil assemblage is found, in which the most abundant species are *Calcidiscus leptoporus*, *Coccolithus pelagicus*, *Reticulofenestra minuta* and *Reticulofenestra minutula*. Strong fluctuations in the abundance of these taxa are observed and may indicate oceanographic changes during the Late Pliocene interval. It is difficult to determine whether those changes could be related to the Eltanin impact or to other important processes occurring during this time interval (*e.g*., closure of the Isthmus of Panama and the onset of Northern Hemisphere glaciation).

References

Felton, E.A.& Crook, K.A.W. 2003. Evaluating the impacts of huge waves on rocky shorelines: an essay review of the book 'Tsunami - the underrated hazard'. *Marine Geology*, **197**: 1-12.

Flores, J.-A., Sierro, F.J. & Gersonde, R. 2002. Calcareous plankton stratigraphy around the Pliocene "Eltanin" Asteroid Impact Area (SE Pacific): documentation and application for geological and paleoceanographic reconstruction. *Deep-Sea Research*, **49**: 1011-1027.

Gersonde, R., Kyte, F.T., Bleil, U., Diekmann, B., Flores, J.-A., Gohl, K., Grahl, G., Hagen, R., Kuhn, G., Sierro, F.J., Völker, D., Abelmann, A. & Bostwick, J.A. 1997. Geological record and reconstruction of the late Pliocene impact of the Eltanin asteroid in the Southern Ocean. *Nature*, **390**: 357-363.

Gersonde, R., Kyte, F.T., Frederichs, T., Bleil, U. & Kuhn, G. 2003. New data on the late Pliocene Eltanin impact into the deep southern ocean. Large meterorite impacts.

Glatz, C.A., Abbott, D.H. & Nunes, A.A. 2002. *GSA Abstr. Prog*., **34**(No.6): 401.

Kyte, F.T., Zhou, Z. & Wasson, J.T. 1981. High noble metal concentrations in a late Pliocene sediment. *Nature*, **292**: 417-420.

Kyte, F.T. 2001. Data report: A search for deposits of the late Pliocene impact of the Eltanin asteroid in rise sediments from the Antarctic Peninsula, Site 1096. *In*: P.F. Barker, A. Camerlenghi, G.D. Acton & A.T.S. Ramsay (Eds). *Proceedings of the ODP, Scientific Results*, **178**: 1-6.

Badenian calcareous nannoplankton from NE Slovenia (Mura depression, western Central Paratethys): paleogeography and paleoecology

Milos Bartol

In the beginning of the Middle Miocene the Central Paratethys reached its maximum extent. It consisted of a series of larger and smaller epicontinental tectonic basins. The Badenian corresponds to Langhian and Lower Serravallian of the Mediterranean and was the last fully marine period in the life of Central Paratethys. It also corresponds to the final stage of the Miocene Climatic Optimum (MCO), when favourable environmental conditions allowed for the thriving of diverse calcareous nannoplankton assemblages, producing a fossil record of great biostratigraphic and paleoecological significance.

The Mura depression was one of the smaller basins near the western coast of the Central Paratethys. Seventeen sections, composed of marls and subordinate sandstones, sands and limestones were sampled. A few hundred samples were collected in 10 cm intervals for micropaleontological analyses. One hundred and seven species of calcareous nanoplankton and three species of calcisphere were determined.

The diversity and abundance of nannoplankton allowed a precise dating of individual sections and their correlation. The total time span of the studied strata comprises the interval between the top of biozone NN4 in the early Badenian and the bottom part of biozone NN6 in the late Badenian. This time interval was divided into six shorter intervals. The oldest nanoplankton assemblages are assigned to the top part of biozone NN4, biozone NN5 contains four successive intervals, and the youngest interval corresponds to the lower part of biozone NN6. The composition of nannoplankton assemblages and facies suggest a heterogeneous nature of the Mura Depression, with deep basins in immediate vicinity of shallow marine environments. This is clearly observable at the top of biozone NN5, represented by marl beds with typically pelagic nannoplankton assemblages in one section and shallow-water rhodoliths in several other sections only a few kilometres away.

The pattern of biostratigraphic events observed in the youngest nanoplankton assemblages, belonging at the beginning of the biozone NN6, is paleogeographically significant, since it is nearly identical to that described in the Mediterranean (Fornaciari *et al*., 1996). The LO of *Sphenolithus heteromorphus*, the FO of *Reticulofenestra pseudoumbilica*, the LCO of *Cyclicargolithus floridanus* and the FO of *Calcidiscus macroporus* were observed in both areas in the same succession. The first of these events is nearly synchronous on a global scale, while the others are diachronous in different regions. The close resemblance in the character and the order of observed events indicate that the Slovenian Corridor, a seaway between the Mediterranean and the Central Paratethys, was still open in the beginning of the late Badenian (Fig. 1).

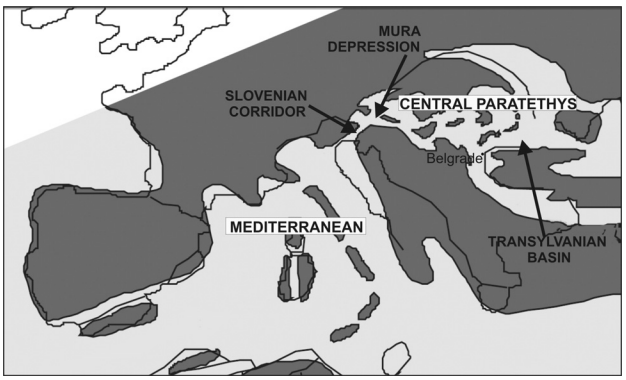


Figure 1: Paleogeographical sketch of the Mediterranean and the Central Paratethys in the early late Badenian (modified after Rögl, 1998)

In the oldest nannoplankton assemblages (NN4), a deepening trend was observed, reflecting a transgression at the beginning of the Badenian. Younger assemblages from this interval are more diverse and contain several pelagic species, which are absent in the oldest assemblages. Throughout the entire biozone NN5, the high species diversity, abundance of *Helicosphaera* spp. coccoliths, and the constant presence of rare specimens of sphenoliths and discoasters indicate relatively warm water. Some assemblages from the middle part of biozone NN5 and the ones from the youngest strata (the upper part of NN5 and the bottom part of NN6) contain several dominant species (*Helicosphaera carteri*, *Coccolithus pelagicus*, *Reticulofenestra minuta*, *R*. spp.) as well as *Reticulofenestra pseudoumbilica* and *R. gelida* (summer and winter variety of the same species). This suggests increased seasonality towards the top of the studied interval, which is in agreement with some published reports (Syabraj *et al*., 2007; Bojar *et al*., 2004). Surprisingly, the warm-water character of the youngest nannoplankton assemblages is very pronounced. An interval characterised by high diversity, enriched in the warm-water genera *Discoaster* and *Sphenolithus*, was observed at the transition between biozones NN5 and NN6 at approximately 13.5 Ma. This is well after the beginning of the drop in temperatures at the end of the MCO, which started at 14 Ma (Bojar *et al*., 2004; Syabraj *et al*., 2007; Böhme, 2003). The enrichment in *Discoaster* spp., followed by an increase in abundance of *Sphenolithus* spp., closely resembles the pattern described in the upper Badenian near Belgrade (Mihajlovic & Knezevic, 1989), and probably reflects the same event. The nannoplankton assemblages from the Transylvanian Basin

(Chira, 2001), belonging to the same interval, also show a pattern similar to that recorded in Slovenia.

Late Badenian pollen and other terrestrial fossil plants from the southernmost sites in Romania, Serbia and Hungary are characterized by thermophilous flora and indicate subtropical climatic conditions, while a general cooling trend appears in other Central Paratethys sites (Kvacek *et al*., 2006). The pattern of paleoclimatic changes in the Central Paratethys region at the end of the MCO has a regional character. Perhaps, this was the result of a gradual termination of the connection between the Central Paratethys and the Mediterranean that persisted in the westernmost and the south-western parts of the region after it ended in the others.

References

Böhme, M. 2003. The Miocene Climatic Optimum: evidence from ectothermic vertebrates of Central Europe. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **195**: 389-401.

Bojar, A.V., Hiden, H., Fenniger, A. & Neubauer, F. 2004. Middle Miocene seasonal temperature changes in the Styrian basin, Austria, as recorded by the isotopic composition of pectinid and brachiopod shells. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **203**: 95-105.

Chira, C. 2001: The Badenian calcareous nannoplankton from Turda and Ocna Dej salt mines (Transylvanian basin, Romania). *Studia Universitatis Babes-Bolyai, Geologia*, **46**(2): 141-150.

Fornaciari, E., Di Stefano, A., Rio, D. & Negri, A. 1996. Middle Miocene calcareous nannofossil biostratigraphy in the Mediterranean region. *Micropaleontology*, **42**(1): 37-62.

Kvacek, Z., Kovác, M., Kovar-Eder, J., Doláková, N., Jechorek, H., Parashiv, V., Kovácová, M. & Sliva, L. 2006. Miocene evolution of landscape and vegetation in the Central Paratethys. *Geologica Carpathica*, **57**(4): 295-310.

Mihajlovic, D. & Knezevic, S. 1989. Calcareous nannoplankton from Badenian and Sarmatian deposits at Visnjica and Karaburma in Belgrade. *Geoloski anali Balkanskoga poluostrva, Knjiga*, **53**: 343-366.

Rögl, F. 1998. Palaeogeographic considerations for Mediterranean and Paratethys Seaways (Oligocene to Miocene). *Ann. Naturhist. Mus., Wien*, **99**(A):279–310.

Syabryaj, S., Utescher, T., Molchanoff, S. & Bruch, A.A. 2007. Vegetation and palaeoclimate in the Miocene of Ukraine. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **253**: 153-168.

Dynamics of the surface-water masses in the North Atlantic during the last 20 000 years as revealed by coccolith assemblages

Karl-Heinz Baumann, Helge Meggers

A coccolith-based micropalaeontological investigation of ODP Sites 980 and 984 from the Feni and Gardar contour drifts of the northern North Atlantic was conducted in order to reconstruct the pattern and timing of surface circulation changes in the area during the last 20 000 years. In addition, sea-surface palaeotemperature records from both sites were generated at high resolution, based on the widely used alkenone palaeothermometer.

The down-core variations in coccolith assemblage composition indicate that changes in properties of surface waters in the northern North Atlantic occurred stepwise during the Termination I. Sparse occurrences of coccolithophores before about 17 000 yrs BP at Site 980 and before about 13 500 yrs BP at Site 984, respectively, indicate harsh environmental conditions and the influence of melt-water. The difference in timing between both sites is due to the position of the Polar Front, which was probably located between the site locations during the interval 17 000 to 13 500 yrs BP. The following stepwise increase of North Atlantic Drift water influence till about 10 000 cal yr BP was associated with the increase in absolute numbers of coccolithophores in the whole area. High coccolith numbers are observed in the early Holocene, which coincide well with maximum Northern Hemisphere summer insolation.

A cooling of the surface waters, as indicated by a prominent change in the relative abundances of the dominant coccolith species, occurred after about 5000 cal yr BP. The numbers of the cold-adapted species *Coccolithus pelagicus* increased considerably. In addition, a successive increase in millennial-scale perturbations of the surface hydrology towards the Neoglaciation (the last *ca*. 5000 years) is documented by changes in accumulation of the species, in particular of *Emiliania huxleyi*. These successive decreases in the numbers of *E. huxleyi*, as previously described by Giraudeau *et al*. (2000), is in phase with recorded Holocene advection of cool, ice-bearing waters from the Greenland-Iceland seas to the North Atlantic. These long-term reorganisations of the surface hydrology are interpreted as the response of the North Atlantic to the combined forces of the solar insolation and the waning Laurentide ice sheet.

Reference

Giraudeau, J., Cremer, M., Manthé, S., Labeyrie, L. & Bond, G. 2000. Coccolith evidence for instabilities in surface circulation south of Iceland during Holocene times. *Earth Planetary Science Letters*, **179**: 257-268.

Coccolith fluxes in the North Atlantic: Assemblage composition and carbonate supply

Karl-Heinz Baumann, Claudia Sprengel, Harald Andruleit

Coccolithophores, one of the main primary producers in the surface waters of the North Atlantic region, were investigated to quantify coccolith and coccolith-carbonate export fluxes and to determine possible seasonal trends in species composition. Coccolithophore flux variations in sediment traps at three mooring locations along an S-N transect at approx. 20˚W from 33˚N (L1) via 47˚N (L2) to 55˚N (L3) were recorded from July 1995 to July 1997. The 20-cup particle traps were deployed at 1000m, 2000m, and 3500m or 4000m below sea-surface; the material of the 2000m traps was studied. Sampling intervals ranged from 14 days to four weeks.

In general, total coccolith fluxes were characterized by a strong seasonality. Maximum coccolith flux values were reached in February-March (Station L1 at 33˚N) or July-September (stations L2 and L3), respectively. Highest total coccolith fluxes and fluxes of different species at the three sites were rather comparable. Surprisingly, the coccolith fluxes at the relatively oligotrophic station L1 are up to 15 x 10^9 coccoliths m^{-2} d^{-1} and slightly higher than those at L2 and L3, where up to 5 x 10^9 coccoliths m^{-2} d^{-1} were observed. The examination of all trap samples revealed a highly diverse coccolithophore assemblage with in total 63 species. Nevertheless, sinking assemblages at all sites are dominated by *E. huxleyi* (generally >35%, >70% at L3), with only *F. profunda* (at L1), *Gephyrocapsa* spp. (mainly *G. muellerae*) and *Syracosphaera* spp. (at L3) contributing considerably to the assemblages. All the other species exhibited maximum relative abundances of generally less than <10%.

In all trap samples, a conversion of coccolith fluxes into coccolith-carbonate fluxes based on mean species-specific carbonate masses was made. The mean contribution of coccolith-carbonate fluxes to the total carbonate fluxes in each trap was approx. 32%. The coccolith-carbonate fluxes are dominated on the one hand by small-sized coccoliths of the dominant species *E. huxleyi*, on the other hand by the larger, but less dominant, species *C. leptoporus* and *C. pelagicus*.

Effect of ocean carbonate chemistry on Isochrysidales calcification: studies from present and past oceans

Luc Beaufort

The calcite weight of Isochrysidales coccoliths and coccospheres from samples taken in water and sediment samples from the 3 oceans was estimated using automated pattern recognition and automated morphometry software. The calcite estimates made from more than 200 water samples collected in the photic zone (more than 1000 individuals measured per sample) indicates that the variability in the degree of calcification of Isochrysidales (weight of their coccoliths and coccospheres) strongly depends on environmental parameters (alkalinity, temperature and calcite saturation state). In areas of high alkalinity, high temperature, and high calcite saturation state, the Isochrysidales secrete the heaviest coccospheres and coccoliths. What is true at the order level (Isochrysidales) is also true at the species level for *Emiliania huxleyi* but in a lesser degree because some regional differences occur for this species.

The Isochrysidales coccolith weight was estimated in 7 cores covering the last 40 kyr (3 from the Atlantic, 3 from the Pacific and 1 from the Indian Ocean) at the order and species (*E. huxleyi*) levels. All records exhibit highest coccolith weight during the Last Glacial Maximum. When all the records are stacked, the pattern of calcite weight mirrors strongly that of the CO_2 concentration in the Vostock ice core. This cannot be due to dissolution for two reasons: (1) dissolution in the Atlantic and Indo-Pacific oceans at the glacial/interglacial scale present opposite histories; (2) laboratory experiments show little effect of dissolution on the weight of the coccoliths. Therefore the weight variability observed at the Glacial/Interglacial time scale is the result of a change in the secretion of Isochrysidales, certainly related to changes in the environmental parameters described in the modern ocean study. Because the Last Glacial Maximum was obviously not a time of higher oceanic temperatures, only changes in the oceanic carbonate chemistry produced the observed variations of Isochrysidales calcification. This study provides a new case on the threat that the future increase in atmospheric CO_2 and consequent ocean acidification induces on oceanic biological calcification.

Campanian nannofossil biostratigraphy from Mississippi (Gulf of Mexico) and correlations to northwest Europe, southwest France and Tunisia

James Bergen

Upper Santonian to lower Maastrichtian nannofossils investigated in the DCH-1 Foun Farms Corehole (Noxubee County), and a composite of 14 outcrop sections from central Mississippi, demonstrate the potential in Campanian calcareous nannofossil biostratigraphy and the possible significance of the Gulf Coast region in global correlation. The exceptional preservation of recovered nannofossil assemblages and geographic-location-optimized biostratigraphic resolution; sample density and analysis-time-limited results. Eighty Campanian nannofossil events were reproduced between the core and composite outcrop section. Approximately 37 new species were observed in this material, of which eleven were utilized for biostratigraphy. Lineages in the families Arkhangelskiellacae, Chiastozygaceae, Polycyclolithaceae, and Stephanolithiaceae are presented.

The boundaries of the Campanian were constrained by analyses of: (1) the Campanian/Maastrichtian GSSP section of Tercis les Bains, southwest France; and (2) Santonian/Campanian boundary sections in southern England (Whitecliff), Texas (Waxahachie), and Mississippi (Plymouth Bluff) containing the boundary fossil criterion, the extinction of the crinoid *Marsupites testudinarius*.

The Mississippi sections contain flora with both high- and low-latitude affinities, but also many cosmopolitan taxa. Latitudinal segregation first observed during the early Campanian had become more severe near the close of the Campanian, making it difficult to correlate between sections in northwest Europe (southern England, Netherlands, North Sea) and low latitudes (southwest France, Tunisia). Nannofossil events in these eastern circum-Atlantic low- and high-latitude sections could be correlated to, and directly integrated within, the Mississippi succession.

Late Eocene to Oligocene preservation history and biochronology of calcareous nannofossils from paleoequatorial Pacific Ocean sediments

Teodora Blaj, Jan Backman, Isabella Raffi

A high resolution biochronologic study of late Eocene and Oligocene calcareous nannofossils from a continuous carbonate sequence recovered at Ocean Drilling Program (ODP) Leg 199 Site 1218 in the paleoequatorial Pacific Ocean led to the recognition of the following biohorizons: the highest occurrences (HO) of *Discoaster barbadiensis* (34.773 Ma), *D. saipanensis* (34.448 Ma), *Ericsonia formosa* (32.923 Ma), *Reticulofenestra umbilicus* (32.019 Ma), *Sphenolithus predistentus* (26.930 Ma), *S. distentus* (26.908 Ma) and *S. ciperoensis* (24.432 Ma), and the lowest occurrences (LO) of *S. distentus* (29.992 Ma) and *S. ciperoensis* (27.093 Ma). In addition, the HO of *S. predistentus* was identified at 26.930 Ma, and the first consistent appearance of *Triquetrorhabdulus carinatus* occurs at 26.555 Ma, while the onset of the peak interval of *T. carinatus* was determined at 24.436 Ma. The stratigraphic

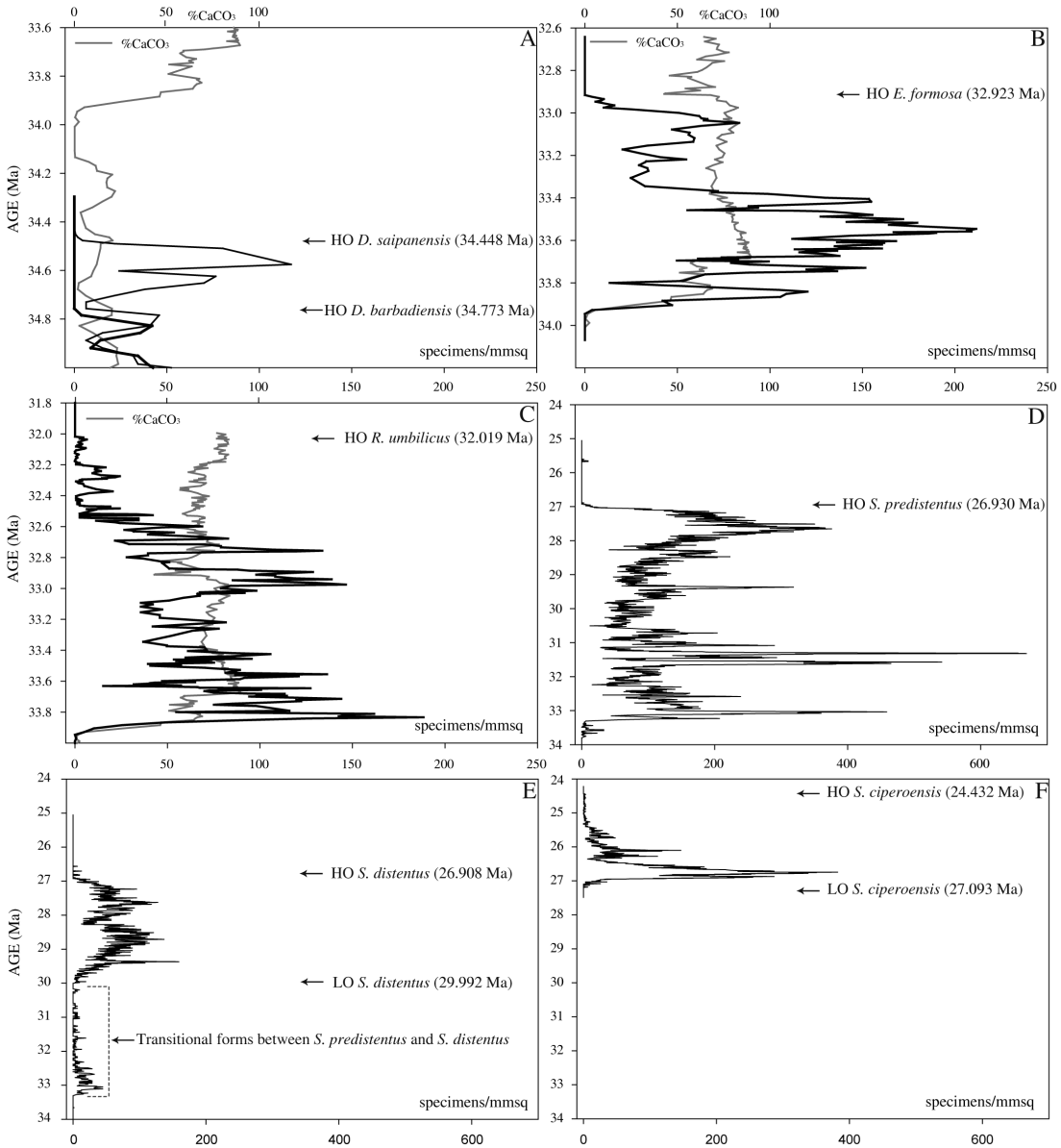


Figure 1: Plots of the range pattern of **A**) *D. barbadiensis* (thicker black line) and *D. saipanensis* (thinner black line), **B**) *E. formosa*, **C**) *R. umbilicus*. Gray line represents carbonate content (weight %) in the panels. **D**) *S. predistentus*, **E**) *S. distentus* and the transitional form between *S. predistentus* and *S. distentus*, **F**) *S. ciperoensis* and **G**) *T. carinatus s.s.* (black line) and *T.* aff. *T. carinatus* (gray line)

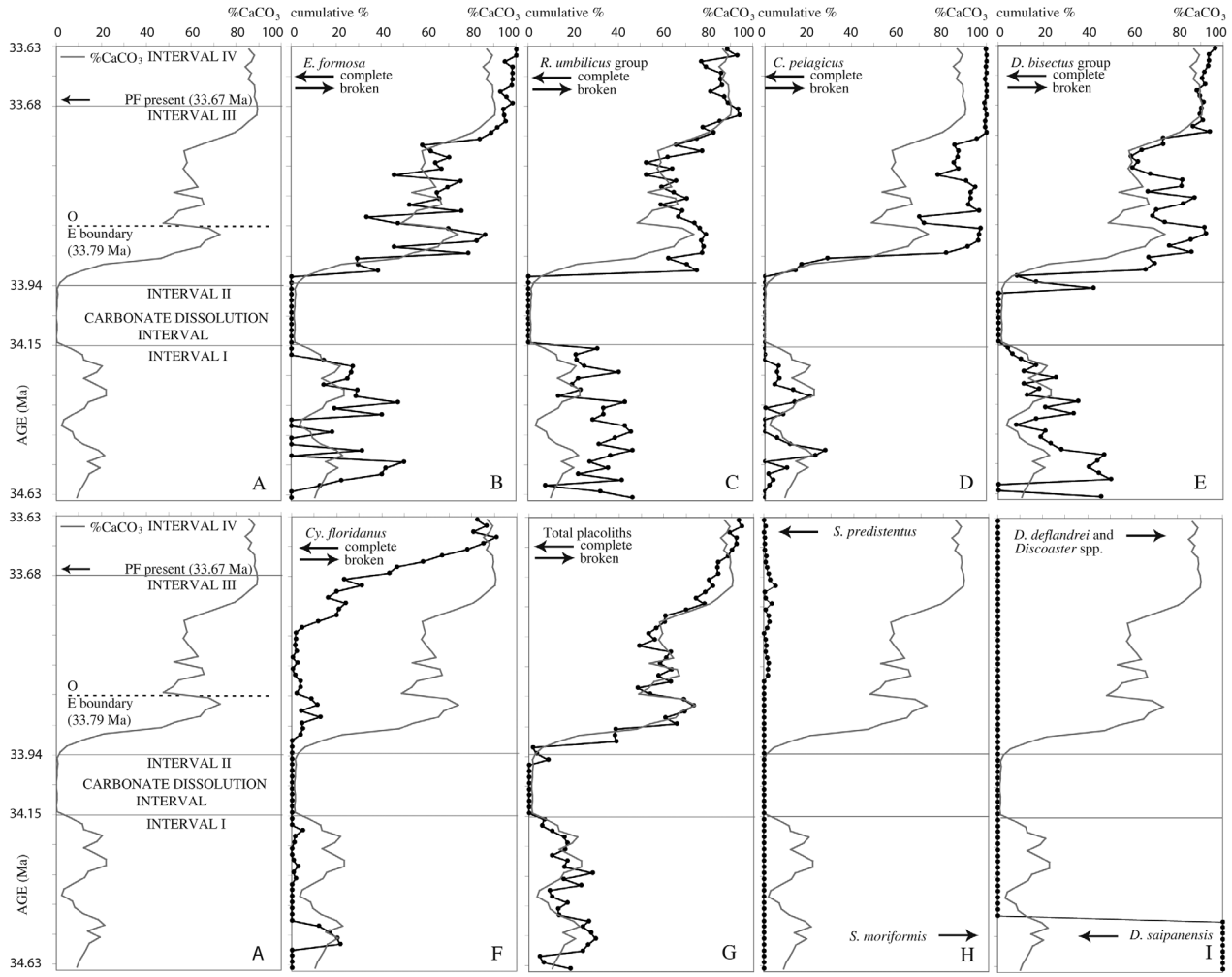


Figure 2: The carbonate dissolution Intervals I – IV (34.63 Ma to 33.63 Ma): **A**) $CaCO_3$%, the position of the E/O boundary and the time of the re-appearance of planktonic foraminifers (PF). Cumulative frequencies (in %) of complete (area left of heavy black line, with filled circles) *versus* broken (area right of heavy black line, with filled circles) specimens: **B**) *E. formosa*, **C**) *R. umbilicus* group, **D**) *C. pelagicus*, **E**) *D. bisectus* group, **F**) *C. floridanus*, **G**) total placoliths. **H**) Abundance (as cumulative %) of *S. moriformis versus S. predistentus*. **I**) Abundance of *D. saipanensis versus D. deflandrei* and *Discoaster* spp. (0% *D. saipanensis* implies 100% of the *D. deflandrei* and the *Discoaster* spp. group, and *vice versa*)

range of *Triquetrorhabdulus* aff. *T. carinatus* has a duration of 3.3 Myr, representing the first complete range ever documented for this morphotype. Information about the preservation history of the selected species across the Eocene/Oligocene boundary was achieved by investigating selected specimens and by studying the cumulative percentages of the complete *versus* broken specimens in the interval between 34.63 and 33.63 Ma. Placolith preservation in this interval is controlled by the variation in the carbonate content values.

Evolutionary trends of selected coccolithophore species in the North Atlantic during the Pliocene to Pleistocene

Babette Boeckel, Karl-Heinz Baumann, Elke Freytag, Markus Geisen

Selected keystone coccolith taxa, which are characterized by a global distribution and a continuous geological record, were quantified and morphologically analyzed. By means of Plio- to Holocene Atlantic time-serie,s the range of their morphological variability is assessed to elucidate their evolutionary development. Geologic investigations on species-level diversity allow tentative concepts on speciation to be tested, evaluated, and long-term patterns to be tracked, in order to identify periods of niche differentiation. Special attention is directed to interactions with biotic and abiotic factors.

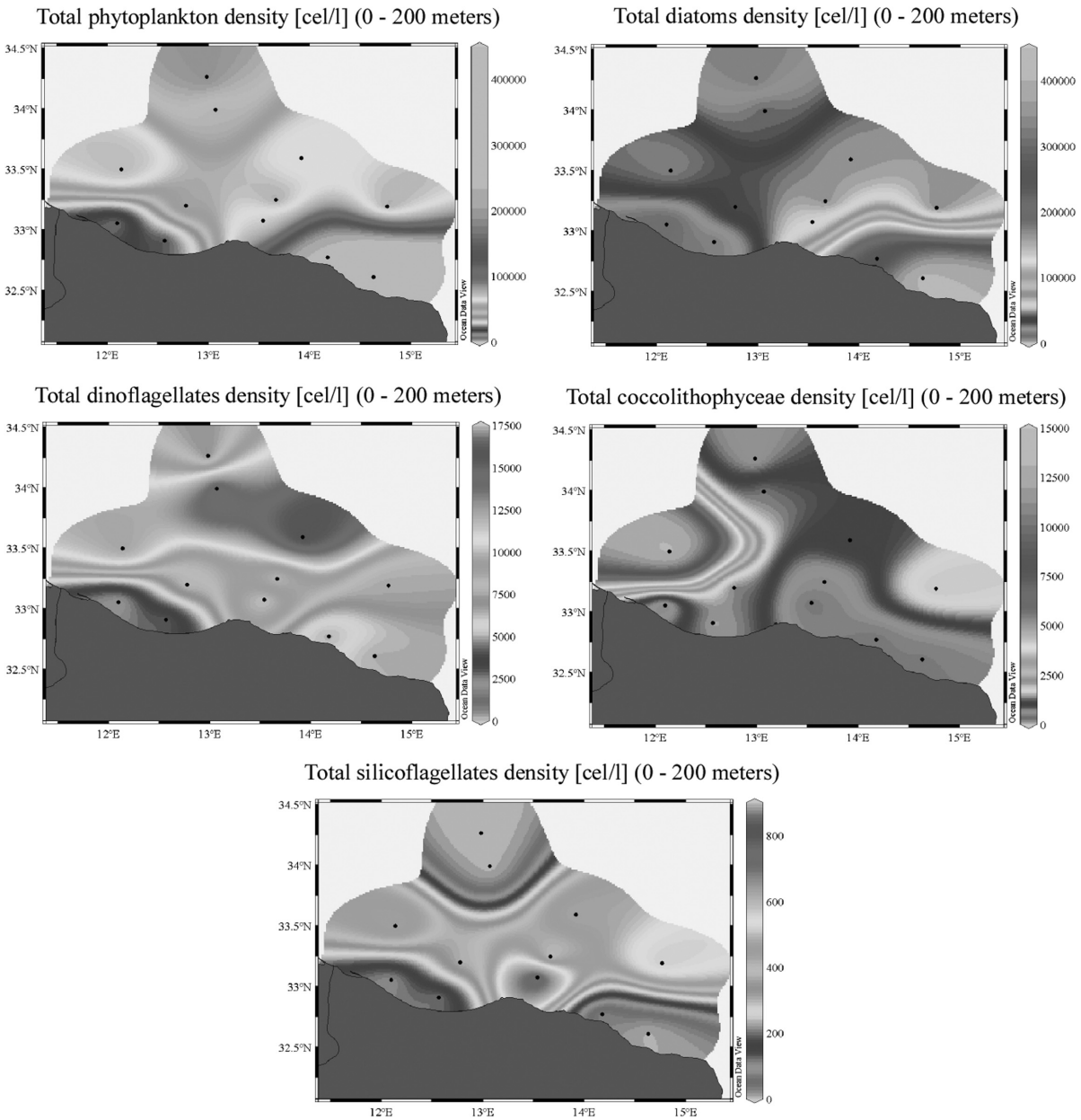
Selected coccolithophorid species from three DSDP/ODP sites in the North Atlantic covering the last 5 Myr were biometrically characterized and the spatial distribution patterns of distinct morphotypes from the tropical to northern NE Atlantic Ocean were reconstructed. Moreover, speciation and species evolution were evaluated with respect to the decline and extinction events of other floral elements.

The chosen time-interval, encompassing the Pliocene to Quaternary, is characterised by significant geologic and climate-relevant events: changes in oceanic and atmospheric circulation linked to the closing of the Isthmus of Panama (4.6 Myr BP); the building up of the Northern Hemisphere ice shields 3.1 Myr ago; the onset of enhanced ice growth between 3.1 and 2.6 Myr BP, and finally the development of the Quaternary glacial-/interglacial-cyclicity. A total of five species complexes was quantitatively and morphologically analysed, including *Calcidiscus leptoporus*, *Florisphaera profunda*, *Syracosphaera pulchra*, *Umbilicosphaera sibogae* and *Coccolithus pelagicus*.

First data on oceanography, phytoplankton density and nutrient distribution of the western Libyan sea area (August, 2006)

Sergio Bonomo, F. Azzaro, T. Bahri, G. Basilone, A. Bonanno, G. Buscaino, A. Cuttitta, E. Di Stefano, O. Drebeka, A. Incarbona, M. Leonardi, A. Marini, F. Massa, S. Mazzola, B. Patti, M. Talha, G. Tranchida, S. Zgozi

A multidisciplinary investigation was carried out in the sea area in front of the western Libyan coast during August, 2006. Hydrological data (CTD and ADCP), distribution of nutrients (NO_3, NH_4, PO_4), and phytoplankton and suspended matter (TSM, POC and PON) were collected during the MedSudMed-06 oceanographic survey, carried out in the framework of the FAO Regional Project MedSudMed ("*Assessment and Monitoring of the Fishery Resources and the Ecosystems in the Straits of Sicily*" funded by the Italian Ministry of Agriculture Food and Forestry Polices (MiPAAF), that promotes the scientific cooperation for fisheries research among four countries of the central Mediterranean - www.faomedsudmed.org). The main aim of the survey was the study of the spatial distribution of the different life stages of small pelagic fish species in relation to environmental parameters of the area, and in



particular the correlations between chemical-physical and biological parameters. Seventy-four water samples were collected from different levels of the water column (5, 25, 50, 100, 150, 200, 500 m, bottom), in 14 stations. The interpretation of water-mass movements has been conducted using both the current measurements of the LADCP and the estimated geostrophic currents. The survey permitted to get evidence on the displacement along the coast of typical Mediterranean waters (AW, ISW and LIW) moving in opposite directions. The temperature profiles single out a well-developed thermocline at a mean depth of about 27 m, and a progressive decrease of temperature from about 28˚C at the surface to 13.6˚C near the bottom. The salinity profiles evidence the AW (Atlantic Water) signature with a minimum (Smin) at about 75 m. The successive increase reaches its maximum of salinity (Smax) at about 175 m (LIW core). Going deeper, both temperature and salinity appear almost constant near the bottom, evidencing a homogeneous bottom layer of about 50-70 m thickness.

Phytoplankton quantitative analyses point out that, in the summer period (August, 2006), the association is generally characterized by abundant diatoms and dinoflagellates, common to rare Coccolithophyceae and rare to very rare silicoflagellates. A very high concentration of phytoplankton in the first 100 m is localized in the easternmost part of the investigated area, near-shore. In this area, the dominant species is *Leptocilindrus danicus*. The dinoflagellate quantitative distribution shows high-density values (16 000 ~ 10 000 cell/l) in the first 25 m in the central-western zone. A lower concentration was found, near-shore, in the western and eastern part of the area. Diatoms exhibit very high-density values (400000 ~ 100000 cell/l) in the first 75 m in the easternmost part and a lesser density in the westernmost area, near-shore. In general, diatoms are the dominant phytoplankton compound in the western Libyan shelf. The coccolithophore quantitative distribution shows a gradual increase in the first 100 m of the western-central zone (14000 ~ 2000 cell/l), and a rapid decrease in the central and eastern part (2000 ~ 400 cell/l density). A low to middle degree of dissolution affects all calcareous phytoplankton species. The silicoflagellates, as expected, show very low values and are confined to the deeper eastern and central zones. The recognized assemblage is constituted only by *Dictyocha fibula* specimens that never reaches over 700 cell/l density.

Surface (0 - 25 m) concentrations of nitrate are elevated (~ 1.5 μM/l) in the transect in front of Tripoli, as well as in the Zauara-Tripoli coastal area (> 1.5 μM/l, 25-60 m). The vertical distribution of dissolved nitrate (1.48 ± 1.32 μM/l) shows an increasing trend with depth (max. 6.08 μM/l at 700 m). Nitrate and ammonia show, as expected, opposite trends, in agreement with the recycling of respective nitrogenous compounds. The max. value of ammonia (4.68 μM/l) was found at 5 m depth in the Zauara station. Values of reactive phosphate in the surface layer (5 m) are more elevated in the Zauara transect, as well as in the coastal station in front of Tripoli (~ 0.6 μM/l). The PO_4 vertical distribution does not appear regular in several investigated stations (PO_4 0.38 ± 0.19 μM/l). The phosphorous and ammonia increments recorded in the Zauara coastal area are probably due to urban discharges. On the other hand, the relatively high nitrate concentration in the coastal Tripoli area could be interpreted as a consequence of agriculture activities, possibly using nitrogen fertilizers. The incidence of Total Suspended Matter (TSM) was high in all considered samples, ranging between 7.60 and 19.65 mg/l. POC and PON are not elevated, but higher than those found in previous investigations in the Strait of Sicily. Higher POC values (>150 μgC/l) were registered in the euphotic layer (max. = 235.60 μgC/l) overall in the off-shore area, while in the near-shore they were generally lower. The C/N ratio values show a general condition of equilibrium between the trophic components (autotrophy, heterotrophy, detritus). In surface waters, a better efficiency level of the autotrophic compartment was found in the easternmost area, where C/N values ranged between 6 and 8. However, in the off-shore area in front of Tripoli, higher C/N ratio values suggest that the phytoplankton community is not very efficient (C/N > 9).

Morphological similarities linking fossil species *E. macellus* to the extant coccolithophorids *Gaarderia* and *Umbellosphaera*: Significant implications for the function of coccoliths

David Bord, Marie-Pierre Aubry

The coccolithophorids are a group of phytoplankton that secretes a carbonate shell called a coccosphere. The latter comprised interlocking mineralized scales called coccoliths. In the extant coccolithophorids, there are, in general, little morphologic differences among coccoliths on individual coccospheres. Two notable exceptions are the spirothecate coccospheres of *Gaarderia* and *Umbellosphaera*. In them, the larger, external coccoliths have a broad marginal cycle and a narrow central cycle; the smaller, inner coccoliths are structurally opposite. Around the spirothecate, there is a gradual modification of the morphology as size increases. Thus size variations of sedimented coccoliths of these genera are not simply indicative of species differences, but reflect the composition of coccospheres.

The coccoliths of one fossil species, *Ellipsolithus macellus*, show a large morphologic variability. The coccoliths of *E. macellus* are very delicate, and no intact coccosphere has been recovered. It is possible that this variability reflects the co-existence of several species under one paleontological name. But it is also possible that it reflects the original composition of the coccosphere, with coccoliths of different shapes and sizes forming a spirothecate coccosphere, analogous to that of *Gaarderia* and *Umbellosphaera*. Although of different basic structures, the morphology of the coccoliths of *E. macellus* are strongly reminiscent of those of *Gaarderia* and *Umbellosphaera* spp.

I have conducted a quantitative analysis on over 400 specimens of *E. macellus* from the lower Paleocene of Egypt, measuring and analyzing variations in the dimensions of coccoliths. I have done the same with published figures of *Gaarderia* and *Umbellosphaera*. The preliminary conclusions of this work are that the coccosphere of *E. macellus* may well have been spirothecate. The function of the coccoliths is still unknown, although several ideas have been offered, including protection, flotation, and/or the regulation of light (Young, 1994). A new function for several of the specialized coccolith groups, including *Gaarderia* and *Umbellosphaera*, has been proposed: these coccoliths may be highly specialized for food collection, which would possibly suggest mixotrophy among at least some extant coccolithophorids (Aubry, in press). If this is the case, morphologic variation in *E. macellus* may be indicative of mixotrophic physiology.

References

Aubry, M.-P. In press. A Sea of Lilliputians. *Palaeogeography, Palaeoclimatology, Palaeoecology*.

Young, J. 1994. Function of coccoliths. In: A. Winter, A. & W.G. Siesser (Eds). *Coccolithophores*. Cambridge University Press, Cambridge: 63-82.

Applying statistical techniques to construct a refined Paleocene-Eocene calcareous nannofossil biozonation

Andrew R. Bowman, David K. Watkins, Felix M. Gradstein

In an effort to refine the resolution of the existing Paleocene-Eocene calcareous nannofossil biostratigraphic zonations, a statistically rigorous methodology was applied to various deepwater sections. Abundance counts on calcareous nannofossils were performed on two ODP sites (Leg 171B, Sites 1051A and 1052A, Blake Nose), and on a deepwater Gulf of Mexico well (Keathley Canyon, Block 774, "Ponza"). In addition, calcareous nannofossil biostratigraphic data were taken from published work, and incorporated into this study to increase the dataset size. After the abundance counts were performed and the data were compiled, a detailed evaluation of the many hundreds of Paleogene-age taxa was carried out, using hardcopies of species distribution charts (BugCAD plots), followed by analysis of results processed through specialized computer software (IPS). This process yielded the placement of the more common types of bioevents (*i.e.*, species range tops and bases), and in addition aided in the recognition of new, useful, subordinate bioevents (*e.g.*, first downhole increases). All bioevents were then analyzed using the ranking and scaling probabilistic sequencing method (RASC). The RASC method resulted in the most probable order, termed the "optimum sequence", for the Paleocene-Eocene calcareous nannofossil bioevents. With the possible discovery of new, non-traditional bioevents, and resulting increased biostratigraphic resolution, the produced optimum sequence has the potential to aid in the success of biostratigraphic correlation within key hydrocarbon fields, as well as between geographically widespread basins.

Calcareous nannoplankton evolution and the Paleocene/Eocene thermal maximum event

Paul Bown, Tom Dunkley Jones

Calcareous plankton are ideally suited to the assessment of evolutionary change through past rapid climate change events because they are abundant, widespread and cosmopolitan organisms. The study of these fossils has been integral to our recognition and emerging understanding of the Paleocene/Eocene thermal maximum (PETM), which is now a major focus of attention as an historic example of a carbon cycle event comparable to that predicted for the next century, *i.e.*, rapidly increasing atmospheric CO_2, global warming and possible ocean acidification. The PETM geological record has provided unambiguous evidence of disruption in the deep-sea environment, with acidification and large temperature rises accompanied by elevated extinction rates in benthic foraminifera. Evidence of similar disruption in the surface ocean plankton, however, currently comprises observations of poleward migration, short-lived 'excursion taxa' and elevated evolutionary turnover in calcareous phytoplankton. This is a somewhat muted evolutionary response, considering the temperature and acidification effects that have been proposed for this interval. Here we examine whether this evidence may be compromised by the quality of the stratigraphic and fossil record by analysing plankton from an expanded, hemipelagic PETM section in southern Tanzania (Tanzania Drilling Project Site 14) that, in background conditions at least, provides exceptionally preserved calcareous microfossils and therefore the optimal prospect of recovering reliable assemblage and diversity data. The calcareous nannoplankton are more diverse than any previously documented sections of the same age, and include small and fragile taxa that are not present in 'normal' preservation states. The PETM onset is marked by rapid and significant nannoplankton assemblage shifts, reduction in abundance and diversity, and synchronous extinctions representing around 10% of the total diversity. These changes clearly indicate severe disruption of the photic zone environment, but the disappearing taxa reveal no strong extinction selectivity bias and the assemblage shifts are not easily explained by the effects of dissolution, dilution, or productivity. Diagnostic nannoplankton components are observed throughout the carbon isotope excursion interval, but are replaced above this level by assemblages that are remarkably similar to those seen prior to the event. Despite synchronous extinctions at the PETM onset, and significantly perturbed assemblages for the duration of the PETM event, the plankton underwent only minor evolutionary changes in the longer term. Nevertheless, the event fell within the interval that saw the highest turnover rates in the history of the calcareous nannoplankton group.

Coccolithophore calcification: cellular mechanisms and constraints

Colin Brownlee, Abul Chrachri, Glenn Wheeler, Alison Taylor

We are adopting a combined cell physiological and genomics approach to understand the cellular mechanisms of calcification in coccolithophores. This work is uncovering some unexpected pathways and mechanisms. In the longer term, our aim is to genetically manipulate specific components of the process to understand their function. An understanding of these mechanisms, and how they vary in different coccolithophore species, will hopefully improve our ability to predict how coccolithophore populations may be affected by, or adapt to, changing ocean chemistry in both the short and long term.

Review of calcareous nannofossil biostratigraphy and biochronology for the upper Miocene-Pliocene at ODP Site 999 (Caribbean Sea)

Margarita Buitrago-Reina, José-Abel Flores, Francisco J. Sierro, Vladimir Torres Torres

Ocean Drilling Program (ODP) Site 999A was drilled by the R/V *Joides Resolution* during Leg 165 in the Caribbean Sea. This site is located in the Colombian Basin (12˚44.639'N, 78˚44.360'W), on a promontory named Kogi Rise, or Chibchas Rise, at a water depth of 2827.9 m (Sigurdsson *et al*., 1997). The calcareous nannofossil biostratigraphy at Site 999A was previously studied by Kameo & Bralower (1997), using bioevent data for the upper Pliocene and Pleistocene (Raffi & Flores, 1995; Takayama *et al*., 1995) and zonal schemes for the Neogene and the Quaternary (Martini, 1971; Bukry, 1973, 1975; Okada & Bukry, 1980). This study provided a low-resolution biostratigraphic scheme. Due to this, the main aim of this work is to achieve a high-resolution biostratigraphic and biochronologic record over the Upper Miocene to Pliocene.

We have prepared 298 samples, with an average spacing of between 3 cm to 24 cm. The slides were prepared following a decantation technique (Flores & Sierro, 1997) and they were analysed using a polarized microscope at a magnification of 1000x. Calcareous nannofossils show good to moderate preservation throughout the studied stratigraphic interval. Evidence of reworking is recorded by the finding of specimens like *Lithostromation perdurum*, with an age range from Late Paleocene to Early Eocene. The identification of some calcareous nannofossil markers allowed the recognition of the biozones proposed by Martini (1971) and Okada & Bukry (1980). The Upper Miocene (Biozone NN10; Okada & Bukry, 1980) is defined in this study by the first ocurrence (FO) datum of *Reticulofenestra rotaria*, which appears approximately at 239.1 mbsf with an average age of 8.76 Ma. Additionally, the FO datums of *Discoaster berggrenii* at ~229.65 mbsf, *Amaurolithus primus* and *Catinaster mexicanus* (both at 229.5 mbsf) were used to locate the boundary between Biozones CN8/CN9 (Okada & Bukry, 1980) and NN10/NN11 (Martini, 1971). Magnetostratigraphic and oxygen and carbon stable isotope records measured in Site 999 will further improve the biochronology of this site.

References

Bukry, D. 1973. Low-latitude coccolith biostratigraphic zonation. *Initial Reports of the Deep Sea Drilling Project*, **15**: 685-703. Texas A & M University, Ocean Drilling Program, College Station, TX, United States.

Bukry, D. 1975. Coccolith and silicoflagellate stratigraphy, northwestern Pacific Ocean, Deep Sea Drilling Project, Leg 32. *Initial Reports of the Deep Sea Drilling Project*, **32**: 677-701. Texas A & M University, Ocean Drilling Program, College Station, TX, United States.

Flores, J.-A. & Sierro, F.J. 1997. Revised technique for calculation of calcareous nannofossil accumulation rates. *Micropaleontology*, **43**: 321-324.

Kameo, K. & Bralower, T.J. 1997. *In*: H. Sigurdsson, R.M. Leckie, G.D. Acton *et al*. (Eds). *Proceedings of the Ocean Drilling Program, Scientific Results*, **165**: 3-17. College Station, TX (Ocean Drilling Program)

Martini, E. 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. *In*: A. Farinacci (Ed.). *Proceedings of the II Planktonic Conference, Roma, 1970*, **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**: 321–325.

Raffi, I. & Flores, J.-A. 1995. Pleistocene through Miocene calcareous nannofossils from the eastern equatorial Pacific Ocean. *Proceedings of the Ocean Drilling Program, Scientific Results*, **138**: 233-286. College Station, TX (Ocean Drilling Program).

Sigurdsson, H., Leckie, R.M., Acton, G.D. *et al*. 1997. *Proceedings of the Ocean Drilling Program, Scientific Results*, **165**: 335pp. College Station, TX (Ocean Drilling Program).

Takayama, T., Sato, T., Kameo, K. & Goto, T. 1995. Quaternary coccolith biostratigraphy and the age of the Pliocene/Pleistocene boundary. *Quaternary Research*, **34**: 157–170.

Multivariate Morphon Analysis of *Braarudosphaera bigelowii* during a Holocene interval at Mira (SW Portugal)

Mário Cachão, Ana Bento, Conceição Freitas, Aurea Narciso

Morphometric analyses of *Braarudosphaera bigelowii* have already been performed by several authors (see Takano *et al*., 2006). Applying slightly distinct methods, all concluded for the existence of several morphotypes. The question of their specific behaviors and (paleo)ecological meaning, however, remained to be addressed most of the time.

With the Multivariate Morphon Analysis (MMA; Parente *et al*., 2004; Narciso *et al*., 2006), one can test on a particular calcareous nannofossil taxon for the existence of distinct morphotypes, with the additional advantage that, simultaneously, their individual behaviors are also described and characterized, opening a door for the understanding of their potential use as individual paleoecological proxies (see Narciso *et al*., 2006).

For the present study, a Holocene section of a core retrieved from the present-day Mira estuary (SW Portugal) was selected due to its abnormal abundance of pentaliths of *B. bigelowii* during an estimated time interval of 2.5 ky, between 8.5 and 6.0 ^{14}C yrs cal BP, when the region was a former paleo-ria (Alday *et al*., 2006).

MMA results suggest the existence of 5 distinct morphotypes, each defined by a particular size interval and a specific behavior along the selected core section. The measurement method, morphotypes, and their paleoecological significance will be presented and discussed.

References

Alday, M., Cearreta, A., Cachão, M., Freitas, M.C., Andrade, C. & Gama, C. 2006. Micropaleontological record of Holocene estuarine and marine stages in the Corgo do Porto rivulet (Mira River, SW Portugal). *Estuarine, Coastal and Shelf Science*, **66**: 532-543.

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 200 kyr. *Marine Micropaleontology*, **59**: 15-34.

Parente, A., Cachão, M., Baumman, K.-H., de Abreu, L. & Ferreira, J. 2004. Morphometry of *Coccolithus pelagicus s.l.* (Coccolithophore, Haptophyta) from offshore Portugal, during the last 200 kyr. *Micropaleontology*, **50** (Supplem 1): 107-120.

Takano, Y., Hagino, K., Tanaka, Y., Horiguchi, T. & Okada, H. 2006. Phylogenetic affinities of an enigmatic nannoplankton, *Braarudosphaera bigelowii* based on the SSU rDNA sequences. *Marine Micropaleontology*, **60**(2): 145-156.

Paleoenvironmental changes in a Kimmeridgian platform (western France) revealed by calcareous nannoplankton and ascidian spicule variations

Damien Carcel, Fabienne Giraud, Claude Colombié

The Kimmeridgian carbonate ramp environments of western France are characterized by limestone-marl alternations with abundant storm deposits. Different orders of cyclicities were recognized in these deposits, revealing a climatic control of the sedimentation linked to changes in orbital cycles. The aim of this work is to study the paleontological content of autochthonous marl-limestone deposits in order to reconstruct paleoenvironmental changes prevailing during the Kimmeridgian. The carbonate fraction was examined in the field and in thin sections for macro- and microfossils, and the fine carbonate fraction was studied in smear slides for calcareous nannofossils. Smear slides were prepared following the random settling method of Geisen *et al*. (1999) in order to calculate absolute abundance. The essential component of the carbonate fraction is mud. The coarse carbonate fraction, which is minor, is composed of benthic organisms (bivalves, echinoderms, agglutinated foraminifers and gastropods). Macro- and microfossils observed are ubiquitous organisms, and do not allow determination of precise paleoenvironmental conditions. The fine carbonate fraction is constituted of three types of calcareous nannofossils (ascidian spicules, coccoliths and schizospheres). Calcareous nannoplankton and ascidian spicules were counted separately. The ascidian spicules, which were attributed in a preceeding work to the genius *Didemnum* (Busson *et al*., 1996), are the dominant contributor. The total abundance of calcareous nannofossils (ascidian spicules and calcareous nannoplankton) is negatively correlated with the calcium carbonate content. However, in marls, ascidian spicules constituted the major part of the fine carbonate fraction. According to Brookfield (1988), ascidians are important members of shallow-water benthic communities. They are rarely described in ancient sediments, and in particular in the Mesozoic. Busson *et al*. (1996) considered that they may not have been recognized, or misinterpreted as calcareous nannofossils. A recent study has shown that ascidian spicule variations were linked to surface-water productivity, revealing the importance of this group in paleoceanographical reconstructions (Toledo *et al*., 2007).

Among the calcareous nannoplankton recognized in the Kimmeridgian limestone-marl alternations, the assemblages are dominated by the small placoliths of *Watznaueria* (in particular, small morhotypes of *W. britannica* described in Giraud *et al*., 2006) and *Cyclagelosphaera margerelii*. Schizospheres, when present, are characterized by small sizes (between 5 and 8 μm). The decrease through the Kimmeridgian in the *Watznaueria*/*Cyclagelosphaera* ratio suggests more proximal conditions, or progradation of the carbonate platform, in the Late Kimmerdigian, with respect to the Early Kimmerdigian. The variations of the nannofossil assemblages (calcareous nannoplankton) and benthic community (represented here by ascidians) through the Kimmeridgian are indicative of variable trophic levels, related to changes in climatic conditions.

References

Busson, B., Noël, D., Monniot, F. & Cornée, A. 1996. Attribution de corpuscules calcaires observés dans des marnes du Jurassique supérieur à des spicules du genre *Didemnum* (Ascidie, Tunicier). *In*: F.G. Bourrouilh-le Jan (Ed.). *Carbonates intertropicaux. Mém. Soc. géol. France, n.s.*, **169**: 145-154.

Geisen, M., Bollmann, J., Herrle, J.O., Mutterlose, J. & Young, J.R. 1999. Calibration of the random settling technique for calculation of absolute abundances of calcareous nannoplankton. *Micropaleontology*, **45**: 123-138.

Giraud, F., Pittet, B., Mattioli, E. & Audouin, V. 2006. Paleoenvironmental controls on morphology and abundance of the coccolith *Watznaueria britannica* (Late Jurassic, southern Germany). *Mar. Micropaleontol*., **60**: 205-225.

Toledo, F.A.L., Cachão, M., Costa, K.B. & Pivel, M.A.G. 2007. Planktonic foraminifera, calcareous nannoplankton and ascidian variations during the last 25 kyr in the Southwestern Atlantic: A paleoproductivity signature? *Mar. Micropaleontol*., **64**: 67-79.

Calcareous nannofossil and calpionellid calcification events across the Tithonian-Berriasian time-interval and low-latitude paleoceanographic implications

Cristina Emanuela Casellato, Gloria Andreini, Elisabetta Erba, Guido Parisi

Calcareous nannofossil and magnetic stratigraphies of several sections spanning the Middle-Upper Jurassic to lowermost Cretaceous have been studied in the Lombardian Basin (Torre di Busi, Colle di Sogno) and Trento Plateau (Colma di Vignole, Foza, Frisoni, Sciapala, Bombatierle, Passo Branchetto) in order to integrate calcareous nannofossil events with the polarity chron sequence and, where available, with calpionellid biostratigraphy. Calcareous nannofossil biostratigraphy has been carried out on smear slides prepared from un-heated end-pieces of the same samples used for magnetostratigraphy. Similar variations in nannofloral abundance and composition have been documented in all sections. In the Jurassic/Cretaceous boundary time-interval, all previously-known calcareous nannofossil zones and corresponding subzones (Bralower *et al*., 1989) have been clearly recognized. In the Callovian-Kimmeridgian interval, a tentative integration of biostratigraphy (De Kaenel *et al*., 1996; Bown, 1998; Cobianchi, 2002) with polarity chrons is proposed. The magnetic stratigraphies span the CM16R (late Berriasian) to the CM25 (Oxfordian) interval. The identification of polarity zones is based on polarity-zone pattern fit, and, where available, on the previously-established correlations of polarity chrons to nannofossil events/zones (Channell & Grandesso, 1987; Channell *et al*., 1987; Weissert & Channell, 1989; Bralower *et al*., 1989).

References

Bown, P.R. & Cooper, M.K.E. 1998. Jurassic. *In*: P.R. Bown (Ed.). *Calcareous Nannofossil Biostratigraphy*. British Micropalaeontological Society Publications Series. Kluwer Academic Publishers, London: 34-85.

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.

Channell, J.E.T., Bralower, T.J. & Grandesso, P. 1987. Biostratigraphic correlation of M-sequence chrons at Capriolo and Xausa (S. Alps, Italy). *Earth Planetary Science Letters*, **85**: 203-221.

Channell, J.E.T., Erba, E., Nakanishi, M. & Tamaki, K. 1995. Late Jurassic-Early Cretaceous time scales and oceanic magnetic anomaly block models. *Geochronology Time Scale and Global Stratigraphic Correlation*, **54**: 51-63.

Channell, J.E.T. & Grandesso, P. 1987. A revised correlation of Mesozoic polarity chrons and calpionellid zones. *Earth Planetary Science Letters*, **85**: 222-240.

Cobianchi, M. 2002. Calcareous nannofossils from the Middle and Upper Jurassic of the Belluno Basin (Southern Calcareous Alps). *Atti Ticinensi di Scienze della Terra*, **43**: 3-24.

De Kaenel, E., Bergen, J.A. & Perch-Nielsen, K. 1996. Jurassic calcareous nannofossil biostratigraphy of Western Europe. Compilation of recent studies and calibration of bioevents. *Bulletin Société geologique de France*, **167**(1): 15-28.

Weissert, H. & Channell, J.E.T. 1989. Tethyan carbonate carbon isotope stratigraphy across the Jurassic/Cretaceous boundary: an indicator of decelerated global carbon cycling? *Paleoceanography*, **4**(4): 483-494.

New bio-magnetostratigraphy for the Upper Jurassic and lowermost Cretaceous of the Southern Alps (Italy)

Cristina Emanuela Casellato, Elisabetta Erba, James E.T. Channell, Giovanni Muttoni

The Tithonian-Berriasian time interval is characterized by a major calcareous nannofossil speciation episode and by the appearance of the calpionellid group: several genera and species first appear and evolve, showing an increase in diversity, abundance and particularly in calcification degree. This time interval is also characterized by a significant, low-latitude increase of carbonate-rich sediments (Rosso ad Aptici Fm. toward Maiolica Fm.).

Calcareous nannofossil and calpionellid biostratigraphy and absolute abundances have been performed on low-latitude selected sections in order to reconstruct biogenic calcite palaeofluxes. Calpionellids have been investigated on thin sections (25mm thick), while calcareous nannofossil on the same, but thinner, thin sections (up to 7μm thick) used for the calpionellids. All specimens have been counted on 1 cm^2 of thin section or 1 mm^2 of ultra-thin section, respectively, for calpionellids and calcareous nannofossils. Paleofluxes have been obtained, integrating absolute abundance with single speciment mass weight (10-12g of calcareous carbonate) per area unit (cm^2) per time unit (yr).

Calcareous biogenic paleofluxes point out a link between the lithologic changes and calcified plankton evolution across the Tithonian-Berriasian interval. During the Lower Tithonian (Rosso ad Aptici Fm.), a first calcification event is characterized by a nannolith (*F. multicolumnatus*, *C. mexicana*, *P. beckmannii*) increase in abundance, size and calcification degree, followed by the occurrence of the first calcified calpionellid (*Tintinopsella*). Across the Upper Tithonian to Lower Berriasian (Rosso ad Aptici Fm.-Maiolica transition and Maiolica Fm.), a second bigger calcification event is characterized by a dramatic increase of nannoconid abundance and calcification degree, reaching lithogenetic amounts, concomitant with a moderate abundance increase of calcified calpionellid (genera *Crassicollaria*, *Calpionella*, *Remaniella*).

Linkages between calcareous nannofossil and calpionellid evolution with geologic, palaeoceanographic or palaeoclimatic events are inferred. The diversification and biomineralization of highly-calcified plankton produced a major increase in pelagic carbonate sedimentation due to the onset of paleoenvironmental conditions favorable to calcification. The diversification and proliferation of nannoliths and nannoconids, interpreted as inhabitants of the lower photic zone, might indicate the establishment of a thermocline/nutricline in the deep photic zone, suggesting the development of oligotrophic and stable oceanic conditions.

It is also suggested that Tithonian-Berriasian calcified plankton evolution could be controlled by a decrease in pCO_2, due to a decreased spreading rate and/or increased weathering rate ($^{87}Sr/^{86}Sr$) and cool climatic conditions, concomitant with a decrease in the oceanic Mg/Ca ratio values. Both factors thermodynamically promoted low Mg-$CaCO_3$ and $CaCO_3$ biomineralization, supporting calpionellid and calcareous nannofossil abundance and calcification rate increases.

Cretaceous and Paleogene calcareous nannofossils from northern Moldavia (Sucevita-Putna area, Romania) and the Cretaceous/Paleogene Boundary

Carmen Mariana Chira, Ramona Balc, Alin Igritan, Florin Florea

Detailed biostratigraphic data are presented here in order to investigate the K/P boundary from northern Moldavia (Bucovina). The sections studied for establishing Cretaceous and Paleogene calcareous nannofossil biostratigraphy are located in the Sucevita – Putna area, and in the Bercheza, Rusca and Putna valleys. Previous, preliminary data concerning a part of this area were presented by Chira *et al*. (2007).

The studied area comprises three tectonic units, from east to west: Pericarpathian, Vrancea and Tarcau, with complex geological structures. The investigated sections belong to the Hangu (Upper Cretaceous), Izvor (Paleocene - Lower Ypresian) and Straja Formations (Middle Ypresian). These formations are part of the Tarcau Nappe (Upper Cretaceous - Oligocene).

In the Sucevita Basin, previous studies on the K/P boundary have been carried out by Ionesi (1975) and Ionesi & Florea (1984, 1996). The K/P boundary was identified in the upper part of the Formation with Inoceramids (Ionesi & Florea, 1996), or upper part of the Hangu Formation in the Tarcau Nappe (Juravle, 2007).

The Izvor Formation from the Sucevita - Putna area was assigned to NP5-NP9 (Paleocene) and NP10-11 (Lower Eocene) (Ionesi & Florea, 1996). The calcareous nannofossil assemblages from the Sucevita and Bercheza valleys contain, among others: *Disco. salisburgensis*, *D. binodosus*, *D. lodoensis*, *D. distinctus*, *Chiasmo. solitus*, *Tribrach. orthostylus*, *Cocco. formosus*, *Helico. lophota*, *Chiasmo. grandis*, which indicate a Cuisian age. The assemblage with *D. binodosus*, *D. lodoensis*, *C. solitus*, *C. formosus*, *C. grandis*, *Towe. pertusus* was assigned to NP12 (middle Ypresian). The assemblage with *D. lodoensis*, *C. formosus*, *C. grandis*, *H. lophota*, *Retic. dictyoda*, *Spheno. moriformis* belong to NP12-13 (middle Ypresian). These two biozones were identified also in the samples from Rusca Valley.

Studies on the K/P boundary were performed by Melinte (2000) and Bojar *et al*. (2007) in the southern part of Moldavia, where was remarked the presence of Upper Maastrichtian/Lower Paleocene deposits, thanks to the identification of the biozones *Neph. frequens*, *Mic. prinsii*, *Biantho. sparsus* and *Cruci. primus*. The K/P deposits from northern Moldavia, and the boundaries between formations of different ages, are usually in tectonic contact.

In Bercheza Valley, in the Sucevita area, Upper Cretaceous deposits contain: *Mic. staurophora*, *Arkh.* cf. *A. maastrichtiana*, *Watz. barnesiae*, *Cribro. ehrenbergii*, *Calc. obscurus*, *Luc.* cf. *L. windii* and *L. maleformis*. The Paleogene deposits comprise: *Disco. saipanensis*, *Black. pinguis*, *Thoracosphaera* sp.

In the Sucevita area, along the Rusca Valley, the Upper Cretaceous samples contain: *Predisco. cretacea*, *M. staurophora*, *Arkh.* sp., *Micro. decoratus*, *L. maleformis*, *Rete. crenulata*, *Eiff. eximius*, *Rein. levis*, *Stauro.* sp., *Trano. orionatus*, *W. barnesiae*, *Uniplan. gothicus*, *Broin. parca constricta*. The Paleogene deposits comprise frequent *D. lodoensis*, *D. saipanensis*, *D. binodosus*, *D. elegans* and also *T. ortostylus*, *Spheno. radians*, *S. pseudoradians*, *Helico.* cf. *H. recta*, *H. bramlettei*, *Cocco. pelagicus*, *Towe. rotundus*, *Chias. gigas*, *Trans.* cf. *T. latus* and *T. pulcher*.

In the Putna Valley were found Upper Cretaceous assemblages with *Cerato. sesquipedalis*, *C. arcuatus*, *C. quasiarcuatus*, *L. maleformis*, *Arkh. cymbiformis*, *Eiff. turriseiffelii*, *M. staurophora*, *W. barnesiae*, *Zeug. scutula*. The Paleogene deposits contain: *B. sparsus*, *B. haqii*, *C. pelagicus* and *Retic. umbilica*.

In the sections from the Rusca and Bercheza valleys, generally assemblages are poorly preserved, with fragmentation and overgrowth. Better-preserved and more abundant assemblages were identified in the Putna Valley. Alternation of Upper Cretaceous and Paleogene deposits was observed, due to the tectonics of the region.

References

Bojar, A.-V., Melinte. C.M. & Bojar, H.-P. 2007. The environmental and tectonic record of a continuous Cretaceous/Paleogene section from the Eastern Carpathians. *Abstracts, Proceedings of the European Society for Isotope Research, ESIR IX. Studia Universitatis Babes-Bolyai, Geologia*, **52**(1): 7-8.

Chira, C., Balc, R., Igritan, A. & Florea, F. 2007. Cretaceous – Paleogene calcareous nannofossil assemblages from Sucevita – Putna area: Bercheza, Rusca and Putna Valleys (northern Moldavia), and the problem of the Cretaceous/Paleogene Boundary. *Abstract, Annual Scientific Session, Department of Geology, Cluj-Napoca*.

Ionesi, L. 1975. *Limite Maestrichtien-Paleocene et Cuisien Nummulitique dans le flysch de Bucovine*. Micropaleontological Guide to the Mesozoic and Tertiary of the Romanian Carpathians. Excursion L. Bucharest: 145-154.

Ionesi, L. & Florea, F. 1984. Quelques aspects concernant la lithostratigraphie et la structure du flysch externe du Bassin de la Sucevita. *Analele stiintifice ale Universitatii Al. I. Cuza din Iasi*, **30**: 5–12.

Ionesi, L. & Florea, F. 1996. Contributii litostratigrafice si sedimentologice asupra Formatiunii cu Inocerami (Hangu s.s.). *Studii si cercetari de geologie*, **41**: 81–92.

Juravle, D.T. 2007. *Geologia regiunii dintre Valea Sucevei si Valea Putnei (Carpatii Orientali)*. Casa Editoriala Demiurg, Iasi: 6-319.

Melinte, M. 2000. Cretaceous/Tertiary boundary in the East Carpathians, based on nannofloral evidence. *Acta Paleontologica Romaniae*, **2**: 269-273.

The Paleogene/Neogene boundary in northern Moldavia (Moldovita Basin, Romania)

Carmen Mariana Chira, Doru Toader Juravle, Ramona Balc, Alin Igritan, Mirela Violetta Popa

The Paleogene/Neogene boundary in the External Flysch area of the Eastern Carpathians (Northern Moldavia) constituted for a long time the topic of a controversial and intense scientific debate. Calcareous nannofossils were previously studied from other basins, situated south of the Moldovita Basin: the Tarcau (Martini & Lebenzon, 1971; Lebenzon, 1973), Tazlau (Ionesi & Gheta, 1978; Dicea & Dicea, 1980) and Buzau Basins (Melinte, 1988).

The present study was carried out in the Moldovita Basin, along the Dumbravnic Brook. In the section from the Dumbravnic Brook, which crosses the Dilma – Deia and Palamina – Ascutita synclinal structures, the sediments belong to the Vinetisu Formation. This Formation represents the last term of the Moldovita lithofacies and it consists of sandstones and clays, 100 – 120 m thick. The calcareous sandstones are disposed in beds with thicknesses of 30 – 40 cm (Grasu *et al*., 2007).

Calcareous nannofossils from the Moldovita Basin, which constitute the object of our study, have been already investigated (Ionesi & Meszaros, 1989), but for another time-interval, with respect to the present work. In the Moldovita Basin, the Oligocene/Miocene boundary was recorded in the northern part of the Tarcau Nappe, in the Vinetisu Formation. Calcareous nannofossils from the Izvor Brook and from the Jaslo Limestone have been studied. The presence of the NP25 Biozone, with *Sphenolithus ciperoensis*, was documented. In the succession from Izvor Brook that crosses the Dilma – Deia and Palamania – Ascutita synclines, the subsequent biozone is represented by NN1, with *Triquetrorhabdulus carinatus* (Ionesi & Meszaros, 1989; Juravle, 2007). Previous studies mainly focused on the Upper Member of the Jaslo Limestone and on the Vinetisu Formation from the Tarcau Nappe – Moldovita lithofacies. In the Upper Member of the Jaslo Limestone, an assemblage with *S. ciperoensis*, typical for the NP25 Biozone was identified. In the Vinetisu Formation, calcareous nannofossils assemblages studied from the three members provided the following biozones: the Lower Member – *Sphenolithus ciperoensis* Biozone - NP25, and an assemblage with *Helicosphaera euphratis*, *H. recta*, *Reticulofenestra bisecta*, *Pontosphaera enormis* (NP25 or NN1); from the Middle Member – NN1 Biozone, with *Triquetrorhabdulus carinatus*; finally, from the Upper Member, any biozone was identified. Thus, the Oligocene/Miocene boundary was evidenced in the terminal part of the Lower Member of the Vinetisu Formation (Ionesi & Meszaros, 1989).

In this work, almost all the calcareous nannofossil taxa have a wide distribution spanning the Eocene and Oligocene in the first part of the section. The most frequent Paleogene species are basically representative of the Oligocene: NP21-22 - *Reticulofenestra umbilica*, *Lanternitus minutus*, *Coccolithus formosus*, *Cyclicargolithus floridanus*, and NP23-24: *Helicosphaera ethologa*. In the second part of the section, calcareous nannofossil assemblages contain species that are present also at the top of the Oligocene/Miocene boundary, and are frequent in the Lower Miocene: *Helicosphaera scissura* (NP24-NN4), *H. recta* (NP24-NN4), *Discoaster deflandre*i (NP11-NN7), *Sphenolithus moriformis* (NP12-NN9); also Paleogene species are present. Thus, the presence of the Paleogene/Neogene boundary can be documented in the section from the Dumbravnic Brook in the Moldovita Basin.

References

Dicea, O. & Dicea, M. 1980. Stratigraphic correlations on nannoplankton basis in the External Flysch of the East Carpathians. *D.S. Inst. Geol. Geofiz*., **65**: 111-126.

Grasu, C., Miclaus, C., Florea, F. & Saramet, M. 2007. *Geologia si valorificarea economica a rocilor bituminoase din Romania*. Ed. Univ. "Alexandru Ioan Cuza", Iasi: 5-253.

Ionesi, L. & Gheta, N. 1978. *Virsta stratelor de Gura Soimului din semifereastra Humor*. Anuarul Muz. de St. Nat. P. Neam, seria Geologie-Geografie IV.

Ionesi, L. & Meszaros, N. 1989. Sur la limite Oligocene-Miocene dans le Flysch Externe Carpatique. *In*: L. Ghergari, N. Meszaros, E. Nicorici & I. Petrescu (Eds). *The Oligocene from the Transylvanian Basin, Romania*. Univ. of Cluj Napoca, Cluj Napoca: 133-141.

Juravle, D.T. 2007. *Geologia regiunii dintre Valea Sucevei si Valea Putnei (Carpatii Orientali)*. Casa Editoriala Demiurg, Iasi: 6-319.

Lebenzon, C. 1973. Nannoplanctonul calcaros al depozitelor Oligocene si Miocen-inferioare din cursul superior al vaii Tarcaului (valea Tarcuta si valea Rachitis). *D.S. Inst. Geol*., **59**: 101-112.

Martini, E. & Lebenzon, C. 1971. Nannoplankton-Untersuchungen im oberen Tal des Tarcau (Ostkarpaten, Rumaenien) und stratigraphische Ergebnisse. *N. Jb. Geol. Palaeont. Mh*., **9**: 552-565.

Melinte, M. 1988. Stabilirea limitei Oligocen/Miocen in bazinul Vaii Buzaului, pe baza nannoplanctonului calcaros. *Rom. J. Stratig*., **75**(4): 91-97.

New coccolithophore records from the southern Svalbard margin: Preliminary results on the SVAIS Cruise sediment cores

Elena Colmenero-Hidalgo, José-Abel Flores, Francisco J. Sierro, M. Ángeles Bárcena, Renata G. Lucchi and the SVAIS project participants*

*Angelo Camerlenghi, David Amblas, Isabel Cacho, Antonio Calafat, Miquel Canals, Jose Luis Casamor, Sergio Costa, Ben De Mol, Jaume Frigola, Olaia Iglesias, Sara Lafuerza, Galderic Lastras, Caroline Lavoie, Camino Liquete, Maria Teresa Pedrosa, Roger Urgeles, Joan Grimalt, Andrea Caburlotto, Mauricio Grossi, Michele Rebesco, Monica Winsborrow

SVAIS is a project supported by the Spanish Government within the 2007-2009 IPY activities. Its main goal is to contribute to the understanding of the evolution of glacial continental margins and the relationships with the changes in ice-sheet dynamics induced by climatic changes by: 1) geophysical and stratigraphic high-resolution studies of an ice-stream-dominated marine depositional system of the Artic margin, and 2) definition of its sedimentary architecture and seafloor morphology, and record of their evolution since the onset of glacial conditions. For those reasons, a glacial depositional system on the Southern Svalbard margin (the Storfjiorden margin) was chosen on account of its relatively small size and its location in a highly climatically sensitive area near the gateway to the Artic Ocean.

The SVAIS cruise took place in August 2007 onboard the *BIO Hesperides*, a Spanish scientific research vessel. Detailed multibeam bathymetric survey, shallow seismics (TOPAS), single-channel seismic reflection, and coring of 6 sediment cores were performed during the cruise. Two of the piston cores (SVAIS01 and 04) were recovered in deep waters in the lower slope, three others (SVAIS02, 03 and 05) were sampled in the upper slope, and the last one (SVAIS06, gravity mode) was recovered in the shelf area.

The micropaleontological studies on the SVAIS materials aim to provide a stratigraphic framework for the evolution of the Storfjiorden margin, to obtain a paleoceanographic record that allows the reconstruction of the margin dynamics in relation to the climatic changes at different temporal scales, and to improve the calibration of micropaleontological proxies (nannoflora, foraminifers and diatoms) in the high-latitude sub-arctic region of the Atlantic. The initial micropalentological analysis indicates that the recovered sediments are of good quality, with absence of major preservation problems. All cores contain material deposited in a time interval that includes the Holocene and presumably the Deglaciation and some parts of the Last Glacial Period; differentiation between these periods is made taking into account criteria such as presence/absence of marker species, taxa abundance, diversity of assemblages, and amount of lithics. Holocene sediments deposited within an oceanographic context similar to the present cover the top centimetres of the study area, while further downcore the sedimentation has occurred most likely in a glacial-like scenario, in which the proximity of ice-sheets and the extension of sea-ice cover played a major role in the oceanographic conditions and deposition processes, with drastic assemblage changes closely associated with the oscillations in the extent of the nearby sea-ice.

Quantitative analysis of Middle Miocene calcareous nannofossils from the scientific drilling at Baden-Sooss (Austria, Central Paratethys)

Stjepan Coriç, Johann Hohenegger

Quantitative analyses on calcareous nannofossils were carried out on 102 Middle Miocene samples from the drilling at Baden-Sooss (Vienna Basin) for scientific investigations. All samples can be assigned to nannoplankton Zone NN5 (Martini, 1971). The low concentration of *Helicosphaera walbersdorfensis* Müller, 1974 allows correlation with the Mediterranean nannoplankton Subzone MNN5a (*S. heteromorphus - H. walbersdorfensis* Interval Subzone of Fornaciari *et al*., 1996).

Typical near-shore forms, such as small reticulofenestrids, accompanied by smaller numbers of *Umbilicosphaera jafari* Müller, 1974, *Reticulofenestra haqii* Backman, 1978, *Coccolithus pelagicus* (Wallich, 1871) Schiller, 1930, and *Reticulofenestra pseudoumbilicus* (Gartner, 1967) Gartner, 1969 dominate the calcareous nannoplankton assemblages. Inter-species correlations and correlations to stable isotopes and magnetic susceptibility, together with multivariate statistical methods (Cluster analysis, Indicator values method, Nonmetric Multidimensional Scaling) enabled the reconstruction of trends in the palaeoenvironment of the upper water mass during this part of the Badenian.

The following calcareous nannoplankton species were analyzed for palaeoecological interpretation: *C. pelagicus*, discoasterids, helicoliths, reticulofenestrids (*R. minuta*, *R. pseudoumbilicus*), sphenoliths (*S. heteromorphus*, *S. moriformis*), *U. jafarii*, and the contribution of reworked nannoplankton from older strata (see figure).

Coccolithus pelagicus is negatively correlated with magnetic susceptibility, thus higher percentages of this form coincide with lower values of magnetic susceptibility and suggest lower water temperature. *Vice versa*, lower percentages of *C. pelagicus* can be correlated with peaks of magnetic susceptibility. These periods suggest warmer water due to the higher insolation. Periods of colder, non-stratified water containing higher proportions of *C. pelagicus* are interpreted in the deeper core between -77 and -71m, then this taxon was replaced in the following interval by stratified, higher-salinity and warmer water. A slight, but continuous, temperature decrease, starting from -50m core-depth upwards, resulted in an abundance increase of *C. pelagicus* indicating also an eutrophication trend.

Small reticulofenestrids, which occupy marine environments along continental margins, dominate the nannoplankton assemblages in the core. Abundance oscillations could indicate changes in temperature, inferring warmer, stratified waters and lower salinity.

Sphenolithids can also be used as temperature indicators. Therefore, higher percentages of *Sphenolithus heteromorphus* Deflandre, 1953 and *S. moriformis* (Brönnimann & Stradner, 1960) Bramlette & Wilcoxon, 1967 coincide with increased magnetic susceptibility and can be used as indicators for increased water temperature. *Umbilicosphaera jafarii* is common in shallow environments; the abundance peaks reflect a slight increase in salinity. The transition from a community with abundant *C. pelagicus* to *U. jafarii* needs a slight temperature increase; these transitions are often found in the core. Transitions from communities with abundant *U. jafarii* to communities where *R. minuta* dominates are discontinuous, needing larger and abrupt environmental changes.

The higher erosion rate on the continent is documented by high percentages of reworked calcareous nannoplankton. This can be correlated with the intensified input of magnetic particles, as documented by magnetic susceptibility.

Low percentages of discoasterids point to a sedimentation environment close to the shoreline.

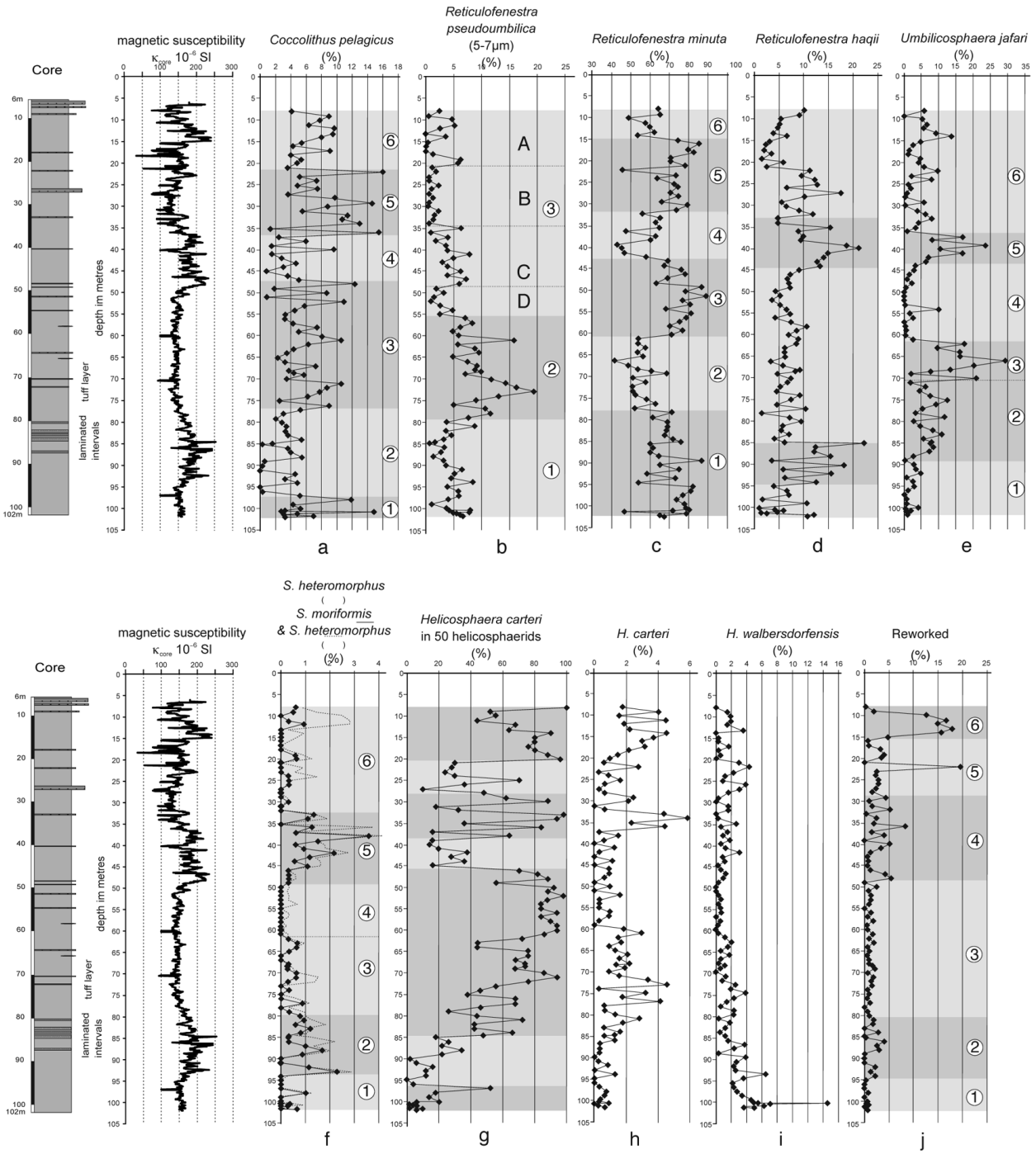
Low variations in abundance of ecological sensitive species suggest relatively low fluctuating environments. The deeper part of the core (-102 to -40m) shows opposite oscillating trends (with long periods) in salinity and temperature. Around -70m, the salinity maximum is combined with a temperature minimum and, *vice versa*, a salinity minimum and temperature maximum can be found around -50m. Trends in the upper core are more discontinuous, possibly due to gaps in the sedimentation record as caused by intensified tectonics. Generally, a linear trend towards slightly increasing salinity, eutrophication and lowered temperatures can be documented for the upper core.

This study was financially supported by the Austrian Science Foundation FWF project P16793-B06.

References

Fornaciari, E., Di Stefano, A., Rio, D. & Negri, A. 1996. Middle Miocene calcareous nannofossil biostratigraphy in the Mediterranean region. *Micropaleontology*, **42**(1): 37-63.

Martini, E. 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. *Proceedings of the II Planktonic Conference, Roma, 1971. Ed. Tecnoscienza, Roma*: 739-785.


Core
magnetic susceptibility
κcore 10-6 SI
Coccolithus pelagicus
(%)
Reticulofenestra pseudoumbilica
(5-7µm)
(%)
Reticulofenestra minuta
(%)
Reticulofenestra haqii
(%)
Umbilicosphaera jafari
(%)
depth im metres
tuff layer
laminated intervals
6m
102m
A
B
C
D
a
b
c
d
e
S. heteromorphus
S. moriformis
& S. heteromorphus
(%)
Helicosphaera carteri
in 50 helicosphaerids
(%)
H. carteri
(%)
H. walbersdorfensis
(%)
Reworked
(%)
f
g
h
i
j
Intervals with higher content of analyzed taxa
Intervals with lower content of analysed taxa

Calcareous nannoplankton composition and flux in response to the passage of Hurricanes Ignacio and Marty in the SW Gulf of California

Mara Y. Cortés, Francisco. J. Urcádiz-Cázares, Jörg Bollmann, F. Aguirre-Bahena, Norman Silverberg

Calcareous nannoplankton comprise a group of organisms that play an important role in the global carbon cycle. Although several studies concerning the vertical flux of coccolithophores to the sediment have been carried out in recent years, little is known about their distribution and response to short-term events.

As part of a multidisciplinary program, a time-series sediment trap has been deployed in Cuenca Alfonso, located in Bahía de La Paz, Gulf of California, since January 2002. This area is often influenced by hurricanes during late summer – early autumn. This has provided a unique opportunity to study the seasonal variation of calcareous nannoplankton and their response to such short-term environmental events.

During 2003, two hurricanes occurred within one month of each other. Hurricane Ignacio and Hurricane Marty, followed similar tracks from south to north across the bay, and brought high winds, intense precipitation, heavy runoff and, for the two weeks including and following the day of each hurricane, high bulk sedimentation rates were observed (Silverberg *et al*., 2007). Very high coccolith fluxes were also registered in all 6 samples recovered during the entire 6-week period. During Hurricane Ignacio, values of $15x10^8$ coccoliths/m^2/d were encountered. In the 2 weeks following the impact of Ignacio, fluxes remained higher than non-hurricane years. Fluxes then peaked again, to even higher values ($129x10^8$ coccoliths/m^2/d), for the 2 weeks following the passage of Marty. Furthermore, the species composition of the nannoplankton changed from a dominance of *G. oceanica* and *E. huxleyi* under normal conditions, to a dominance of *F. profunda* during the hurricane-influenced period. Some species encountered rarely or in low abundance during non-hurricane seasons were more common or abundant during the hurricane period, while some minor species were apparently unaffected.

Reference

Silverberg, N., Shumilin, E., Aguirre-Bahena, F., Rodríguez-Castañeda, A.P. & Sapozhnikov, D. 2007. The impact of hurricanes on sedimenting particulate matter in the semi-arid Bahía de La Paz, Gulf of California. *Continental Shelf Research*, **27**: 2513–2522.

Coccolithophore spatial distribution from an extremely oligotrophic gyre to an intense upwelling in the subtropical South Pacific

Martine J.J. Couapel, Luc Beaufort

Water samples were collected at multiple depths in the euphotic zone on an oceanic transect from the Marquises Archipelagos to the Chilean upwelling, via the South Pacific Gyre, during the BIOSOPE cruise in austral summer, 2004. Based on full taxonomic identification of the coccolithophore community, we describe the spatial distribution of over 60 species. The coccolith concentration ranges from 400 to about 360 000 coccospheres/l, while the species richness ranges from 7 to 47 species per sample. The highest species richness is reached at each station along the transect in the vicinity of the deep chlorophyll maximum. The highest number of coccospheres and the greatest species richness are found in the margin of the Chilean upwelling system. The low-nutrient, low-chlorophyll South Pacific Gyre, often described as the world's poorest desert, is in fact inhabited by a deep coccolithophore community living down to 300 m depth. The concentration of this community, which is composed of 25 species, reaches about 18 000 coccospheres/l. This is the first report of such a deep coccolithophore community present in an oligotrophic region.

A Principal Component Analysis allowed the definition of 7 coccolithophore assemblages, each corresponding to an ecological niche. These niches are distributed longitudinally in the upper part of the water column and in depth in the deepest part of the water column. Assemblage characteristics and distributions can be summarised as follows:

1. in the western part of the transect, in the mesotrophic area of the Marquise plume, is dominated by *Gephyrocapsa* spp., *Umbellosphaera tenuis* and *Calcidiscus leptoporus*;
2. essentially composed of *Umbellosphaera tenuis*, *Emiliania huxleyi*, mini placoliths and *Calcidiscus leptoporus* corresponds to a high-salinity, high-temperature area;
3. found in the oligotrophic area of the South Pacific Gyre, is characterised by a domination of *Syracosphaera* spp. and large coccospheres, such as *Rhabdosphaera clavigera* and *Discosphaera tubifera*;
4. mainly composed of placolith bearing coccospheres, is present on the outerside of the Chilean upwelling margin and within it;
5. corresponds to the higher-diversity assemblage on the oriental margin of the Chilean upwelling, and below the 4 other assemblages, around 150 m depth;
6. spread along the transect in the deeper sampling area, dominated by *Florisphaera profunda*, *Gladiolithus* spp;
7. located in the deeper part of the Chilean upwelling, is exclusively represented by small-sized placolith bearing coccospheres, and results of the mixing of water masses.

Ecological implications of the haplo-diploid versatility in coccolithophores

Lluïsa Cros, Marta Estrada

Coccolithophores tend to occupy ecological environments with an intermediate degree of fertility, midway between the extremes represented by turbulent, nutrient-rich waters, which favour diatom growth, and stratified, nutrient-poor waters, where dinoflagellates and other flagellates dominate (Margalef, 1978).

Studies of the distribution of extant coccolithophores in well-stratified, summer Mediterranean waters have shown that the different forms of *Helicosphaera carteri* inhabit different water depths. The heterococcolith form is associated with a relatively nutrient-rich DCM (Deep Chorophyll Maximum) layer, located within the nutricline, whilst the holococcolith form inhabits the impoverished upper water levels (Cros, 2001). An interpolation of these *Helicosphaera* data, within the conceptual model of Margalef's Mandala, supports the idea (Houdan *et al*., 2006) that the diploid heterococcolithophores and the haploid holococcolithophores might be exploiting a range of trophic environmental situations, with ecological niches closer to those of diatoms for heterococcolithophores and to those of dinoflagellates for holococcolithophores. Thus, it can be hypothesised that the haplo-diploid versatility of coccolithophores represents a survival strategy in a changing ecological environment.

References

Cros, L. 2002. *Planktonic coccolithophores of the NW Mediterranean*. Published PhD thesis. Publicacions de la Universitat de Barcelona, Barcelona: 365pp.

Houdan, A., Probert, I., Zatylny, C., Véron, B. & Billard, C. 2006. Ecology of oceanic coccolithophores. I. Nutritional preferences of the two stages in the life cycle of *Coccolithus braarudii* and *Calcidiscus leptoporus*. *Aquatic Microbial Ecology*, **44**: 291-301.

Margalef, R. 1978. Life-forms of phytoplankton as survival alternatives in an unstable environment. *Oceanologica Acta*, **1**: 493–509.

Volume calculation of Paleocene calcareous nannofossils

Bianca De Bernardi, Claudia Agnini

During the past decades, volume calculation of extant calcareous nannoplankton has been performed in order to convert coccolith fluxe data into carbonate export productivity. The most useful and relatively recent method to estimate the volume of coccoliths is described by Young & Ziveri (2000). Several studies on estimates of recent coccolithophore carbonate contribution have been published, and this methodology has also been successfully applied to Mesozoic sediments (Tremolada & Young, 2002), thus providing a new, promising proxy to be used in paleoceanographic reconstructions. Based on these fruitful practices, we have decided to test these methodologies on Paleocene sediments from several DSDP/ODP sites. The study areas are located at different latitudes, both in the Atlantic (401, 690, 1051, 1260 and 1263) and Pacific (ODP Site 1209) Oceans, with the intention of giving a global perspective.

We have investigated well-preserved, deep-sea sediments in order to determine the average dimensions, and calculate the volume of, the most abundant Paleocene nannofossils, which include *Coccolithus*, *Toweius*, *Sphenolithus*, *Fasciculithus*, *Discoaster* and *Zygrhablithus*. For each taxon, we have measured at least 250 specimens to obtain accurate size estimates; furthermore, we have analyzed 30 specimens of each species to calculate the shape constant (Ks), which, in turn, is used to obtain calcareous nannofossil volumes. This approach permits to evaluate the total amount of $CaCO_3$ produced by coccoliths and could be used to provide an important tool for palaeoecological and biogeochemical interpretations. However, the present work represents the first attempt to investigate the significance of volume variation within Paleocene nannofloras.

References

Tremolada, F. & Young, J.R. 2002. Volume calculation of Cretaceous calcareous nannofossils. *Journal of Nannoplankton Research*, **24**(3): 199-202.

Young, J.R. & Ziveri, P. 2000. Calculation of coccolith volume and its use in calibration of carbonate flux estimates. *Deep-Sea Research. Part II: Topical Studies in Oceanography*, **47**: 1679-1700.

Morphologic evolution of *Discoaster multiradiatus* from the Late Paleocene to the Early Eocene: abiotic and biotic causes

Bianca De Bernardi, Elisabetta Erba

A detailed investigation of sediments recovered at ODP Site 1209 (Shatsky Rise, Pacific Ocean) shows a significant change in *Discoaster multiradiatus* (*incertae sedis*) morphology and size during the Late Paleocene-Early Eocene. This analysis was extended to selected samples from other sediment sections at various paleolatitudes and from different sedimentary basins to decipher local *vs*. global changes.

This time interval is crucial, both for biotic evolution and environmental changes, being characterized by a series of hyperthermal events. Significant modifications in calcareous phytoplankton morphometry are known in the geological record but the causes of these size variations are still under debate. Several authors suggested that size variations could be triggered by paleoceanographic conditions; however, size variability also occurred during times of environmental stability. The goal of the present study is to understand if the observed changes in size result from ephemeral adaptation-malformations or true evolutionary changes.

For size determination, images of *D. multiradiatus* were collected using a digital image-capture system (Young *et al*., 1996), then an image analyses program (NIH-IMAGE software) was used in order to document fluctuations in their maximum diameter. At least 100 specimens were randomly selected through the smear slide of each sample, to provide accurate size estimate.

Results from morphometric analyses highlight a clear increase in size through time, overprinted by rapid shifts to gigantic forms. The relative timing between climate perturbations and biotic evolution in the Late Paleocene-Early Eocene, and specifically during the Paleocene/Eocene Thermal Maximum (PETM) interval, indicates that short-term size variations and malformations were strongly influenced by environmental pressure. The size variations of *D. multiradiatus* suggest that both long-term evolutionary trends and transient adaptations are somehow controlled by environmental pressure.

References

Young, J., Kucera, M. & Chung, H.-W. 1996. Automated biometrics on captured light microscope images of *Emiliania huxleyi*. *In*: A. Moguilesky & R. Whatley (Eds). *Microfossils and Oceanic Environments*. University of Wales, Aberystwyth Press: 261-280.

Productivity of calcareous nannoplankton during hyperthermal events: results from Sr/Ca ratios and biometry

Mascha Dedert, Heather Stoll, Jeremy Young, Patrizia Ziveri

Reconstructing the productivity of calcareous nannoplankton during hyperthermal events can contribute to our understanding of feedbacks to the high atmospheric CO_2 concentrations that characterized these events. Increased primary productivity resulting from increased weathering and consequently an increased nutrient availability has been suggested as an important negative feedback (Bains *et al*., 2000).

The Sr/Ca ratio in coccolith calcite has been shown to be related to the productivity of calcareous nannoplankton (Stoll & Schrag, 2000; Rickaby *et al*., 2002). We have measured Sr/Ca ratios in monogeneric samples of five different genera, covering the Paleocene Eocene Thermal Maximum (PETM) and the Early Eocene Hyperthermal Event (ETM2) Elmo, in order to reconstruct the productivity response of calcareous nannoplankton to these events. Nannofossils were isolated from ODP Cores 1263C and 1265A, located on the Walvis Ridge, using the method described by Stoll *et al*. (2007).

During the PETM, the Sr/Ca ratios in both *C. pelagicus* and *Toweius* increased, suggesting a high nutrient availability. Initial Sr/Ca ratio measurements in individual discoasters and *Zygrhablithus bijugatus* revealed a different ecological response, with *Discoaster* increasing in productivity at the onset of the PETM, followed by an increase in productivity of *Zygrhablithus*. The cold-water taxon *Chiasmolithus* did not show a response to the event, except for a small increase in productivity at the onset of the PETM.

We will compare the PETM Sr/Ca record with the Sr/Ca and oxygen isotope record covering the Early Eocene Hyperthermal Event (ETM2) Elmo at ODP Site 1265, which is closely located to Site 1263. The oxygen isotopes were measured in size fractions that are dominated by pelagic nannofossil carbonate. The warming trend found in the O-isotope signal coincides with the increase in Sr/Ca ratios in two dominating genera, *C. pelagicus* and *Toweius*.

Biometric analyses of *C. pelagicus* and *Toweius* demonstrate an increase in average coccolith size. These increases correlate with the Sr/Ca productivity and O-isotope warming signal, and could indicate an ecological response.

References

Bains, S., Norris, R.D., Corfield, R.M. & Faul, K.L. 2000. Termination of global warmth at the Paleocene/Eocene boundary through productivity feedback. *Nature*, **407**: 171-174.

Rickaby, R.E.M., Schrag, D.P., Zondervan, I. & Riebesell, U. 2002. Growth rate dependence of Sr incorporation during calcification of *Emiliania huxleyi*. *Glob. Biogeochem. Cycles*, **16**(1).

Stoll, H.M. & Schrag, D.P. 2000. Coccolith Sr/Ca as a new indicator of coccolithophorid calcification and growth rate. *Geochemistry, Geophysics and Geosystems*, **1**: 1999GC000015.

Stoll, H.M., Shimizu, N., Arevalos, A., Matell, N., Banasiak, A. & Zeren, S. 2007. Insights on coccolith chemistry from a new ion probe method for analysis of individually picked coccoliths. *Geochemistry, Geophysics and Geosystems*, **8**: Q06020, doi: 10.1029/2006GC001546.

Overgrowth on *Discoaster* and *Zygrhablithus* during the PETM: results from Sr/Ca measurements, stable isotopes and SEM analyses

Mascha Dedert, Heather Stoll, Jeremy Young, Patrizia Ziveri

Discoasters are useful biostratigraphic markers. Their origin, however, is still under debate. SEM analysis revealed that discoasters and *Zygrhablithus*, present in sediments covering the Late Paleocene to Early Eocene, are severely overgrown. This overgrowth was demonstrated geochemically by measuring Sr/Ca ratios in individual specimens of *Discoaster* covering the Early Eocene Hyperthermal Event (ETM2) Elmo. Also, stable isotope results obtained from separated size fractions that are dominated by discoasters indicate that calcification either took place deep in the water column, which would be in agreement with the general assumption that discoasters are deep-dwellers, or could be interpreted as discoasters being largely composed of carbonate that was formed during early diagenesis.

As a means of demonstrating the overgrowth on both nannolith taxa, we present overgrowth profiles of *Discoaster* and *Zygrhablithus* during the Paleocene Eocene Thermal Maximum (PETM), ODP Core 1263C, Walvis Ridge. The overgrowth profiles were obtained during measurements of Sr/Ca ratios through individual *Discoaster* and *Zygrhablithus* with an ion probe. The amount of overgrowth was calculated by comparing the primary calcite Sr/Ca with the Sr/Ca measured in the *Discoaster* size fractions. Overgrowth profiles and SEM images imply that the secondary calcite covering the nannoliths is dissolved during deep-sea carbonate dissolution that accompanied the PETM or was never formed.

Furthermore, we analysed the overgrowth on these two nannolith species throughout the PETM interval at different sites. The degree of overgrowth varied throughout the interval and at different sites, and correlates to geochemical conditions in the sediment.

Middle Miocene lineages in the calcareous nannofossil genus *Discoaster*

Eric de Kaenel, James Bergen

Research was conducted on the entire Miocene composite section from ODP Leg 154 (Ceara Rise, Western Equatorial Atlantic) between 2001 and 2008. The main purpose was to calibrate the latest cyclostratigraphic-based time scale to the nannofossil biostratigraphic framework in the deep-water Gulf of Mexico. Routine sampling was done at 20 kyr intervals, with some intervals sampled at 10 kyr resolution.

Middle Miocene lineages for discoasters with large central areas are presented, including four species described between 1954 and 1981: *Discoaster deflandrei*, *Discoaster musicus*, *Discoaster kugleri* and *Discoaster sanmiguelensis*. Eight new species within these lineages are proposed to account for variations in morphology with demonstrated stratigraphic utility. The main variations in morphology used to delineate these forms with large central areas are:

1) central area periphery (rounded or hexagonal);
2) distal central area (presence/absence of a knob);
3) proximal central area (presence/absence of knobs and ridges)
4) ray dimensions (length and width);
5) ray outline (tapered, parallel-sided, flared);
6) ray terminations (bifurcated, rounded, pointed, indented, notched).

These species normally range between 8-15 microns, but very rare specimens less than 8 microns also occur. Comparisons, including schematic drawings and light micrographs, are presented to differentiate four different lineages and their associated species. Their stratigraphy is then presented relative to defined middle Miocene zones. The total range of *Discoaster sanmiguelensis* and its variants is lowermost NN4 (17.69 Ma) to uppermost NN8 (11.04 Ma). The *Discoaster musicus* group ranges from the upper NN5 to the upper NN6 (13.08 Ma). *Discoaster kugleri* variants clearly predate (12.97 Ma) the base of Zone NN7 (11.910 Ma), as defined in both the NN and CN zonal schemes, by the first occurrence of *Discoaster kugleri*.

New tools for detecting the Miocene/Pliocene boundary in the Mediterranean region by means of calcareous nannofossils

Agata Di Stefano, Gioconda Sturiale

The recognition of the Miocene/Pliocene boundary in the Mediterranean region by means of calcareous nannofossil has been widely debated. Three important biological events take place very close to the Zanclean base and are very well constrained outside the Mediterranean: the last occurrence (LO) of *Triquetrorhabdulus rugosus*, the first occurrence (FO) of *Ceratholithus acutus* and the LO of *Discoaster quinqueramus*, respectively astronomically calibrated at 5.231 Ma, 5.372 Ma and 5.537 Ma by Backman & Raffi (1997). All these biohorizons anyway show low applicability in the Mediterranean region. The presence of typical *Discoaster quinqueramus* is a controversial point. Many authors (*e.g.* Raffi *et al.*, 2003 and reference therein) assess that this species, and the co-distributed, similar *D. bergrenii*, are not present in the Mediterranean area. On the other hand, the presence of typical specimens is documented in the Mediterranean area (Mazzei, 1985; Cipollari & Cosentino, 1995; Iaccarino *et al.*, in press), but the scattered distribution and the low frequencies do not allow to define either a FO or a LO at synchronous levels in the Mediterranean area.

Both *T. rugosus* and *C. acutus* are rare in the Mediterranean area. Rio *et al.* (1984) and Di Stefano *et al.* (1996) did not mention the presence of *C. acutus* in the Zanclean of the Capo Rossello area and southern Italy. Castradori (1998) points out the presence of very rare *C. acutus* only in one sample in the basal Zanclean sediment of Site 969B succession (Eastern Mediterranean).

Here, we present data from four sedimentary sequences encompassing the Miocene/Pliocene boundary, located in different areas of the Mediterranean basin. From west to east, we have selected ODP Hole 975B (Balearic Basin, western Mediterranean), the Cava Serredi section (Tuscany, central Italy), the Montepetra borehole (Emilian Apennines, NE Italy) and ODP Hole 969B (Mediterranean Ridge, eastern Mediterranean). All the selected sections have been investigated at high resolution, with the exception of the Montepetra borehole, performing quantitative analyses on the whole assemblage, to better highlight the presence of useful biohorizons.

Our study confirms that *C. acutus* and *T. rugosus* are very rare in the Mediterranean area, and do not provide useful bioevents through the investigated sections. Particular attention has been payed to selected taxa that were known to be potentially useful for biostratigraphy. The quantitative analyses on the *Reticulofenestra* genus pointed out the presence of a sharp paracme interval, very close to the Zanclean base, previously documented on a qualitative basis (Castradori, 1998; Di Stefano *et al.*, 1996). On the contrary, small reticulofenestrids (less than 7 μm) dominates the nannofossil assemblage within the same stratigraphic interval. In addition, we have tested the biostratigraphic value of a peculiar circular morphotype of *Reticulofenestra*, whose presence seems to be restricted to the lowermost part of the Zanclean.

References

Backman, J. & Raffi, I. 1997. Calibration of Miocene nannofossil events to orbitally tuned cyclostratigraphies from Ceara Rise. *In*: N.J. Shackleton *et al.* (Eds). *Proc. ODP, Sci. Res.*, **154**: 83-99.

Castradori, D. 1998. Calcareous nannofossils in the basal Zanclean of the Eastern Mediterranean Sea: remarks on paleoceanography and sapropel formation. *In*: A.H.F. Robertson et al. (Eds). *Proc. ODP, Sci. Res.*, **160**: 113-123.

Cipollari, P. & Cosentino, D. 1995. Miocene unconformities in the central Apennines: geodynamic significance and sedimentary basin. *Tectonophysics*, **252**: 375-389.

Di Stefano, E., Sprovieri, R. & Scarantino, S. 1996. Chronology of biostratigraphic events at the base of the Pliocene. *Paleopelagos*, **6**: 401-414.

Iaccarino, S.M., Bertini, A., Di Stefano, A., Ferraro, L., Gennari, R., Grossi, F., Lirer, F., Manzi, V., Menichetti, E., Ricci Lucchi, M., Taviani, M., Sturiale, G. & Angeletti, L. 2008. The Trave section (Monte dei Corvi, Ancona, Central Italy): an integrated paleontological study of the Messinian deposits. *Stratigraphy*, in press.

Mazzei, R. 1985. The Miocene sequence of the Maltese Islands: biostratigraphic and chronostratigraphic reference based on nannofossils. *Atti della Società Toscana di Scienze Naturali, Serie A*, **92**: 165-197.

Raffi, I., Mozzato, C., Fornaciari, E., Hilgen, F.J. & Rio, D. 2003. Late Miocene calcareous nannofossil biostratigraphy and astrochronology for the Mediterranean region. *Micropaleontology*, **49**: 1-26.

Rio, D., Sprovieri, R. & Raffi, I. 1984. Calcareous plankton biostratigraphy and biochronology of the Pliocene-lower Pleistocene succession of the Capo Rossello area, Sicily. *Mar. Micropaleontol.*, **9**: 135-180.

New perspectives on the Cenozoic history of the Syracosphaerales

Tom Dunkley Jones, Paul Bown, Jeremy Young

The Order Syracosphaerales includes the two most diverse modern coccolithophore families, the Syracosphaeraceae and Rhabdosphaeraceae, and forms approximately half of modern heterococcolithophore biodiversity. An understanding of its evolutionary history has, however, been hampered by the relatively poor fossil record of the often small and fragile coccoliths produced by these taxa, and by some dubious assignments of taxa to the modern genera. Recently acquired palaeontological data from locations with exquisite nannofossil preservation (Tanzania, New Zealand, US Gulf Coast and Para-Tethys) provide new morphological and taxonomic data, constraints on origination times for major extant genera, and an outline of long-term patterns of diversity through the Cenozoic.

The pattern of Rhabdosphaeraceae diversification in the early Eocene, with peak diversities in the middle Eocene, before a long-term decline through the late Eocene and early Oligocene, is supported, but new, deep-time occurrences of the extant genera *Acanthoica* (late Paleocene), *Rhabdosphaera* (middle Eocene) and *Algirosphaera* (late Eocene) are documented for the first time, together with exceptional morphological and species diversities in the Eocene genus *Blackites*.

The Syracosphaeraceae are present in the fossil record by at least the late Paleocene, but remain at relatively low (preserved) diversities and with conservative morphologies through the Eocene, Oligocene and Miocene in contrast to their high diversity in the modern oceans. Available molecular genetic data indicate a late Mesozoic divergence time for the Syracosphaeraceae, and the relationship between the Cenozoic families and the Mesozoic to modern Calciosoleniaceae will be discussed.

Dwarf coccoliths at the onset of Cretaceous Oceanic Anoxic Events 1a and 2: an example of calcareous nannoplankton sensitivity to excess CO_2?

Elisabetta Erba, Cinzia Bottini

High-resolution sampling of the initial phase of both early Aptian Oceanic Anoxic Event (OAE) 1a and latest Cenomanian OAE 2 was applied to relatively expanded sections from the western Tethys. Quantitative and morphometric investigations of calcareous nannofossil assemblages pointed out the occurrence of dwarf coccoliths. Small specimens of genera *Biscutum*, *Zeugrhabdotus* and *Discorhabdus* become relatively common, and parallel the decrease in abundance of large nannofossils, such as the heavily calcified nannoconids and other nannoliths.

During the mid-Cretaceous, the natural source of atmospheric CO_2 was Earth's degassing, and emplacement of the Ontong Java-Manihiki and Caribbean Plateau large igneous provinces (LIPs) is recognized as responsible for pCO_2 as high as 2000 ppm. Coeval (and synchronous) biocalcification crises have been documented in pelagic and neritic settings, suggesting a causal link between high concentrations of carbon dioxide in the atmosphere-ocean system and drops in benthic and planktonic calcifiers' efficiency.

Coccolith dwarfism is here interpreted as forced by rapidly increasing pCO_2, and might be the counterpart of the major decrease in nannolith abundance. Our data are consistent with works by Riebesell *et al*. (2000), but are apparently contradicted by recent data by Iglesias-Rodriguez *et al*. (2008), documenting enlarged *Emiliania huxleyi* coccoliths under high CO_2.

We stress the fact that: (1) coccolith size alone is not a measure of calcite production (number of coccoliths must be taken into account) and of calcification rate; (2) *E. huxleyi* is not the best taxon for testing biocalcification: this species is super-opportunistic and might take advantage in any environment; (3) during OAEs pCO_2 concentrations were so elevated as to exceed threshold values, and current lab experiments might not be good analogues.

Although dwarf coccoliths might result from enhanced fertility associated with OAE1a and OAE2, regardless of ocean alkalinity, all geological data indicate a rapid, 4 to 10 times increase of pCO_2 associated with both episodes of global anoxia. We believe that the observed tiny specimens derive from difficult/reduced calcification and suspect that in order to reproduce and understand rates of Cretaceous nannoplankton mineralization, future lab experiments should be run under pCO_2 as high as 1500-2000 ppm.

References

Iglesias-Rodriguez, D., Halloran, P.R., Rickaby, R.E.M., Hall, I.R., Colmenero-Hidalgo, E., Gittins, J.R., Green, D.R.H., Tyrrell, T., Gibbs, S.J., von Dassow, P., Rehm, E., Armbrust, E.V. & Boessenkool, K.P. 2008. Phytoplankton Calcification in a High-CO2 World. *Science*, **320**: 336-340.

Riebesell, U., Zondervan, I., Rost, B., Tortell, P.D., Zeebe, R.E. & Morel, F.M.M. 2000. Reduced calcification of marine plankton in response to increased atmospheric CO_2. *Nature*, **407**: 364-367.

Calcareous nannofossils of the Turonian-Santonian sediments, Zagros Basin, Iran

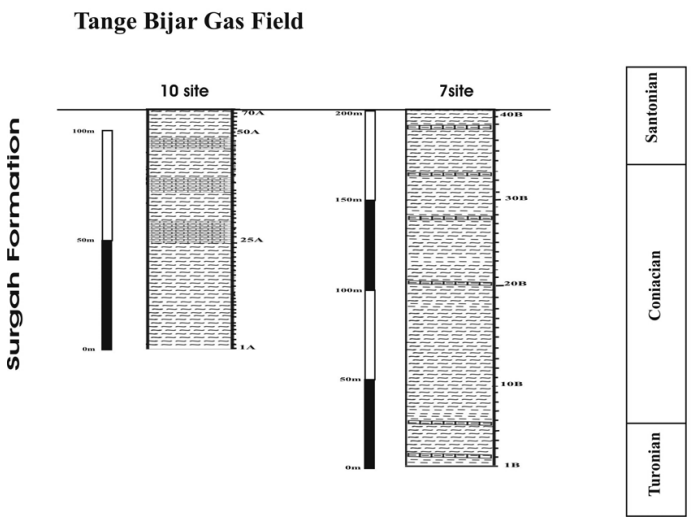
Fereshte Farhad, Anoshiravan L. Kani

Due to the lack of any precise paleontological study, the sediments of the Surgah Formation from two well sections in the Tange Bijar Gas Field (Sites 7 and 10; see figure) were investigated for their calcareous nannoplankton content to obtain their exact age. Lithostratigraphically, the Surgah Formation consists of an alternating sequence of marls and shales with argillaceous limestone intercalations. Forty samples from Site 7 (with a sample spacing of 5 meters) and seventy samples from Site 10 (with a sample spacing of 2 meters) were collected, prepared and studied under the light microscope. These samples yielded a rich nannofloral assemblage of 56 species and 31 genera. The distribution of the nannofossil taxa reveals the presence of UC8-UC12 zones of Burnett (1998) equivalent to CC13-CC15 zones of Sissingh (1977), thus pointing to an early Late Turonian – Early Santonian age for the sediments. Based on the obtained data, the environmental conditions of the sedimentary basin of the Surgah Formation is presumed to correspond to a low-latitude, shallow sea, with warm surface waters rich in nutrients.

References

Burnett, J.A. 1998. Upper Cretaceous. *In*: P.R. Bown (Ed.). *Calcareous Nannofossil Biostratigraphy*. Chapman & Hall/Kluwer Academic Publishing, London: 132-200.

Sissingh, W. 1977. Biostratigraphy of Cretaceous calcareous nannoplankton. *Geol. Mijnbouw*, **56**: 37-65.



High-resolution calcareous nannofossil biostratigraphy and chemostratigraphy of the Cenomanian-Turonian boundary in the Vocontian Basin, south-east France

Allan Gil S. Fernando, Reishi Takashima, Hiroshi Nishi, Hisatake Okada

The Cenomanian-Turonian boundary (CTB) Oceanic Anoxic Event 2 (OAE2) is considered the type example of the Mesozoic OAEs, associated with a large and abrupt perturbation in atmospheric pCO_2, changes/turnover in the marine macro- and microfauna, changes in ocean water chemistry, and a pronounced positive excursion in the $\delta^{13}C$ record of the marine carbonate and marine and terrestrial organic matter. The positive shift in the $\delta^{13}C$ curve is believed to be related to the widespread burial of isotopically light organic matter, in response to enhanced oceanic productivity during a period of large igneous province (LIP) formation (*i.e.*, Caribbean Plateau) and increased submarine volcanism, ocean crust production and hydrothermal activity, as substantiated by available strontium ($^{87}Sr/^{86}Sr$) isotope and trace metal distribution data.

The Thomel Level of the Lambruisse section in the Vocontian Basin in south-east France accumulated during the CTB OAE2, and is marked by intercalations of black shale and organic-rich marl. Biostratigraphic analysis of the section revealed a total of 6 nannofossil zones, corresponding to the UC2-UC9 zones (Lower Cenomanian-Middle Turonian). The result correlates well with the previously established planktonic foraminiferal biostratigraphy in the section. Biostratigraphically important taxa observed in the section include *Cretarhabdus striatus*, *Axopodorhabdus albianus*, *Lithraphidites acutus*, *Corollithion kennedyi*, *Helenea chiastia*, *Quadrum gartneri*, *Q. intermedium*, *Eiffellithus eximius*, *Eprolithus octopetalus* and *E. eptapetalus*. *Helenea chiastia* and *Q. gartneri*, the two nannofossil taxa commonly used in the delineation of the C-T boundary (*e.g.*, Sissingh, 1977; Perch-Nielsen, 1985; Bralower, 1988; Bralower *et al.*, 1995; Burnett, 1998; Luciani & Cobianchi, 1999; Paul *et al.*, 1999; Tsikos *et al.*, 2004), occur less than 2m apart in the studied section, within the UC6 and the *Whiteinella archaeocretacea* zones. Detailed litho- and chemostratigraphic analyses indicate that the $\delta^{13}C$ profile of the section corresponds well with changes in lithofacies and fluctuations in the total organic carbon (TOC) and calcium carbonate content of the section. Initial increase in the $\delta^{13}C$ values occurs within the UC3-UC4a composite zone, coinciding with the onset of the deposition of the organic-rich sediments of the Thomel Level and drastic decline in the $CaCO_3$ values. The plateau of high $\delta^{13}C$ values, on the other hand, occurs within the UC5 zone, between the LO of C. kennedyi and the LO of *H. chiastia*. This interval of high $\delta^{13}C$ values also corresponds to the interval of high TOC and low $CaCO_3$ values.

During the biostratigraphic investigation of the Lambruisse section, the common occurrence of large specimens (>8 μm) of *Assipetra terebrodentarius* (*i.e.*, *A. terebrodentarius youngii*) was observed in the black shales of the Thomel Level, within the UC3-UC5 nannofossil zones. The increase in abundance and size of this nannolith is well-documented in the Early Aptian OAE1a (*e.g.*, Erba, 1994, 2004; Tremolada & Erba, 2002), but these trends have never been documented in younger OAEs, particularly OAE2. Although the paleoecology of *Assipetra* is still poorly understood, the taxon's presence in OAE1a and OAE2 (both considered as high productivity events or P-OAEs; Erbacher *et al.*, 1996) suggests possible affinity for higher fertility of surface waters and, therefore, supports its potential as a high-productivity indicator-taxon, as suggested by earlier studies (*e.g.*, Tremolada & Erba, 2002). One new holococcolith taxon, a species of *Owenia*, is described in this study.

References

Bralower, T.J. 1988. Calcareous nannofossil biostratigraphy and assemblages of the Cenomanian-Turonian boundary interval: implications for the origin and timing of oceanic anoxia. *Paleoceanography*, **3**: 275-316.

Bralower, T.J., Leckie, R.M., Sliter, W.V. & Thierstein, H.R. 1995. An Integrated Cretaceous Microfossil Biostratigraphy. *In*: W.A. Berggren, D.V. Kent, M.-P. Aubry & J. Hardenbol (Eds). *Geochronology, Time Scales and Global Stratigraphic Correlation*. *SEPM Special Publication*, **No.54**: 65-79.

Burnett, J.A. 1998. Upper Cretaceous. *In*: P.R. Bown (Ed.). *Calcareous Nannofossil Biostratigraphy*. British Micropalaeontological Society Publications Series, Chapman & Hall/Kluwer Academic Publishers: 132-199.

Erba, E. 1994. Nannofossils and superplumes: The early Aptian "nannoconid crisis". *Paleoceanography*, **9**(3): 483-501.

Erba, E. 2004. Calcareous nannofossils and Mesozoic anoxic events. *Marine Micropaleontology*, **52**(1-4): 85-106.

Erbacher, J., Thurow, J. & Littke, R. 1996. Evolution patterns of radiolaria and organic matter variations: A new approach to identify sea-level changes in mid-Cretaceous pelagic environments. *Geology*, **24**(6): 499-502.

Luciani, V. & Cobianchi, M. 1999. The Bonarelli Level and other black shales in the Cenomanian-Turonian of the northeastern Dolomites (Italy): calcareous nannofossil and foraminiferal data. *Cretaceous Research*, **20**: 135-167.

Paul, C.R.C., Lamolda, M.A., Mitchell, S.F., Vaziri, M.R., Gorostidi, A. & Marshall, J.D. 1999. The Cenomanian-Turonian boundary at Eastbourne (Sussex, UK): a proposed European reference section. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **150**: 83-121.

Perch-Nielsen, K. 1985. Mesozoic calcareous nannofossils. *In*: H.M. Bolli, J.B. Saunders & K. Perch-Nielsen (Eds). *Plankton Stratigraphy*. Cambridge University Press: 17-86.

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

Tremolada, F. & Erba, E. 2002. Morphometric analyses of Aptian *Assipetra infracretacea* and *Rucinolithus terebrodentarius*

nannoliths: implications for taxonomy, biostratigraphy and paleoceanography. *Marine Micropaleontology*, **44**: 77-92.

Tsikos, H., Jenkyns, H.C., Walsworth-Bell, B., Petrizzo, M.R., Erba, E. Premoli Silva, I., Forster, A., Kolonic, S., Wagner, T. & Sinninghe Damste, J.S. 2004. Carbon isotope stratigraphy recorded by the Cenomanian/Turonian Oceanic Anoxic Event: Correlation and implications based on three key-localities. *Journal of the Geological Society of London*, **161**(4): 711-719.

Distribution of 'minor' calcareous nannofossil species in the surface sediments along the Vietnam upwelling zone: western South China Sea revisited

Adrian Raymund C. Fernandez, Allan Gil S. Fernando

The South China Sea has been studied for calcareous nannofossils (and nannoplankton) since the 1970s and, thus, has a well established database regarding nannofossil distribution. Similar to other marginal basins, however, the assemblage is dominated by a very few number of taxa, particularly *Emiliania huxleyi*, *Florisphaera profunda* and *Gephyrocapsa oceanica*. Minor species (*i.e.*, species with abundance values <3% and percent occurrence <70%) comprise <28% of total assemblages (Fernando *et al.*, 2007). Although some of these minor species show possible affinities for particular oceanographic conditions, the initial data is insufficient to clearly establish their environmental preference due to the overwhelming dominance of *E. huxleyi*, *F. profunda* and *G. oceanica*. Examples include *Reticulofenestra* spp., *Calciosolenia murrayi*, *Helicosphaera carteri* and *Syracosphaera* spp. for neritic conditions, *G. ericsonii* for low sea-surface temperature conditions (SSTs) and *C. murrayi* and *Syracosphaera* spp. for warmer SSTs (Fernando *et al.*, 2007). To validate and confirm these observations, a separate count exclusive of the three major taxa will be done and subjected to multivariate analysis, along with several oceanographic parameters, including salinity, whose relationship with some species in the South China Sea (*e.g.*, *G. ericsonii*, *Calcidiscus leptoporus*, *C. murrayi* and *Syracosphaera* spp.) remains uncertain.

Reference

Fernando, A.G.S., Peleo-Alampay, A.M. & Wiesner, M.G. 2007. Calcareous nannofossils in surface sediments of the eastern and western South China Sea. *Marine Micropaleontology*, **66**: 1-26.

Geochemical and isotopic signals (Sr/Ca ratios, stable $\delta^{13}C$ and $\delta^{18}O$ isotopes) in coccolith carbonate of different grain-size fractions in Atlantic sediments

Christina Fink, Karl-Heinz Baumann

Coccolithophores are unicellular, marine algae and therefore directly dependent on the surface-water conditions in world oceans. They are one of the main open ocean primary producers and one of the dominant carbonate contributors to pelagic sediments (Westbroek *et al*., 1993). Therefore, these organisms influence the chemical composition of surface water by their calcification and photosynthetic mechanisms in different ways. As photosynthetic organisms, their chemistry and stable isotope composition can provide a sensitive tool for understanding photic zone processes (Honjo, 1976). The chemistry of coccoliths serves both as a record of changes in the chemistry of the ocean, and a record of environmental and biological conditions like temperature and productivity (Stoll & Ziveri, 2004). Nevertheless, their effect on, and response to, the climate system is one of the big questions facing our field today, since coccolith geochemistry has hardly been explored.

The studied surface sediment samples from the equatorial to South Atlantic show that the geochemistry and isotopic composition of coccoliths is dependent on coccolith growth rate and environmental influences, such as temperature and nutrient supply. The investigations also indicate a great variability between the different grain size fractions. Even if the absolute values show a great difference, the general trends are similar: the $\delta^{18}O$ ratios in these samples show a decreasing trend with increasing temperature, while $\delta^{13}C$ and Sr/Ca ratios are influenced by a mixture of processes, such as temperature, nutrient- and probably freshwater supply. The knowledge of geochemical and isotopic behaviour of coccoliths is used to reconstruct long-term-changes in paleoceanography and paleoclimate. The coccolith assemblages in ODP Site 659, from the eastern north-eastern Atlantic, show a distinct shift at the Plio-Pleistocene boundary. The reticulofenestrids, which are very abundant in the Pliocene, are replaced by gephyrocapsids in Pleistocene times (Su, 1996). The variation in accumulation rates of coccolith species and variation in benthic $\delta^{18}O$ values have shown climatic instability during the late Pliocene and Pleistocene, where low coccolith fluctuation rates are often parallel to low $\delta^{18}O$ values (Su, 1996). To examine the main influences that caused the shift in faunal association, the geochemical and isotopic parameters in monospecific coccolith carbonate will be measured.

References

Honjo, S. 1976. Coccoliths: Production, transportation and sedimentation. *Marine Micropaleontology*, **1**: 65-79

Stoll, H.M. & Ziveri, P. 2004. Coccolithophorid-based geochemical paleoproxies. *In*: H.R. Thierstein & J. Young (Eds). Coccolithophores - from molecular processes to global impact. Springer, Berlin: 529-562.

Su, X. 1996. Development of late Tertiary and Quaternary coccolith assemblages in the Northeast Atlantic. *Glomar Report*, **48**: 1-119.

Westbroek, P., Brown, C.W., Bleijswijk, J.v., Brownlee, C., Brummer, G.J., Conte, M., Egge, J., Fernandez, E., Jordan, R., Knappertsbusch, M., Stefels, J., Veldhuis, M., van der Wal, P. & Young, J. 1993. A model system approach to biological climate forcing. The example of *Emiliania huxleyi*. *Global and Planetary Change*, **8**(1-2): 27-46.

High-resolution Late Eocene-Late Oligocene biostratigraphy from Site 1090 (Agulhas Ridge, South Atlantic)

Chiara Fioroni, Davide Persico, Laura Pea, Silvia Palandri, Giuliana Villa

Results are presented of a quantitative biostratigraphic study of the calcareous nannofossils from the ODP Site 1090 Hole B. It is located in the central part of the Subantarctic Zone on the southern flank of the Agulhas Ridge in the Atlantic sector of the Southern Ocean, above the calcium-carbonate compensation depth (CCD). The base of the section is composed of late Eocene nannofossil oozes mixed with red clays deposited at low sedimentation rates overlain by an extended succession of biosiliceous oozes and muds, comprising most of the late Eocene, and the late Oligocene.

Site 1090 proved to be a suitable section for high-resolution biostratigraphic studies (Marino and Flores, 2002). Part of their nannofossil biostratigraphy was reexamined using closely spaced samples and new data are presented here for the Late Oligocene. For this Site, also a detailed planktonic foraminiferal biostratigraphy (Galeotti et al., 2002), a robust magnetostratigraphy (Channell et al, 2003) and a late Oligocene astronomical calibration (Billups et al., 2004) are available. Age estimates for the nannofossil biohorizons recognized in the section were obtained through direct correlation to the magnetostratigraphy.

Although nannofossils are at times scarce, some intervals are barren, and preservation varies from good to very poor, it has been possible to precisely define most of the biostratigraphic events of the Martini (1971) and Okada and Bukry (1980) schemes. Nevertheless being Sphenoliths rare at these southern latitudes, it was difficult to recognize the Oligocene standard biozones, therefore additional bioevents have been proposed. This study allows the comparison and the improvement of the Paleogene calcareous nannofossil Zonal Scheme for the Southern Ocean. Part of the scheme has been previously proposed for the Middle Eocene-Late Oligocene interval (Wei and Wise, 1992; Villa et al., submitted).

We compared our biochronology with data available from other Southern Ocean sections (748, 689, 744, 738), confirming the diachronous character of some bioevents and highlighting in particular how the modified climatic conditions affected nannofossil assemblages of different latitudes.

Additionally, nannofossil total abundances, relative abundance of dominant species, and species group abundances were determined to evaluate the potential of this section for obtaining palaeoecological information.

References

Billups, K., Palike, H., Channell, J.E.T, Zachos, J.C. & Shackleton, N.J. 2004. Astronomic calibration of the late Oligocene through early Miocene geomagnetic polarity time scale. *Earth Planetary Science Letters*, **224**: 33-44.

Channell, J.E.T., Galeotti, S., Martin, E.E., Billups, K., Scher, H. & Stoner, J.S. 2003. Eocene to Miocene magnetostratigraphy, biostratigraphy, and chemostratigraphy at ODP Site 1090 (sub-Antarctic South Atlantic). *Geological Society of America Bulletin*, **115**: 607-623.

Galeotti, S., Coccioni, R. & Gersonde, R. 2002. Middle Eocene – Early Pliocene Subantarctic planktic foraminiferal biostratigraphy of Site 1090, Agulhas Ridge. *Marine Micropaleontology*, **45**: 357-381.

Marino, M. & Flores, J.-A. 2002. Middle Eocene to Early Oligocene calcareous nannofossil stratigraphy at Leg 177 Site 1090. *Marine Micropaleontology*, **45**: 383-398.

Martini, E. 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. *In*: A. Farinacci (Eds). *Proceedings 2nd Int. Conf. Planktonic Microfossils, Roma*, **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**: 321-325.

Villa, G., Fioroni, C., Pea, L., Bohaty, S. & Persico, D. Submitted. Middle Eocene – Late Oligocene climate variability: calcareous nannofossil response at Kerguelen Plateau, Site 748. *Marine Micropaleontology*.

Wei, W. & Wise, S.W., Jr. 1990. Middle Eocene to Pleistocene calcareous nannofossils recovered by Ocean Drilling Program Leg 113 from the Weddell Sea. *In*: P.F. Barker, J.P. Kennet *et al*. *Proceedings ODP, Scientific Results*, **113**: 639-666.

Coccolithophore response to abrupt and short-term climate changes in the Gulf of Lions (western Mediterranean) for the last 25 000 years

José-Abel Flores, Francisco J. Sierro, Elena Colmenero-Hidalgo, José M. Gravalosa, Miquel Canals, Jaume Frigola, Joan O. Grimalt, Serge Berné, Bernard Dennielou

Cores PRGL-1 (310 m long) and MD99-2348 (21.5 m long) were recovered in the Gulf of Lions (42.690N; 03.838 E) at 298.48 m water depth, during the PROMESS 1 (SRV *Bavenit* drilling vessel) and IMAGES V (RV *Marion Dufresne*, Calypso piston core) cruises, respectively. The high sedimentation rates, estimated by robust ^{14}C dating, have given us an excellent opportunity to perform high-resolution analyses on these materials.

In this study, we present data from the last 25 kyr. The retrieved sediments consist of silty-clay terrigenous material mixed with small amounts of calcareous microfossils. Quantitative analyses of coccolithophore assemblages allow us to identify significant changes in sea-surface temperatures (SST) in this period. Cold peaks are marked by increases in the proportion of *Gephyrocapsa muellerae* and large morphotypes of *Emiliania huxleyi* (>5 μm); some of the most significant can be correlated with Heinrich events. The high sedimentation rates observed during most of the studied interval also allow us to identify an overprinted multicentennial-scale pattern related to Dansgaard-Oeschger cycles. The combined analyses of coccolithophores and planktonic foraminifers permit to produce a SST record in which sharp fluctuations of around 4˚C in amplitude have been detected. These abrupt changes in SST are also linked to changes in surface productivity and in the deep and intermediate water dynamics, probably related to variations in the atmospheric patterns (NAO-like oscillations).

PROMESS 1 is funded by the European Community (EVR1-T-40024).

Biostratigraphy of late Sinemurian-Pliensbachian calcareous nannofossils in northern Spain (Basque-Cantabrian Basin)

Ángela Fraguas, Nicola Perilli, María José Comas-Rengifo

The aim of this work is to improve the knowledge of nannofossil biohorizons in the Basque-Cantabrian Basin (BCB), through comparison of our results to the scheme proposed by Bown & Cooper (1998) for NW Europe. The four ammonite-controlled successions we studied consist of Upper Sinemurian (Raricostatum Ammonite Zone) limestones of shallow platform, grading to a regular alternation of hemipelagic marlstones and limestones, Pliensbachian in age. Our results are based on semiquantitative analysis of more than 140 smear slides from the Tudanca and Santotis sections, and the re-analysis of more than 200 samples from the Camino and San Andrés sections (Perilli & Comas-Rengifo, 2002).

In the BCB, the most relevant composition changes in Pliensbachian calcareous nannofossil assemblages are the first occurrences (FO) of the genera *Similiscutum* (*jamesoni* AZ) and *Lotharingius* (*stokesi* AZ). During the late Pliensbachian, the assemblages change remarkably due to 1) the FO of the genus *Biscutum* (*davoei* AZ), 2) an increase in abundance of *Schizosphaerella*, *Calcivascularis* and *Lotharingius*, 3) a decrease in abundance of *Crepidolithus* and *Parhabdolithus* and, 4) the first common occurrence (FCO) of *C. jansae* and *L. hauffii*. Related to these composition changes, we have recognized and calibrated against the ammonite zones and subzones, two main events (the FO of *S. cruciulus* and the FO of *L. hauffii*) and six secondary events (1. FO of *B. novum*; 2. FO of *B. grandis*; 3. FO of *B. finchii*; 4. FO of *L. barozii*; 5. FCO of *C. jansae*; 6. FCO of *L. hauffii*). In the Camino and San Andrés sections, we have also identified the FOs of *B. dubium*, *Bussonius prinsii* and *L. sigillatus*.

The first zone recognized is the NJ3 *Crepidolithus crassus* (Bown, 1987) Bown & Cooper (1998), including the time interval from the FO of *C. crassus* to the FO of *S. cruciulus*. This zone is dominated by the genera *Orthogonoides* and *Schizosphaerella* spp. and shows an increase in the abundance of *Crepidolithus* and *Parhabdolithus*.

The base of the NJ4 *Similiscutum cruciulus* Zone Bown (1987), emend. Bown & Cooper (1998), is defined by the FO of *S. cruciulus* within the *jamesoni* AZ, as it is observed in NW Europe, Portugal and Italy. The assemblages of this zone show an abundance increase of the genera *Calcivascularis* and *Biscutum*, and a decrease of *Crucirhabdus*, *Crepidolithus* and *Parhabdolithus*. In this zone, the last occurrences of *C. pliensbachensis* and *P. robustus*, and the

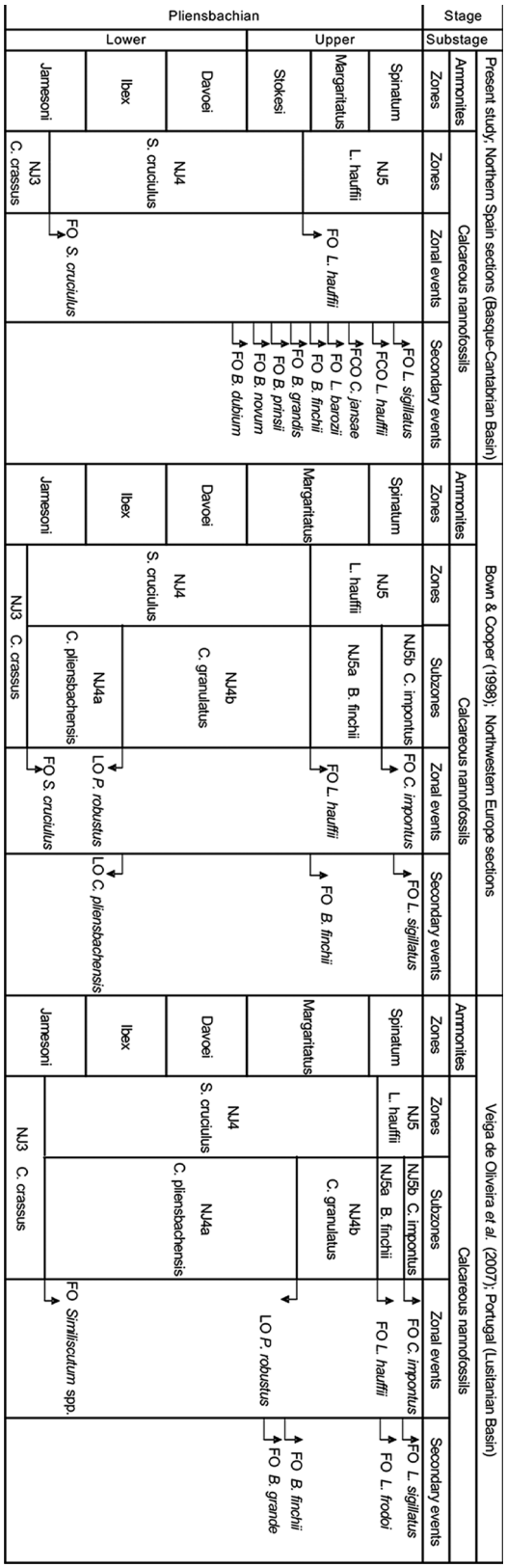


Figure 1: Sketch showing ammonite zones and calcareous nannofossil zones, with zonal and secondary events, in the Basque-Cantabrian Basin (present study), NW Europe (Bown & Cooper, 1998), and the Lusitanian Basin (Veiga de Oliveira *et al*., 2007)

FO of the genus *Biscutum* have been identified. In NW Europe and Portugal, the NJ4 Zone is divided in two subzones based on the LO of *P. robustus*, that in the BCB shows low abundances and a discontinuous record. In our sections, the NJ4 Zone can be subdived using the FO of *B. novum*.

The base of the NJ5 *Lotharingius hauffii* Zone Bown (1987) is defined by the FO of *L. hauffii* (*stokesi* AZ). In NW Europe, this event lies in the *margaritatus* AZ, which includes the *stokesi* and *margaritatus* AZs of the BCB. In Portugal, it has been recognized in the uppermost levels of the *spinatum* AZ. The lower part of the NJ5 Zone is characterized by the abundance decrease of *Crepidolithus* and *Similiscutum*, and the increase of *Calcivascularis*, *Biscutum* and *Lotharingius*. This last genus shows an increase in abundance and diversity along the late Pliensbachian, related to the FOs of *L. barozii* and *L. umbriensis* (*margaritatus* AZ), and the FCO of *L. hauffii* and FO *L. sigillatus* (*spinatum* AZ). In NW Europe, the NJ5 Zone is divided in two subzones, based on the FO of *C. impontus* also used in Portugal. Because of the difficulty to distinguish *C. impontus* from *C. cavus*, and the low abundance and discontinuous record of the first species in the BCB, it seems to be useful to divide this zone using the FO of *L. sigillatus*, as proposed by Mattioli & Erba (1999) for the NJT5b subzone.

In summary, the scheme of Bown & Cooper (1998) for NW Europe is reproducible also in the BCB, where it is possible to calibrate the bases of NJ4 and NJ5 zones with respect to the ammonite subzones. Though in the BCB, the NJ4a/NJ4b and NJ5a/NJ5b boundaries are not easily recognizable. The FOs of *B. novum* and *L. sigillatus* are helpful to subdivide the NJ4 and NJ5 zones, respectively.

This work was supported by the research project CGL 2005-01765/BTE and an UCM research fellowship.

References

Bown, P.R. 1987. Taxonomy, evolution, and biostratigraphy of Late Triassic-Early Jurassic calcareous nannofossils. *Special Papers in Palaeontology*, **38**: 1-118.

Bown, P.R. & Cooper, M.K.E. 1998. Jurassic. **In**: P.R. Bown (Ed.). *Calcareous Nannofossil Biostratigraphy*. Kluwer Academic, London: 34-86.

Mattioli, E. & Erba, E. 1999. Synthesis of calcareous nannofossil events in Tethyan Lower and Middle Jurassic successions. *Rivista Italiana di Paleontologia e Stratigrafia*, **105**(3): 343-376.

Perilli, N. & Comas-Rengifo, M.J. 2002. Calibration of Pliensbachian calcareous nannofossil events in two ammonite-controlled sections from Northern Spain. *Rivista Italiana di Paleontologia e Stratigrafia*, **108**(1): 133-152.

Veiga de Oliveira, L.C., Duarte, L., Lemos, V.B., Comas-Rengifo, M.J. & Perilli, N. 2007. Bioestratigrafia de nanofósseis calcários e correlação com as zonas de amonites do Pliensbaquiano-Toarciano basal (Jurássico Inferior) de Peniche (Bacia Lusitânica, Portugal). *In*: de Souza Carvalho *et al*. (Eds). *Paleontologia, Cenários de Vida. Interciência, Rio de Janeiro*, **2**: 411-420.

Correlation between Paratethys-Mediterranean (NN-MNN) calcareous nannoplankton zonations

Ines Galoviç

In many cases, the nannofossil zonal-markers for the Sarmatian, *i.e*. Serravalian to Tortonian, are absent or rare in sediments of the Paratethys and Mediterranean regions. It is often difficult to correlate the Paratethys calcareous nannofossils zonation to the Mediterranean one because assemblage, abundance and bio-horizons of a certain number of species/genera are somewhat different.

The Badenian/Sarmatian boundary in Central Paratethys is identified on the basis of abundance and first occurrence of certain species/genera. Namely, close to the top of NN6 zone or close to the base of NN7 zone, *Cyclicargolithus floridanus* decreases in abundance or disappears, and is replaced in the assemblage by abundant, large *R. pseudoumbilicus* (≥ 7 μm) (Perch-Nielsen, 1985). This event is reported in some other basins at different stratigraphic levels (Raffi *et al*., 1995). The last occurrence (LO) of *Cyclicargolithus floridanus* is noticed somewhat earlier in the Mediterranean than in the Paratethys (Mărunţeanu, 1999; Hilgen *et al*., 2003). Its LO also differs between the Central and Eastern Paratethys. The first occurrence (FO) of *Calcidiscus pataecus*, which is significant for the Lower Sarmatian of the Croatian Basin, differs within the Paratethys as well. Its FO in the Transylvanian Basin is characteristic for the end of the Badenian NN6d zone (Chira & Mărunţeanu, 2000), the same as in the investigated area (Slavonian Mts). In the Vienna Basin, the FO of *C. pataecus* is noticed at the beginning of the Sarmatian (S. Ćorić, pers. comm., 2008).

A first, rare appearance of *Discoaster* cf. *D. kugleri* in Mediterranean sapropel sediments (8.05 m in thickness) is detected at 11.88-11.91 Ma (Ancona, Italy). Its LO is at 11.6 Ma, (Hilgen *et al*., 2003). Based on astronomical data, the Serravalian/Tortonian boundary has been calibrated at 11.6 Ma. Nevertheless, the last appearance/disappearance of *Discoaster aulakos*, *D. deflandrei* and *H. walbersdorfensis* in the Mediterranean region is within the NN7 zone (Iaccarino *et al*., 2001). However, later investigations locate the LO of *H. walbersdorfensis* species at 10.74-10.76 Ma (Hilgen *et al*., 2003), which is in contradiction with earlier mentioned duration of NN7 zone for the Mediterranean region. Radiometric analyses of the Central and Eastern Paratethys are given by Vass (1999), who made numerical calibration with Berggren's records (Berggren *et al*., 1995). Considering the rare occurrence of *Discoaster kugleri* in sediments they placed the NN 7 zone between 11.85 – 11.3 (10.9) Ma. In the North Croatia Basin, the LO of *H. walbersdorfensis* species is detected at the end of the Lower Sarmatian; this record supports a different distribution of the species in the Paratethys.

Catinaster coalitus, whose FO defines the base of the NN8 zone, is rare or absent in many Mediterranean sections. The last occurrence of *Coccolithus miopelagicus* has been detected a little earlier than this event (NN7/NN8 zone), before the first occurrence of *Discoaster hamatus* in the Mediterranean. Thus the LO of *Coccolithus miopelagicus* could be considered as an alternative marker for the NN7/NN8 boundary (Marino & Flores, 2002). This event belongs to 'Chron C5r' (Hilgen *et al*., 2000) that happened at 11.2 Ma based on astronomical data for the Mediterranean region (Aguilar *et al*., 2004). In the North Croatian Basin, the LO of *Coccolithus miopelagicus* is also observed at the NN7/NN8 boundary.

The FO of *Catinaster coalitus* in the Mediterranean is observed at 10.73-10.74 Ma (Hilgen *et al*., 2003). Radiometric analyses from the Paratethys (Poland and Eastern Slovakian Basin) placed the period between 11.3-10.9 Ma (Vass, 1999; Kováč *et al*., 2001).

The first appearance of *D. hamatus* in the Romanian part of the Paratethys is found in the NN9 zone, which corresponds to the Mediterranean Serravalian/Tortonian boundary (Mărunţeanu, 1999). This bioevent is recorded at 10.15 Ma in the Mediterranean. The Serravalian/Tortonian boundary is put at 11.6 Ma for the Mediterranean and low-latitude ocean (Hilgen *et al*., 2003). Lack of reliable magnetostratigraphy data for the boundary interval in other regions may cause misfits in correlations. The reason for the different FO might also be the reduction of connection between the Mediterranean and Paratethys at the end of the Sarmatian, and the re-opening of connections during the Pannonian. Further studies on magnetostratigraphy and astronomical cycles should give us a better understanding of correlations.

The paleomagnetic measurements in the Našice section (Slavonian Mts.) put the Sarmatian/Pannonian boundary at Chron C5r.1r, which corresponds to 11.1 Ma (Agusti *et al*., 2001; Vasilev, 2006). It is obvious that the Sarmatian/Pannonian boundary, previously placed at 11.6 Ma in the Paratethys, needs to be revised.

References

Aguilar, J.-P., Berggren, W.A., Aubry, M.-P:, Kent, D.V., Clauzon, G., Benammi, M. & Michaux J. 2004. Mid-Neogene Mediterranean marine - continental correlations: an alternative interpretation. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **204**: 165-186.

Agustí, J., Cabrera, L., Garcés, M., Krijgsman, W., Oms, O. & Parés, J.M.A. 2001. Calibrated mammal scale for the Neogene of Western Europe, State of the art. *Earth-Science Reviews*, **52**: 247–260.

Berggren, W.A., Kent, D.V., Swisher, C.C. & Aubry, M.-P. 1995. A revised Cenozoic geochronology and chronostratigraphy, *In*: W.A. Berggren *et al*. (Eds). *Geochronology, Time Scales and Global Stratigraphic correlations: A Unified Temporal Framework for an Historical Geology. Soc. Econ. Paleont.*

Miner., Spec. Pub., **54**: 126pp.

Chira, C.M. & Mărunţeanu, M. 2000. Calcareous nannofossils and dinoflagellates from the Middle Miocene of the Transylvanian Basin, Romania. *Journal of Nannoplankton Research*, **22**(2): 89-90.

Hilgen, F.J., Aziz, H.A., Krijgsman, W., Raffi, I. & Turco E. 2003. Integrated stratigraphy and astronomical tuning of the Serravalian and lower Tortonian at Monte dei Corvi (Middle – Upper Miocene, northern Italy). *Palaeogeography, Palaeoclimatology, Palaeoecology*, **199**: 229-264.

Hilgen, F.J., Krijgsman, W., Raffi, I., Turco, E. & Zachariasse, W.J. 2000. Integrated stratigraphy and astronomical calibration of the Serravallian/Tortonian boundary section at Monte Gibliscemi, Sicily. *Marine Micropalaeontology*, **38**: 181-211.

Iaccarino, S.M., Foresi, L.M., Mazzei, R. & Salvatorini, G. 2001. Calcareous plankton biostratigraphy of the Miocene sediments of the Tremiti Islands (S Italy). Revista Española de Micropaleontologia, **33**(2:) 237-248.

Kováč, M., Nagymarosy, A., Holcova, K., Hudáčková, N., Zlinska, A. 2001. Paleogeography, paleoecology and eustacy: Miocene 3rd order cycles of relative sea-level changes in the Western Carpathian - North Pannonian basins. *Acta Geol. Hungarica*, **44**(1): 1-45.

Marino, M. & Flores, J.-A. 2002. Miocene to Pliocene calcareous nannofossil biostratigraphy at ODP Leg 177 Sites 1088 and 1090. *Marine Micropaleontology*, **45**: 291-307.

Mărunţeanu, M. 1999. Litho- and Biostratigraphy (calcareous nannoplankton) of the Miocene deposits from the outher Moldavides. *Geol. Carpathica*, **50**(4): 313-324.

Perch-Nielsen, K. 1985. Cenozoic calcareous nannofossils. *In*: H.M. Bolli, K. Perch-Nielsen & J.B. Saunders (Eds). *Plankton stratigraphy*. Cambridge University Press, Cambridge: 811-846.

Raffi, I., Rio, D., D'atri, A., Fornaciari, E. & Rocchetti, S. 1995. Quantitative distribution patterns and biomagnetostratigraphy and astrobiochronology of Middle to Late Miocene calcareous nannofossils from equatorial Indian and Pacific Oceans (Legs 115, 130 and 138). *Proceedings ODP, Scientific Results*, **138**: 479-502.

Vasiliev, I. 2006. A new chronology for the Dacian Basin (Romania). Consequences for the kinematic and paleoenvironmental evolution of the Paratethys region. *Geologica Ultraiectina*, **267**: 193pp.

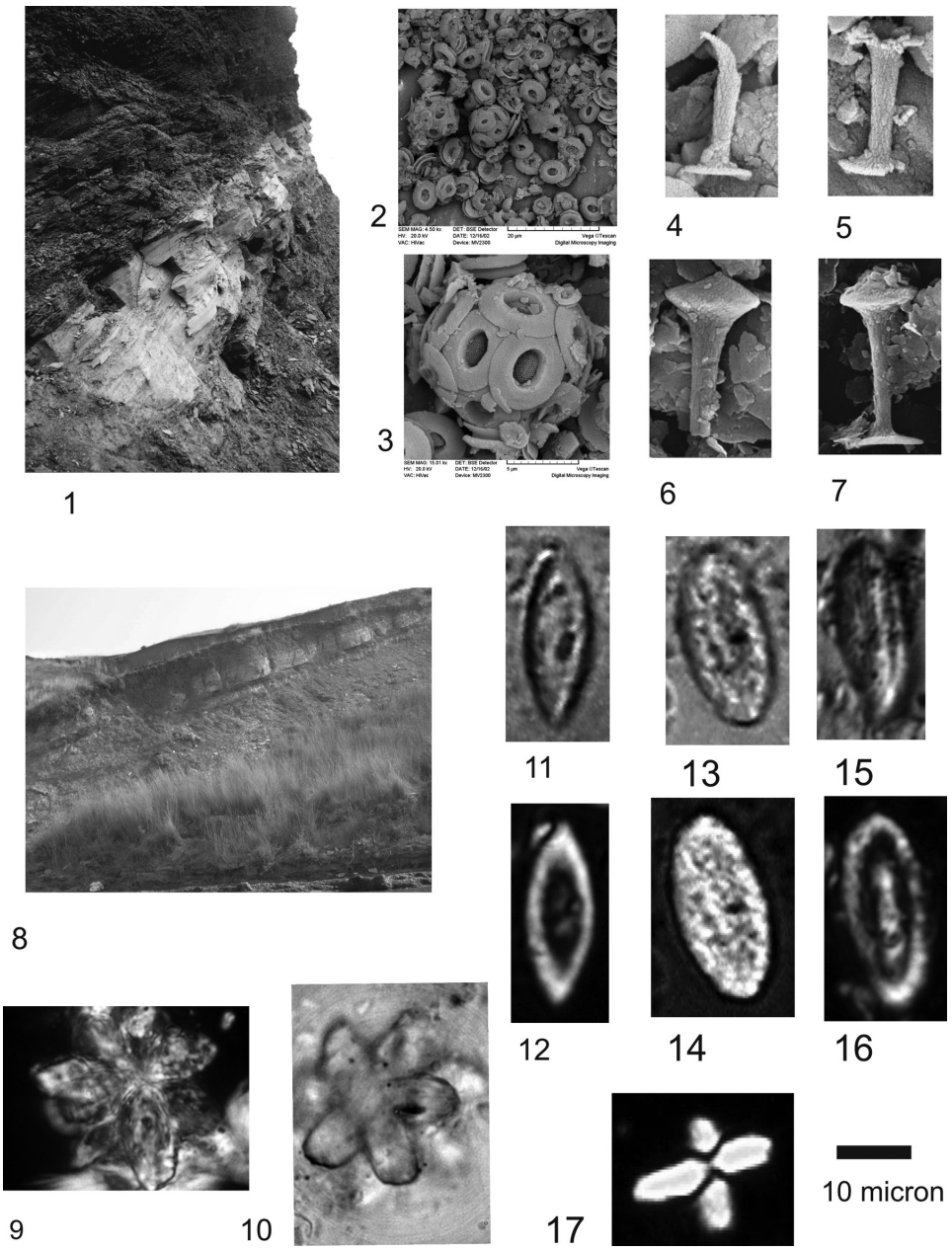
Vass, D. 1999. Numeric age of the Sarmatian boundaries (Suess 1866). *Slovak Geol. Mag.*, **5**(3): 227-232.

Biostratigraphic study of Middle and Upper Miocene nannofossils from the eastern Paratethys (Tamanskii Peninsula and northern Ciscaucasia)

Larisa Golovina

The main problem with stratigraphy of the Neogene eastern Paratethyan sediments is the correlation of its regional stages with the central Paratethys and Mediterranean units, as well as with standard nannoplankton NN zones. Problems in correlation of calcareous nannofossils in the Konkian, Maeotian and Pontian regional stages have not yet been successfully resolved (Krasheninnikov *et al*., 2003).

Calcareous nannofossils were investigated in the deep-sea sections of the Middle and Upper Miocene sediments. The sections of the Zelenskii Mountain anticline in the Tamanskii Peninsula and on the Pshekha River are among the most complete Miocene sections of the eastern Paratethys in Russia. The section on the Pshekha River belongs to the Afips-Pshekha structural facies subzone of the West Caucasian zone, which occurs in the Psekups–Pshekha–Kurdzhips interfluve. The high-resolution, bed-by-bed studies of the Konkian have established the presence of *Braarudosphaera bigelowii*, *Calcidiscus macintyrei*, *Coccolithus pelagicus*, *Cyclicargolithus floridanus*, *Cricolithus jonesii*, *Helicosphaera carteri*, *Helicosphaera* sp., *Reticulofenestra pseudoumbilica*, *Rhabdosphaera pannonica*, *Rhabdosphaera sicca*, *Rhabdosphaera* sp. and *Sphenolithus moriformis*. The impoverished, compared to the oceanic assemblages, nannoplankton complex lacks zonal species. The most diverse assemblage occurs in a thin interval and is correlated with the Sartagan Beds; subsequently it became rapidly impoverished and was replaced by the monospecific *Reticulofenestra pseudoumbilica* assemblage. The abundance of *Reticulofenestra* coccoliths is so great that they became rock-forming and make up a 1-m-thick marker marl bed traceable from the Tamanskii Peninsula in the west to the Pshekha River (Northern Ciscaucasia) in the east (Golovina *et al*., 2004). This interval is correlated with the Veselyanka Beds. The



flourishing of *Reticulofenestra pseudoumbilica* was most likely associated with a frontal contact zone of fluvial and marine waters or with the upwelling zone. Therefore, in the studied region, the Konkian stage terminated with peculiar bionomic conditions.

Calcareous nannofossils from the Maeotian and Pontian deposits in the Tamanskii Peninsula (Taman' and Iron Horn sections) are represented by poor assemblages bearing only one or two genera and likely indicating shallow-water and/or nearshore conditions; they are mostly of no biostratigraphic value. The Upper Maeotian deposits contain a great number of specific calcareous elements that in our opinion belong to the ascidian spicules. The abundant ascidian spicules are an excellent indicator of sublittoral and littoral conditions of sedimentation. Transition from the Maeotian to Pontian is characterized by a powerful development of monospecific *Braarudosphaera bigelowii* assemblages along with the diatom monospecific *Actinocyclus ehrenbergii* assemblages. These deposits mark a zone of the ancient hydrological front. Cyclicity of hydrological conditions is excellently illustrated by alternation of nannoplankton and diatom monospecific assemblages.

This work was supported by the Russian Foundation for Basic Research, project nos 06-05-64049-a and 07-05-00795-a.

References

Golovina, L.A., Goncharova, I.A. & Rostovtseva, Y.V. 2004. New Data on the Middle Miocene Biostratigraphy (Nannofossils, Mollusks) and Lithology of the Tamanskii Peninsula and Western Ciscaucasia. *Stratigraphy and Geological Correlation*, **12**(6). MAIK "Nauka/Interperiodica" Publishing: 637-646.

Krasheninnikov, V.A., Basov, I.A. & Golovina, L.A. 2003. *Tarkhanian and Konkian Regional Stages of the Eastern Paratethys (Stratigraphy, Micropaleontology, Bionomy, Paleogeographic Connections)*. Nauchnyi Mir, Moscow.

Calcareous nannofossil biostratigraphy of the Gurpi Formation in the Kangan Anticline

Fatemeh Hadavi

The Zagros bBasin is situated in southwestern Iran, the region known as the 1954 Agreement Area. The northwestern limit of this region coincides with the well-known tectonic zone called the 'Main Zagros Thrust'. The southwestern limit coincides with the southwestern boundary of Iran. Several thousand meters of carbonate, siliciclastics and evaporites were deposited in the Zagros Basin. These sediments are folded into simple anticlines and synclines. The basin is one of the biggest oilfields in the world.

The Gurpi Formation is one of the most complete Early Santonian – Early Danian sequences, and it is widespread over most of the Agreement Area, although it displays lateral changes in lithology. This study focuses on the Gurpi Formation in Kangan Anticline. In this area, the Gurpi Formation consists of 100 m of bluish-gray marls with intercalation of marly limestone. The Gurpi Formation is in contact (disconformity) on the Ilam Formation that is represented by thin-bedded limestone with intercalation of nodular shale, and it is overlain in disconformity by the Pabdeh Formation. Between the Gurpi and Pabdeh Formations, 30 cm of glauconite-rich sediments area present.

Calcareous nannofossils of this formation were studied in different localities by Hadavi *et al*. (2007). This study focuses on the boundary between the Gurpi and Pabdeh Formation. According to the presence of *Micula murus* and *Biantholithus sparsus* in the glauconites, the boundary is placed in the uppermost part of the Gurpi Formation. On the other hand the presence of *Discoaster multiradiatus*, *Discoaster bramlettei* in the lower Pabdeh Formation is discontinuous in this area.

References

Hadavi, F., Khosrowtehrani, K. & Senmari, S. 2007. Biostratigraphy of calcareous nannofossil biostratigraphy of the Gurpi Formation in north Gachsaran. *Scientific Quarterly Journal*. Geo. Surv., Iran.

Pseudocryptic speciation of living *Braarudosphaera bigelowii*

Kyoko Hagino, Yoshihito Takano, Takeo Horiguchi

Notable size variations have been reported from living and fossil populations of *Braarudosphaera bigelowii* (Gran & Braarud, 1935) Deflandre (1947), however, size factor has not been integrated in the taxonomy of *B. bigelowii* due to lack of genetic evidence (Hagino, 1997; Svábenická, 1999; Konno *et al*., 2007). Takano *et al*. (2006) subdivided the living *B. bigelowii* population into three morphotypes; Small forms, Intermediate forms –A and –B, based on size of the pentaliths. They obtained SSU rDNA sequences of two natural cells of *B. bigelowii* based on the single-cell PCR technique, and found 16-bp differences, including indels between the cells belonging to Intermediate form-A and Intermediate form-B. However, they did not emend their taxonomic position, since the size range of these two forms overlapped.

To examine the taxonomic position of morphotypes of living *B. bigelowii*, we studied sufficient number of living cells of *B. bigelowii* from various parts of Japan, genetically. In this study, partial SSU rDNA sequences (>1600-bp) of 14 cells of *B. bigelowii*, which were different in size, were obtained using the single-cell PCR technique. In addition to the previously reported three morphotypes by Takano *et al*. (2006), a new morphotype, Intermediate form –C (>7.0μm in side length of pentalith), was recognized. Together with the sequences reported by Takano *et al*. (2006), the number of specimens of Intermediate forms -A, -B and -C sequenced increased to six, seven and three, respectively. Signature sequences that represent Intermediate forms –A, –B and –C were found; ten substitutions separate Intermediate forms –A and –B from each other, and an additional one substitution separates Intermediate form–C from Intermediate form–B. SSU rDNA sequences of seven specimens belonging to the Intermediate form-B were consistent. However, one additional substitution was found from one of the Intermediate form–A cells and also from one of the Intermediate form–C cells, regardless of sampling area.

SSU rDNA sequence types were correlated with morphotypes classified based on size, not on sampling area. Therefore, it is evident that the Intermediate forms A-C are genetically distinct species. Since the Intermediate form-B corresponds in size to the original description by Gran & Braarud (1935), Intermediate forms –A and –C should be raised to species rank.

References

Deflandre, G. 1947. *Braarudosphaera* nov. gen., type d'une famille nouvelle de Coccolithophoridés actuels à elements composites. *C. R. Hébd. Séances Acad. Sci., Paris*, **225**: 439–441.

Gran, H.H. & Braarud, T. 1935. A quantitative study of the phytoplankton in the Bay of Fundy and the Gulf of Maine (including observations on hydrography, chemistry and turbidity). *J. Biol. Board Can*., **1**(5): 279–467.

Hagino, K. 1997. Distribution of living coccolithophores in the western Pacific Ocean off the coast of Northeast Japan. *Fossils*, **63**: 1-19.

Konno, S., Harada, N., Narita, H. & Jordan, R.W. 2007. Living *Braarudosphaera bigelowii* (Gran & Braarud) Deflandre in the Bering Sea. *J. Nannoplankton Res*., **29**(2): 78-87.

Svábenická, L. 1999. *Braarudosphaera*-rich sediments in the Turonian of the Bohemian Cretaceous Basin, Czech Republic. *Cretaceous Res*., **20**: 773-782.

Takano, Y., Hagino, K., Tanaka, Y., Horiguchi, T. & Okada, H. 2006. Phylogenetic affinities of an enigmatic nannoplankton, *Braarudosphaera bigelowii* based on the SSU rDNA sequences. *Mar. Micropaleontol*., **60**: 145-156.

Calcareous nannofossil study of a possible West Carpathian regional stratotype profile of the Jurassic/Cretaceous boundary (the Brodno section, near Zilina)

Eva Halásová

This contribution presents some results on calcareous nannofossils in the Brodno section, a possible candidate for a Western Carpathian regional J/K boundary stratotype. The continuous Jurassic-Cretaceous pelagic limestone sequence of the Brodno section offers the possibility to document the J/K passage in a wide area of the Western Carpathians. The Brodno section is situated in an ancient quarry on the eastern side of the narrow straits of the Kysuca River Valley, north of the town of Zilina (NW Slovakia). It yields a record of hemipelagic marine sedimentation in a marginal zone (the Pieniny Klippen Belt) of the Outer Western Carpathians. The Late Jurassic sedimentation rate in the Pieniny Klippen Belt was low. The condensed red nodular limestones of the 'Ammonitico Rosso Facies' (the Czorsztyn Formation), which represent the Kimmeridgian and Tithonian part of the Kysuca Succession, received only a limited terrigenous clastic input. During the Berriasian, subsiding West Carpathian basins were affected by a great acceleration in the 'planktic rain' of organic matter and calcareous microskeletons. This change produced pelagic sediments of the 'maiolica' type (the Pieniny Limestone Formation). This sedimentary pattern persisted until the Early Aptian in the Pieniny Klippen Belt.

Calcareous nannofossils were analyzed in 40 smear slides prepared from all the lithologies under a light microscope at 1250x magnification. The abundance was determined by counting all specimens in at least 200 fields of view in each sample. The preservation of the fossil material has been characterized as moderately to heavily etched by dissolution.

Calcareous nannofossils form relatively low-diversity associations. Eighteen nannofossil species were recognised. The coccolithophorids are represented by Watznaueriaceae: *Watznaueria barnesiae*, *W. britannica*, *W. manivitiae*, *W. ovata*, *Cyclagelosphaera margerelii* and *C. deflandrei*. *Zeugrhabdotus embergeri* is also frequently recorded. Dissolution-resistant coccolith taxa, such as *Helenea chiastia*, *Cruciellipsis cuvillieri*, and other more delicate taxa, such as *Z. erectus*, *Diazomatolithus lehmanii* and *Discorhabdus ignotus* occur more sporadically. Nannoliths *Conusphaera mexicana mexicana*, *C. mexicana minor*, *Polycostella beckmannii*, *Assipetra* spp., *Hexalithus noeliae*, *Lithraphidites carniolensis*, *Nannoconus infans*, *N. wintereri*, *N. steinmanni minor*, *N. globulus minor* and *N. kamptneri minor* are also present. Abundance fluctuations of dissolution-resistant nannoliths (*Conusphaera*, *Polycostella*, *Nannoconus*) and coccoliths (*C. margerelii*, *W. barnesiae*, *W. manivitiae*) have been detected by quantitative study. The nannofossil zonation of Bralower *et al.* (1989), as modified by Tavera *et al.* (1994), was used. Two nannozones, the *C. mexicana mexicana* and *H. chiastia* zones, were distinguished in the Western Carpathians. Calcareous nannofossils from the lower half of the studied sequence (L52 to L96) are correlated with the Early to middle Tithonian *C. mexicana mexicana* Zone (NJ20). This zone comprises the *P. beckmanii* Subzone; the latter one consists of the *H. noeliae,* or NJKA, NJKB and NJKC subzones.

For this section, calpionellid stratigraphy is also available, along with older paleomagnetic data. Calcareous nannofossils formed poorly diversified associations at the J/K boundary. The abundance of *Watznaueria*, *Cyclagelosphaera*, *Conusphaera* and *Polycostella* species in the section studied is relatively high. Other nannofossils are rather rare. *Conusphaera* predominates in the Tithonian (showing a Middle Tithonian peak). *Polycostella* increased in abundance during the *Boneti* Subzone of the *Chitinoidella* Zone. The Middle/Late Tithonian boundary was detected by means of the FO of *H. chiastia* accompanied by the first small nannoconids. Small nannoconids appeared in the Late Tithonian and increased in size and abundance during the Berriasian. *Polycostella* diminished in abundance towards the onset of the *Crassicollaria* Zone. The Late Tithonian interval was delimited by the FOs of *L. carniolensis*, *N. infans*, *N. wintereri* and *C. cuvillieri* within the *H. chiastia* Zone, which is correlated with the standard *Crassicollaria* Zone. From the point of view of nannofossil stratigraphy, the Tithonian/Berriasian boundary interval should be placed between the FO of *N. wintereri* (Sample C17, Upper Tithonian) and the FO of *N. steinmanni minor* (Sample C28, lowermost Berriasian). In this interval, the onset of the *Alpina* Subzone of the standard calpionellid zonation is also recorded (the C23A-C25A beds), which corresponds to the calpionellid J/K boundary zone.

Sequence stratigraphy and stable isotope ($\delta^{18}O$, $\delta^{13}C$) data also provided good results, enabling the studied section to be compared to important key sections in the Mediterranean Tethys area.

This is a contribution to the 506 IGCP UNESCO Project, supported by VEGA grant projects 6026, 2035 and 3178, APVV-0465-06, APVT 51-011305 and Project APVV - 0280-07.

References

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.

Tavera, J.M., Aguado, R., Company, M. & Olóriz, F. 1994. Integrated biostratigraphy of the Durangites and Jacobi Zones (J/K boundary) at the Puerto Escaño section in southern Spain (Province of Cordoba). *Geobios*, **17**: 469-476.

Environmental control on size and genotype of *Emiliania huxleyi*

Jorijntje Henderiks, Amos Winter, Malte Elbrächter, Anja van der Plas, Rainer Feistel

Coccolithophores play an important role in the global carbon cycle as primary producers and marine calcifiers. Because of ocean acidification due to increased atmospheric CO_2 we need to constrain how natural coccolithophore populations can acclimatize or adapt to projected changes, and how their natural feedback mechanisms may operate in future. In recent years, numerous experimental studies have highlighted environmental controls on coccolith calcification and malformation, mostly using monoclonal cultures of *Emiliania huxleyi* (*e.g*. Paasche *et al*., 1996; Paasche, 1998; Riebesell *et al*., 2000; Sorrosa *et al*., 2005; Iglesias-Rodriguez *et al*., 2008). However, extrapolating laboratory-based results to the scales and dynamics of the 'real' ocean remains speculative. The upwelling region offshore Namibia, characterized by small-scale but large gradients in temperature, nutrient availability and CO_2 concentrations, serves as a natural laboratory where we can test hypotheses concerning the environmental controls on coccolith calcification/malformation and ecological responses in natural populations.

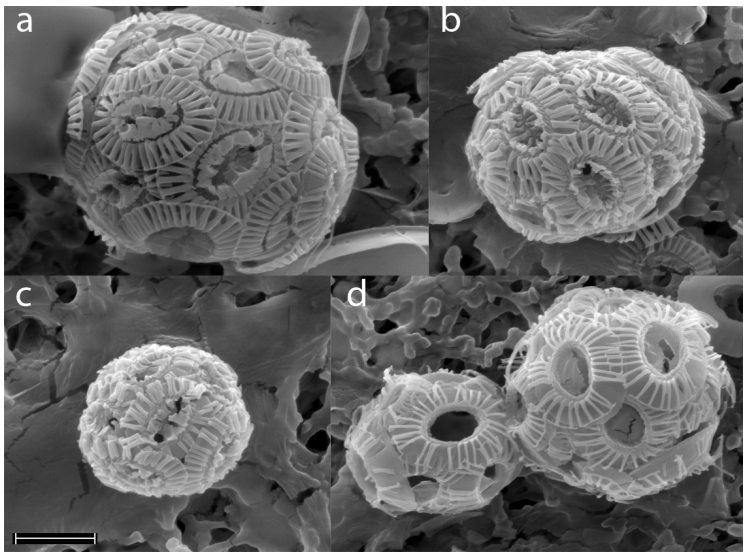


Figure 1: Examples of living *E. huxleyi* sampled offshore Namibia. **a**) Type A heavily calcified, large coccosphere; **b, c**) Type A coccospheres with malformed coccoliths; **d**) Type B/C with delicate distal shield elements and open central areas. Scale-bar = 2μm

Here we present coccolithophore and *in situ* environmental data from water-column samples collected during cruise 48/5 of the RV *Meteor* (October 2000) from transect lines perpendicular to the Namibian coast. Samples cover a wide spectrum, from recently upwelled waters to oceanic surface waters. Closest to shore in recently upwelled waters, large blooms of diatoms dominate the phytoplankton biomass. *E. huxleyi* is the most dominant species in older upwelling waters above the shelf edge and slope. Coccoliths in these waters were often malformed. Two different morphotypes (likely genotypes) of *E. huxleyi* occurred in environmentally distinct zones (Fig. 1). *E. huxleyi* with delicate distal shield elements and open central areas (Type B/C cf. Young *et al*., 2003) dominated in highly nitrogen-depleted surface waters above the continental slope. At these stations, cell abundances reached 300×10^3 cells/liter. More heavily calcified *E. huxleyi* (Type A cf. Young & Westbroek, 1991) were dominant at stations above the shelf edge and slope, with cell abundances ranging from 2000 to $>10^6$ cells/liter. Most populations of *E. huxleyi* Type A were malformed, with irregularly arranged distal shield elements that appear detached from a central coccolith rim. A bloom of anomalously large Type A coccospheres with well-developed and heavily calcified coccoliths was observed in relatively cool water where nutrient concentrations were closer to the Redfield N:P ratio. Our observations suggest a scenario where *E. huxleyi* populations thrive under elevated levels of dissolved inorganic carbon (DIC), although nitrate deficiency and/or lower calcite saturation/ocean pH may contribute to extensive coccolith malformation in this upwelling region.

References

Iglesias-Rodriguez, D., Halloran, P.R., Rickaby, R.E.M., Hall, I., Colmenero-Hidalgo, E. & others 2008. Phytoplankton calcification in a high-CO_2 world. *Science*, **320**: 336-340.

Paasche, E. 1998. Roles of nitrogen and phosphorus in coccolith formation in *Emiliania huxleyi* (Prymnesiophyceae). *Eur. J. Phycol*., **33**: 33-42.

Paasche, E., Brubak, S., Skattebøl, S., Young, J.R. & Green, J.C. 1996. Growth and calcification in the coccolithophorid *Emiliania huxleyi* (Haptophyceae) at low salinities. *Phycologia*, **35**(5): 394-403.

Riebesell, U., Zondervan, I., Rost, B., Tortell, P.D., Zeebe, R.E. & Morel, F.M.M. 2000. Reduced calcification of marine plankton in response to increased atmospheric CO_2. *Nature*, **407**: 364-367.

Sorrosa, J.M., Satoh, M., Shiraiwa, Y. 2005. Low temperature stimulates cell enlargement and intracellular calcification of coccolithophorids. *Marine Biotechnology*, **7**(2): 128-133.

Young, J.R., Geisen, M., Cros, L., Kleijne, A., Sprengel, C., Probert, I. & Østergaard, J. 2003. A guide to extant coccolithophore taxonomy. *J. Nannoplankton Res., Special Issue*, **1**: 8.

Young, J.R. & Westbroek, P. 1991. Genotypic variation in the coccolithophorid species *Emiliania huxleyi*. *Marine Micropaleontology*, **18**: 5-23.

Response of coccolith size to paleoceanographic changes during the Pliocene at Site 999A, Southern Caribbean Sea

Sandra Herrmann, Gretta Bartoli, Andrew F. Weller, Hans R. Thierstein

Our studies of global Holocene surface sediments have demonstrated that temperature is the dominant factor controlling coccolith size variability in Recent assemblages. However, the role of other parameters, such as salinity, pH and pCO_2 has not been completely decoded. We have now compared the coccolith size variability with environmental parameters in the Holocene to the response to paleoceanographic changes during the Pliocene Epoch in order to disentangle the multiple environmental dependencies and to possibly identify evolutionary adaptations.

Site 999A in the Caribbean Basin was chosen because of its excellent carbonate preservation and the broad variety of data available on ocean circulation patterns, environmental parameters and nannofossil assemblages. We investigated a period from 5 to 2 Ma with a ~30 kyr resolution. The age model used was taken from Steph *et al*. (2006) and re-tuned to the benthic $\delta^{18}O$ stack LR04 from Lisiecki & Raymo (2005). Samples were prepared on SEM stubs according to a specific spraying method (Henderiks & Törner, 2006), image frames of coccoliths were captured in a Philips XL30 SEM with an automated scanning module. The frame series were then automatically segmented and the maximum sizes of coccoliths measured.

Our Pliocene study indicates a general decrease of coccolith size between 5 and 2 Ma. Additionally, strong variations in coccolith sizes are recorded during 4.3-3.8 Ma and 2.9-2.5 Ma. The older of these intervals of coccolith size change might be related to the temperature change recorded in benthic $\delta^{18}O$ records (Lisiecki & Raymo, 2005). The interval 2.9 to 2.5 Ma equals the period of the closure of the Panamanian Seaway, which was causing a reorganization of paleoceanographical settings in the Caribbean Sea and thus might be reflected in size changes in the plankton assemblage.

References

Henderiks, J. & Törner, A. 2006. Reproducibility of coccolith morphometry: Evaluation of spraying and smear slide preparation techniques. *Marine Micropaleontology*, **58**: 207-218.

Lisiecki, L.E. & Raymo, M.E. 2005. A Pliocene-Pleistocene stack of 57 globally distributed benthic $\delta^{18}O$ records. *Paleoceanography*, **20**: PA1003, doi:10.1029/2004PA001071.

Steph, S., Tiedemann, R., Prange, M., Groeneveld, J., Nürnberg, D., Reuning, L., Schulz, M. & Haug, G.H. 2006. Changes in Caribbean surface hydrography during the Pliocene shoaling of the Central American Seaway. *Paleoceanography*, **21**: PA4221, doi:10.1029/2004PA001092.

Millennial-scale paleoenvironmental changes in the central Mediterranean during the Last Interglacial: comparison with European and North Atlantic records

Alessandro Incarbona, Sergio Bonomo, Enrico Di Stefano, Rodolfo Sprovieri, Nicola Pelosi, Mario Sprovieri

The occurrence and the meaning of high-frequency climatic fluctuations from the upper part of MIS 6 to the lower part of MIS 4 in Hole 963A (37˚01.938'N, 13˚10.896'E, central Mediterranean Sea) have already been discussed, on the basis of high-resolution planktonic foraminifera and calcareous nannofossil data (mean sampling resolutions, respectively, of about 80 and 160 yr), and of benthic and planktonic oxygen isotope records (Sprovieri *et al*., 2006). Here we show the distribution patterns of other 8 planktonic foraminifera and 6 calcareous nannofossils with the aim to investigate the marine environment of the Sicily Channel during MIS 5, mainly in terms of temperature and stability of the water column.

Both calcareous plankton groups show a co-ordinated response to environmental changes, as demonstrated by significant correlation indexes among the main taxa. For instance, *Gephyrocapsa muellerae* is anti-correlated to *Globigerinoides ruber* (-0.77, n = 401) and to *Florisphaera profunda* (-0.7, n = 401). MIS 5 is generally characterized by warm, oligotrophic and stratified waters, where coccolithophore communities developed a vertical zonation. In today's oceans, a similar vertical zonation is typical of the low-latitude gyres (Winter *et al*., 1994). The temperate-subtropical assemblages of planktonic foraminifera and calcareous nannofossils repeatedly changed into temperate-subpolar assemblages during the suborbital cooling episodes C25-C18.

A comparison with European pollen sequences and North Atlantic cores over the interval between ~128 and 110 kyr BP has been performed. Records from this broad geographical area show a series of environmental changes that occurred at comparable times. However, the first cooling episodes were more severe at high-latitude (approximately north of 50˚N), where an earlier end of interglacial conditions can be inferred (Sánchez-Goñi *et al*., 2005). An objective definition of interglacial conditions at Site 963 appears difficult, given that planktonic organisms respond not only to water mass temperature, but to a wide range of physical-chemical conditions. Nevertheless, the slight increase of *G. ruber* and the new development of a vertical zonation in the coccolithophore community after the C25 episode, suggest the re-establishment of weaker interglacial-like conditions, which gradually degraded until the severe C24 event. Therefore, interglacial-like conditions were probably maintained for 16-18 kyr. A similar duration can be also deduced for the Alboran Sea. Such a long duration is similar to that reported from southern European continental records, but it is in contrast with the shorter duration of the Eemian, north of the Alps.

The similarity of European/Mediterranean and North Atlantic environmental changes during the last interglacial at about 122, 118 and 110 kyr BP, and an earlier end of interglacial conditions at higher latitudes, need to be interpreted in terms of an adequate climate-forcing model, able to affect such a broad region as well as to generate such a latitudinal pattern. Both the southward expansion of the Polar Vortex and disturbances in the meridional overturning circulation can explain the contemporary environmental changes across this area and the progressive involvement of lower-latitude sites in the glaciation process.

References

Sanchez Goñi, M.F., Loutre, M.F., Crucifix, M., Peyron, O., Santos, L., Duprat, J., Malaizé, B., Turon, J.-L. & Peypouquet, J.-P. 2005. Increasing vegetation and climate gradient in western Europe over the Last Glacial Inception (122-110 ka): data model comparison. *Earth and Planetary Science Letters*, **231**: 111-130.

Sprovieri, R., Di Stefano, E., Incarbona, A. & Oppo, D.W. 2006. Suborbital climate variability during Marine Isotopic Stage 5 in the central Mediterranean Basin: evidence from calcareous plankton. *Quaternary Science Reviews*, **25**: 2332-2342.

Winter, A., Jordan, R.W. & Roth, P.H. 1994. Biogeography of living coccolithophores in ocean waters. *In*: A. Winter & W.G. Siesser (Eds). *Coccolithophores*. Cambridge University Press, Cambridge: 199-218.

Coccolithophorid distribution in Palauan lagoons

Atsuko Kijima, Richard W. Jordan

The Republic of Palau consists of a group of islands in the NW equatorial Pacific characterized by reefal lagoons and marine lakes. The environmental conditions are relatively stable throughout the year, but with a rainy (June-October) and dry (November-May) season associated with the Asian monsoon. Since 2001, we have conducted expeditions to Palau at least once a year, although the sampling season has varied. Using May-July samples from three different years, Konno & Jordan (2006) provided the first account of a coccolithophorid community from Palau, with a low species diversity in the lagoons, but a higher diversity in the open sea. Abundance was also low, reaching up to 1 x 10^4 cells/litre, and they were always outnumbered by the diatoms. *Gephyrocapsa oceanica* dominated all of their 21 samples, which were collected from two marine lakes as well as very shallow (<1 m), shallow (<5 m) and deep (up to 40 m) lagoon sites. Of the 23 spp. recorded by them, surprisingly none were holococcolithophorids. However, they did find some rarely reported species such as *Cruciplacolithus neohelis* and *Anacanthoica cidaris*.

New observations on 65 samples collected during the dry season (November 2006 and late October 2007) were compared with those of Konno & Jordan (2006). *Gephyrocapsa oceanica* dominated almost all of the samples, with its highest absolute abundances closely correlated to low Simpson's Index of Diversity scores, whereas species diversity was generally highest in the more offshore waters. However, abundances (up to 5 x 10^3 cells/litre) in 2006 were somewhat lower than those of Konno & Jordan (2006). Of the 21 species observed in the 2006 samples, 6 of them were recorded for the first time, including the holococcolithophorid *Calicasphaera blokii*. Of the 11 species recorded in 2007, only two were new to Palau, *Syracosphaera rotula* and the holococcolithophorid *Helladosphaera cornifera*. So in total, 31 species have been found, but clearly further work is needed to fully document the total floral composition. Expeditions to other coral reef islands within Micronesia are now being planned.

Reference

Konno, S. & Jordan, R.W. 2006. Lagoon coccolithophorids from the Republic of Palau, NW Equatorial Pacific. *Journal of Nannoplankton Research*, **28**(2): 95-110.

Effects of ocean acidification on the calcification of coccolithophores – Evidence from experimental studies

Gerald Langer, Ian Probert, Björn Rost, Patrizia Ziveri

Anthropogenic CO_2 emissions, and a concomitant decrease in seawater pH, a process termed 'ocean acidification', have attracted much attention in the last decade. Results from experimental studies on corals and foraminifera have lead to the hypothesis that calcification of coccolithophores might be hampered at elevated concentrations of CO_2 in seawater. This was indeed found to be true in an initial study using the bloom-forming species *Emiliania huxleyi* and *Gephyrocapsa oceanica*. The relationship between calcification rate and CO_2 concentration was described by linear regression. However, the question whether the observed response is typical for the group of coccolithophores, remained unanswered. Therefore, the two productive calcite producers *Calcidiscus leptoporus* and *Coccolithus pelagicus* were tested. The latter species was insensitive over the CO_2 range tested, while *C. leptoporus* showed an optimum curve with the highest calcification rate at present day CO_2 levels. This study clearly demonstrated that species-specific effects play a role in coccolithophore response to altered carbonate chemistry of seawater. More experimental studies using species of different phylogenetic origin are clearly warranted to obtain detailed information about the possible effect of ocean acidification on coccolithophores. Considering the different timescales of laboratory experiments, and change of carbonate chemistry in the oceans, it will certainly be necessary to investigate the potential of adaptation in these algae.

Changes in photic-zone habitats through the equatorial Atlantic Palaeocene/Eocene Thermal Maximum: contributions from species-specific nannofossil geochemistry

Jackie A. Lees, Paul R. Bown, Jeremy R. Young, Stuart Robinson, Ken MacLeod, Darren Gröcke, Fab Minoletti

Stable isotope patterns through the Palaeocene/Eocene Thermal Maximum (PETM) show clear distinctions between per-sample size-fractions that equate to individual species or morphotypes of calcareous nannofossil. Geochemistry of a sequence of size-fractionated samples through the pre- to post-PETM interval of Demerara Rise (equatorial Atlantic) reveals that the *Coccolithus* and *Discoaster* $\delta^{13}C$ curves mimic the positive excursion, but with the *Coccolithus* signal lagging behind that of *Discoaster*. *Toweius* shows increasing $\delta^{18}O$ prior to the PETM, whilst *Discoaster* shows a pre-PETM increase and an intra-PETM decrease. *Coccolithus* appears to split into two morphotypes through the PETM. A 'medium'-sized form is more dominant during the PETM, and shows relatively stable $\delta^{18}O$ values, whilst a 'small' form has a widely variable signal, showing first a decrease, then an increase in $\delta^{18}O$ through the PETM.

These data are complex and mediated by preservation, which in these oceanic oozes is only moderate. Furthermore, data is not available for every species in each sample, due to the limitations of the fractionation technique. Despite this, we will present our first interpretations of the palaeoecologies of these species, based on the stable isotope data, in tandem with elemental data (hopefully), from which we will hypothesise changes in the photic-zone habitats.

Evidence of increasing surface-water oligotrophy during the Campanian-Maastrichtian boundary interval: calcareous nannofossil assemblages of DSDP Hole 390A (Blake Nose)

Christian Linnert, Jörg Mutterlose

Several stable isotope studies imply a general cooling trend throughout the Campanian-Maastrichtian period (*e.g.* Huber *et al.*, 2002; Miller *et al.*, 2005). Recently, this view has been modified with two short termed cooling events of early and middle Maastrichtian age, which interrupt the progressive cooling trend (*e.g.* Barrera & Savin, 1999; Thibault & Gardin, 2006). In order to better understand this climatic evolution, material from DSDP Site 390A has been studied for calcareous nannofossils. This site contains a chalky, 13.8m-thick uppermost Campanian-lower Maastrichtian interval (Benson *et al.*, 1978). Stable isotope studies on planktic foraminifera of DSDP Site 390 indicate three minor cooling events (events A, B, C) instead of one major event (Friedrich *et al.*, 2004). Subsequent studies on benthic foraminfera suggested an increasing oligotrophy throughout this interval (Friedrich & Hemleben, 2006).

We collected 60 samples from the Campanian-Maastrichtian boundary interval. For the study of calcareous nannofossil assemblages we used the settling technique (Geisen *et al.*, 1999). Abundances were determined by counting 372 to 469 specimens in each sample. Two traverses were investigated for rare species. Finally, we obtained biometrical data (coccolith length, width and central area) of 50 specimens of *Arkhangelskiella* in each sample.

The preservation of nannofossil specimens is generally good. A total number of 118 taxa has been encountered, the mean species richness is around 80 species per sample. The absolute abundance varies between 3.74 * 10^9 and 11.52 * 10^9 (mean 6.80 * 10^9) specimens/g sediment. The assemblage is dominated by *Prediscosphaera* spp. (20.5%), *Watznaueria* spp. (20.3%), *Retecapsa* spp. (9.8%) and *Micula* spp. (5.1%). Other abundant taxa are *Cribrosphaerella ehrenbergii* (3.9%), *Ceratolithoides* spp. (3.5%) and *Discorhabdus ignotus* (3.3%). Around 133mbsf, several taxa (*D. ignotus*, *Zygodiscus exmouthiensis*, *Zeugrabdotus bicrescenticus*) decrease, while *Staurolithites flavus* increases (Fig. 1). The oligotrophic taxa *Watznaueria* spp. and *Micula* spp. increase slightly around this level (Fig. 1). On the

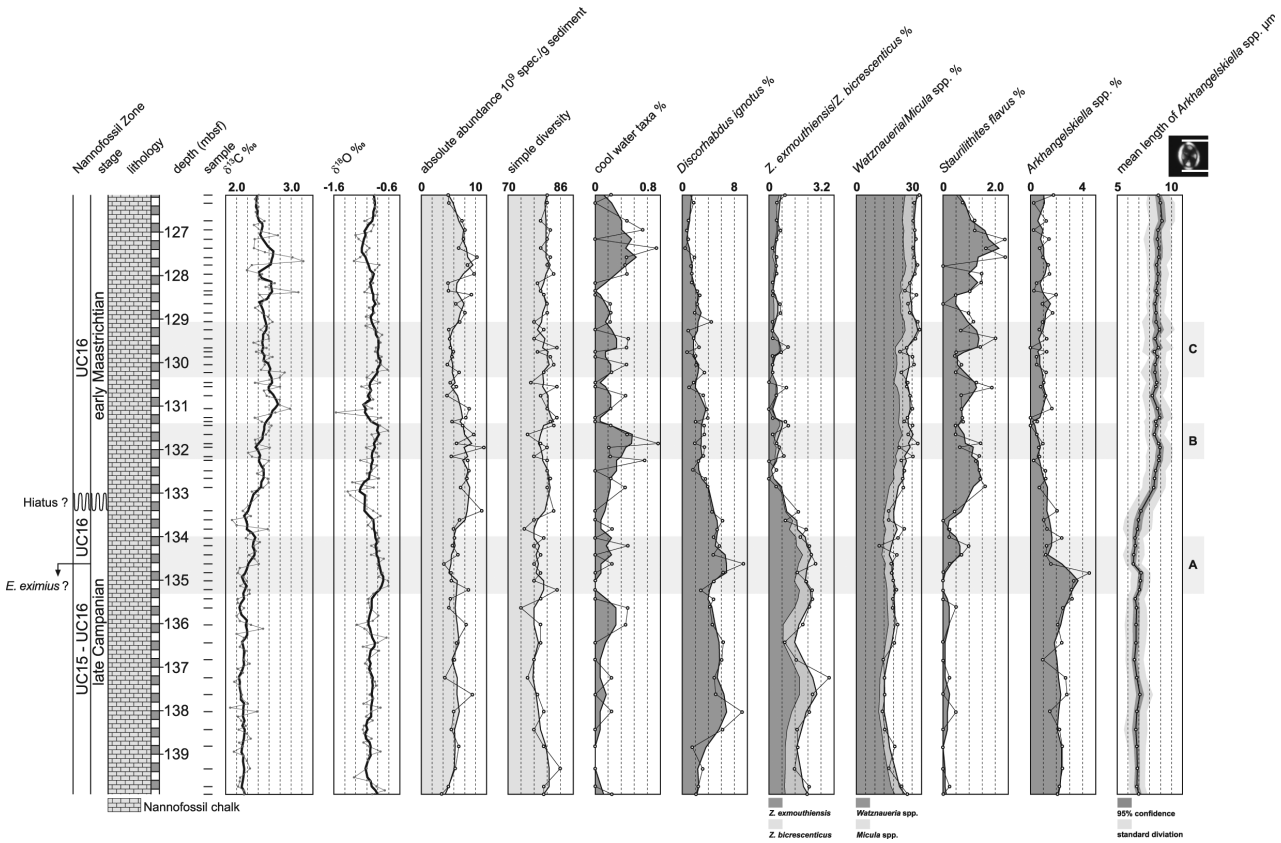


Figure 1: Fluctuations of absolute abundance, simple diversity (= species richness), relative abundances of several nannofossil taxa (*Arkhangelskiella* spp., cool-water taxa, *D. ignotus*, *Micula* spp., *S. flavus*, *Watznaueria* spp., *Z. exmouthensis*, *Z. bicrescenticus*) and the mean size of *Arkhangelskiella* during the Campanian-Maastrichtian boundary interval at Hole 390A. Cool-water taxa include *A. octoradiata*, *G. segmentatum* and *K. magnificus*. Stable isotopes are after Friedrich *et al.* (2004)

same level, the average length of *Arkhangelskiella* spp. coccoliths increases from 6.8 to 8.7μm (Fig. 1). Cool-water taxa (*Ahmuellerella octoradiata*, *Gartnerago segmentatum*, *Kamptnerius magnificus*) are present, but their relative abundance is always below 1%.

The oxygen isotope data of Friedrich *et al*. (2004) indicate three surface-water cooling events (A, B, C; Fig. 1). The rare cool-water taxa show an increase during cooling event B, but no significant increases during events A and B. On the other hand, the cool-water taxa show a similar increase around 127-128mbsf. Several taxa show a turnover at the level 133mbsf. While oligotrophic taxa, like *Watzanueria* spp. and *S. flavus* increase, the eutrophic zeugrhabdotids decrease (Fig. 1). This suggests a turnover to more oligotrophic surface-waters. The benthic foraminiferal studies of Friedrich & Hemleben (2007) support this interpretation. The different sizes of *Arkhangelskiella* seem to correspond to ecophenotypes. In the lower part of the succession, *Arkhangelskiella* is more abundant, but the specimens are predominantly small (mean 6.8μm). These small specimens are probably eutrophic ecophenotypes, having a r-selected life strategy. Above 133mbsf, the average size increases to 8.7μm, but the abundance declines. The large specimens may have been oligotrophic, K-selected ecophenotypes. Thus the decrease in nutrients would have caused an increase in average size. Girgis (1987) measured the length of *Arkhangelskiella* specimens throughout the Maastrichtian of a Tethyan outcrop (Egypt), and observed a continuous increase in mean length from 7.4μm (Upper Campanian) to 12.5μm (Upper Maastrichtian). The abrupt increase in size of *Arkhangelskiella* specimens from 6.8μm to 8.7μm in DSDP Hole 390A may hint towards a hiatus between the Upper Campanian below 133mbsf and the Lower Maastrichtian above 133mbsf.

The Campanian-Mastrichtian boundary interval is thought to be a time of massive global changes. In several localities, a prominent cooling event occurred. In other settings, a change in nutrient influx is recorded. Our results show a clear response of fossil coccolithophores, primary producers, to environmental changes at the Campanian-Maastrichtian transition.

References

Barrera, E. & Savin, S.M. 1999. Evolution of late Campanian-Maastrichtian marine climates and oceans. *In*: E. Barrera & CC. Johnson (Eds). *Evolution of the Cretaceous ocean climate system. Geological Society of America, Special Paper*, **332**: 245-282.

Benson, W.E., Sheridan, R.E., Pastourt, L., Enos, P., Freeman, T., Murdmaa, I.O., Worstell, P., Gradstein, F., Schmidt, R.R., Weaver, F.M. & Stuermer, D.H. 1978. *Initial Reports of the Deep Sea Drilling Project*, **44**. Washington (US Government Printing Office).

Friedrich, O. & Hemleben, C. 2007. Early Maastrichtian benthic foraminiferal assemblages from the western North Atlantic (Blake Nose) and their relation to paleoenvironmental changes. *Marine Micropaleontology*, **62**: 31-44.

Friedrich, O., Herrle, J.O., Kößler, P. & Hemleben, C. 2004. Early Maastrichtian stable isotopes: changing deep water sources in the North Atlantic? *Palaeogeography, Palaeoclimatology, Palaeoecology*, **211**: 171-184.

Geisen, M., Bollmann, J., Herrle, J., Mutterlose, J. & Young, J. 1999. Calibration of the random settling technique for calculation of absolute abundances of calcareous nannoplankton. *Micropaleontology*, **45**: 437-442.

Girgis, M.H. 1987. A morphometric analysis of the *Arkhangelskiella* group and its stratigraphical and palaeoenvironmental importance. *In*: J.A. Crux & S.E. van Heck (Eds). *Nannofossils and their applications*. Ellis Horwood Limited, Chichester, England: 327-339.

Huber, B.T., Norris, R.D. & MacLeod, K.G. 2002. Deep-sea paleotemperature record of extreme warmth during the Cretaceous. *Geology*, **30**: 123-126.

Miller, K.G., Wright, J.D. & Browning, J.V. 2005. Visions of ice sheets in a greenhouse world. *Marine Geology*, **217**: 215-231.

Thibault, N. & Gardin, S. 2006. Maastrichtian calcareous nannofossil biostratigraphy and paleoecology in the Equatorial Atlantic (Demerara Rise, ODP Leg 207 Hole 1258A). *Revue de Micropaléontologie*, **49**: 199-214.

Coccolith evidence of upper ocean water variations for the past 1.53Myr in the Western Pacific Warm Pool

Chuanlian Liu, Shiying Zhang, Haiyan Jin

Coccolith analysis has been carried out for the past 1.53 Myr sediment from ODP Site 807, which is located in the center of the Western Pacific Warm Pool. The results show that the depth of nutricline experienced significant changes, mainly at 0.9, 0.48 and 0.28 Ma, respectively, enabling the recognition of four stages of change for the last 1.53 Myr. From 1.53 Ma to 0.9 Ma, the depth of nutricline shoaled gradually. At about 0.9 Ma, the nutricline abruptly deepened and remained stable until 0.48 Ma. The nutricline became very shallower during the time interval between 0.48 to 0.28 Ma. At 0.28 Ma, it deepened again and increased gradually up to the present. Variations in primary productivity match with the nutricline fluctuations, and also with the depth of thermocline derived from planktonic foraminifera. Comparison between the percentage of *F. profunda* and primary productivity, from ODP Site 807 and ODP Site 1143 in the southern South China Sea, indicates opposite changes before 0.9 Ma, but similar changes after 0.9 Ma. This implies that variations in the upper ocean water are different between the center and the margin of the Western Pacific Warm Pool before 0.9 Ma, but after 0.9 Ma they have the same trends.

Variability of the coccolith-derived carbonate at ODP Site 1242 in the eastern tropical Pacific during the middle and late Pleistocene

Gatsby-Emperatriz López-Otálvaro, José-Abel Flores, Francisco Javier Sierro, Alan C. Mix

This study is focused on the sedimentary sequence recovered during Ocean Drilling Program Leg 202 at Site 1242 on board the R/V *Joides Resolution*. Site 1242 is located in the Panama Basin (7°51.352'N, 83°36.418'W at 1364 m water depth) under the relatively low-salinity waters of the warm pool in the eastern tropical Pacific. Sediments mostly consist of hemipelagic clay. Calcareous nannofossils are the primary biogenic component, exceeding up to 70% (Mix *et al*., 2003).

Calcareous nannofossils take part in the biogeochemical cycles of the Earth since they play an important role in the carbon cycle through photosynthesis and calcification processes (Young, 1994; Baumman *et al*., 2004). Based upon quantitative estimations of the absolute abundances and the species-specific mean coccolith mass, we assess the paleoproductivity pattern and the temporal distribution of accumulation rates of coccolith-derived carbonate at ODP Site 1242 in the upper 108.01 mcd (meter composite depth) which extend back over the past 925 kyr (MIS 22 to 1).

The $\delta^{18}O$ data on planktonic foraminifera sustain the chronostratigraphic framework (Mix *et al*., in prep.) through the past 925 kyr. The overall pattern of paleoproductivity increases downhole, reflecting the gradual rise in coccolith-derived carbonate, especially significant during the Mid-Brunhes Event (MIS 8 to 15). Paleoproductivity and accumulation rates of coccolith-derived carbonate also follow a glacial/interglacial variability, showing maxima during glacial events. This variability is in agreement with the typical glacial/interglacial pattern of carbonate production in the Pacific Ocean, previously observed by several authors (Arrhenius, 1952; Archer, 1991a, b, among others). Although few intervals of poor preservation obscure the paleoecological significance of the coccolith carbonate profile, the overall preservation pattern of calcareous nannofossils is good to moderate and supports high paleoproductivity and accumulation rates of coccolith carbonate during glacials.

References

Archer, D.E. 1991a. Equatorial Pacific calcite preservation cycles: production or dissolution. *Paleoceanography*, **6**: 561–571.

Archer, D.E. 1991b. Modelling the calcite lysocline. *Journal of Gephysical Research*, **96**: 17037–17050.

Arrhenius, G. 1952. Properties of the sediment and their distribution: Sediment cores from the East Pacific. *Swedish Deep-Sea Expedition 1947-1948*, **5**: 1-228.

Baumann, K.-H., Böckel, 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-Verlag, Berlin: 367–402.

Mix, A.C., Tiedemann, R., Blum, P. *et al*. 2003. *Proceedings ODP, Init. Repts*., **202**. Ocean Drilling Program, College Station, TX. doi:10.2973/odp.proc. ir.202.2003.

Young, J.R. 1994. Functions of coccoliths. *In*: A. Winter & W.G. Siesser (Eds). *Coccolithophores*. Cambridge Univ. Press, Cambridge: 63–82.

Nutri-thermocline dynamics reconstruction and coccolith carbonate contribution during the middle and late Pleistocene in the eastern equatorial Pacific ODP Site 1241

Gatsby-Emperatriz López-Otálvaro, José-Abel Flores, Francisco Javier Sierro

Sediments recovered at Ocean Drilling Program (ODP) Site 1241, located in the warm pool of the eastern tropical Pacific (5˚50'N, 86˚26'W at 2027 m water depth), are mostly constituted of clayey foraminiferal-nannofossil ooze, calcareous nannofossils being the dominant biogenic component (30-60%; Mix *et al*., 2003). The sedimentary sequence studied is controlled by the warm-water regime of the North Equatorial Countercurrent (NECC), the displacement of the Equatorial Front and the displacement of the Intertropical Convergence Zone (ITCZ).

A quantitative analysis, taking into account the nannofossil assemblage, the N index (ratio between upper photic zone species *vs*. lower photic zone species) and the carbonate-mass produced, allow us to reconstruct the paleoproductivity pattern and the nutri-thermocline variability over the middle and late Pleistocene. Higher N ratio values reflect high paleoproductivity and an uplifted nutri-thermocline, and lower N ratio values indicate low paleoproductivity and a deep nutri-thermocline. Furthermore, species-specific mean coccolith carbonate mass allowed us to estimate the coccolith carbonate contribution to the sedimentation at our site, revealing a close relationship with the paleoproductivity profile, and thus with the vertical displacement of the nutri-thermocline. Good and moderate preservation of the total coccolith content in the sediments infer that variations in the coccolith carbonate content responded to variations in the paleo-production of calcareous nannofossils, rather than dissolution. This strong relationship suggests maxima of productivity during glacial events, when the ITCZ migrated southward and the warm-water regime of the NECC was weakened, giving way to a shoaling of the nutri-thermocline.

Furthermore, the overall pattern of the N ratio reflects a gradual migration to a more oligotrophic setting during the past 130 kyr, particularly stressed during Marine Isotope Stage (MIS) 5, suggesting the influence of an El Niño-like setting, as was earlier stated for the eastern tropical Pacific (Beaufort *et al*., 2001; López-Otálvaro *et al*., 2008).

References

Beaufort, L., de Garidel-Thoron, T., Mix, A.C. & Pisias, N.G. 2001. ENSO-like forcing on oceanic primary production during the Late Pleistocene. *Science*, **293**: 2440–2444.

López-Otálvaro, G.-E., Flores, J.-A., Sierro, F.J. & Cachão, I. 2008. Variations in coccolithophorid production in the Eastern Equatorial Pacific at ODP Site 1240 over the last seven glacial-interglacial cycles. *Marine Micropaleontology*: doi: 10.1016/j.marmicro.2007.11.009.

Mix, A.C., Tiedemann, R., Blum, P. *et al*. 2003. *Proceedings ODP, Init. Repts*., **202**. Ocean Drilling Program, College Station, TX. doi:10.2973/odp.proc.ir.202.2003.

Insight into calcareous nannofossil palaeoecology at the beginning of the Messinian Salinity Crisis in the classical section of Alba (NW Italy)

Francesca Lozar, Simona Cavagna, Pierangelo Clari, Francesco Dela Pierre, Edoardo Martinetto, Donata Violanti, Andrea Irace, Stefania Trenkwalder

In the last decade, a renewed interest on the onset and developement of the Messinian Salinity Crisis (MSC) led to a general revision of several classic sections in the Mediterranean area (see review in Rouchy & Caruso, 2006). One of the classical land Messinian sections, the composite Alba section of Sturani (1973), has been recently revisited. New stratigraphical, palaeontological, sedimentological, geochemical and petrographical data were collected in the Tortonian-Messinian sediments cropping out along the Tanaro River, near Verduno, in order to re-examine the onset and development of the MSC in this critical area of the Tertiary Piedmont Basin (BTP).

This work only deals with calcareous nannofossil (CN) data, while integrated biostratigraphical, palaeoecological, sedimentological and petrographical analyses are in progress.

The sampled section consists of five main lithologic units: 1) hemipelagic, laminated marly clay, up to 37 m thick; 2) three primary selenitic gypsum beds intercalated with thinly laminated marly clays (14 m); 3) finely-laminated, fine- to coarse-grained primary 'balatino' gypsum (7 m); 4) thinly-bedded marly clays intercalated with coarse-grained, diagenetic gypsum beds (34 m); 5) marly clays of the Lago-Mare facies, with root traces; 6) marly clays of Pliocene age, with abundant marine fossils.

Unit 1 only contains well to moderately preserved CN assemblages, whose composition reflects the progressive deterioration of the marine environment prior to the onset of the MSC (Unit 2).

The occurrence of Messinian marker species, such as *Amaurolithus primus/delicatus*, *Amaurolithus tricorniculatus* identifies the MNN11c subzone of Raffi *et al*. (2003). The absence of *Nicklithus amplificus*, whose occurrence is restricted to the lower part of the MNN11c subzone, could indicate the uppermost MNN11c subzone above the LO of *Nicklithus amplificus* or, alternatively, could be due to unfavourable palaeoenvironmental conditions. The scattered occurrence of *Reticulofenestra rotaria*, usually recorded only in MNN11b, may be ascribed to reworking, as strongly supported by the occurrence of high percentages of Cretaceous, Paleogene and Early-Middle Miocene CN. The topmost 3 m of Unit 1 are barren of CN.

The relative abundance of stress-tolerant CN species supports a pulsating environment with different characteristics of the water column. According to recent studies on the ecological preferences of several Messinian CN species (Flores *et al*., 2005; Kowenhoven *et al*., 2006; Wade & Bown, 2006), we can reconstruct the changes in the environment during the successive phases of the onset of the MSC. In general, the upper 14 metres of Unit 1 'normal' Messinian CN assemblages alternate with several strongly oligotypic assemblages, with changing composition at different stratigraphic levels. In particular, 12 metres below the first selenitic gypsum bed, the relative abundance of 'small' *Reticulofenestra* (*R. minuta* and *R. haqii* combined, up to 70% of the total assemblage) suggests episodes of eutrophic and brackish-to-hypersaline surface-waters. An abundance peak of *Sphenolithus abies* (up to 60% of the total assemblage) and high relative abundance of *Helicosphaera carteri* (up to 20% of the total assemblage) are recorded 8 metres below Unit 2. The concomitant abundance of both species in our material suggests a shallow-water environment (supported by *H. carteri*), rich in nutrients and with fluctuating, possibly high, salinity. In fact, *S. abies* is interpreted as a schizohaline species, and *H. carteri* as tolerating high-salinity waters (Kowenhoven *et al*., 2006). Another peak of 'small' *Reticulofenestra* is recorded 3 metres below the selenitic gypsum bed, and supports the hypothesis of eutrophic surface-waters, and increasing salinity.

The occurrence of discrete oligotypic CN assemblages, in a succession of 'normal' Messinian CN assemblages, suggests the presence of surface waters relatively rich in nutrients and progressively increasing in salinity towards the top of Unit 1. The presence of shallow-water markers supports the idea of a decreasing depth of the basin during the pre-evaporitic phase, and the development of a progressively restricted environment. The occurrence of 'normal' Messinian CN assemblages also testifies that this trend towards increasing salinity and more restricted environment was interrupted by several episodes of re-establishment of salt concentration close to the global ocean values during the pre-evaporitic phase.

The occurrence of euryhaline fishes (*Aphanius* sp.) just 1.5 m below the selenitic gypsum beds of Unit 2 also testifies that the increase in salinity started before the precipitation of gypsum, during the pre-evaporitic phase.

References

Flores, J.-A., Sierro, F.J., Filippelli, G.M., Barcena, M.A., Perez-Folgado, M., Vazquez, A. & Utrilla, R. 2005. Surface water dynamics and phytoplankton communities during deposition of cyclic late Messinian sapropel sequences in the western Mediterranean. *Marine Micropaleontology*, **56**: 50-79.

Kouwenhoven, T.J., Morigi, C., Negri, A., Giunta, S., Krijgsman, W. & Rouchy, J.M. 2006. Palaeoenvironmental evolution of the eastern Mediterranean during the Messinian: constraints from integrated microfossil data of the Pissouri Basin (Cyprus). *Marine Micropalaeontology*, **60**: 17–44.

Raffi, I., Mozzato, C., Fornaciari, E., Hilgen, F.J. & Rio, D. 2003. Late Miocene calcareous nannofossil biostratigraphy and astrobiochronology for the Mediterranean region. *Micropalaeontology*, **49**(1): 1-26.

Rouchy, J.M. & Caruso, A. 2006. The Messinian salinity crisis in the Mediterranean basin: A reassessment of the data and an integrated scenario. *Sedimentary Geology*, **188-189**: 35-67.

Sturani, C. 1973. A fossil eel (*Anguilla* sp.) from the Messinian of Alba (Tertiary Piemontese Basin). Palaeoenvironmental and palaeogeographic implications. *In*: C.W. Drooger (Ed.). *Messinian events in the Mediterranean*. K. Ned. Akad. Wetensch., Amsterdam: 243-255.

Wade, B.S. & Bown, P. 2006. Calcareous nannofossils in extreme environments: the Messinian Salinity Crisis, Polemi Basin, Cyprus. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **233**: 271–286.

Calcareous nannofossil, benthic foraminiferal and geochemical responses to nutrient availability in the SW Pacific Ocean during the Pleistocene

Claudia Lupi, Iacopo Trattenero, Nicoletta Mancin, Miriam Cobianchi

An integrated micropaleontological (calcareous nannofossils and benthic foraminifera) and geochemical study was carried out from the IMAGES Site MD97 2114 (eastern New Zealand, Pacific Ocean), mostly to reconstruct the oceanographic events that occurred in this area during Pleistocene climate changes. The site studied is located north of the Chatham Rise at a water depth of 1935 meters, recording the last 1.07 Myr, with substantial continuity of sedimentation.

Micropaleontological data have been collected using standard methodologies, then processed by means of the most common and useful statistical methods of mono- and multivariate analyses. The Principal Component Analysis applied to relative abundances of the most abundant calcareous nannofossil and benthic foraminiferal species shows that the distribution patterns of the two groups are mainly driven by nutrient availability controlling primary productivity.

Calcareous nannofossil data document: up to MIS 18, the occurrence of a stratified water-column, predominantly characterised by meso-oligotrophic conditions (*e.g.*, occurrence of *Oolithotus fragilis*); from MIS 14 to MIS 8, enhanced nutrient levels characterised by high abundance of *Gephyrocapsa caribbeanica*; finally, from MIS 8 to the core top, variable trophic conditions. Changes in food supply to the sea floor, related to shallow-water primary productivity, appear to be the main factor controlling benthic foraminifer distribution. The lower portion of the IMAGES core, up to MIS 18, is in fact characterized by benthic foraminifer assemblages indicative of mesotrophic conditions. In the central part of the core, a slow increase in the relative abundances of eutrophic taxa is documented. Then, after a period of re-establishment of mesotrophic conditions (up to MIS 7), a new trend of increasing productivity characterises the upper part of the core.

The biological events are quite well mirrored by the $\delta^{13}C$ curve: the lowermost portion of the core records a predominantly negative $\delta^{13}C$ interval, the middle portion (MIS 15-8) is characterised by heavier values of the $\delta^{13}C$, and finally, after an interval of re-established negative values, several positive peaks are documented up to the MIS 4.

Calcareous nannofossil biostratigraphy of the Sarcheshmeh and Sanganeh Formations from the Takal Kuh section, Kopet Dagh Basin (NE Iran)

Azam Mahanipour, Anoshiravan L. Kani, Naser Raisossadat

The Sarcheshmeh and Sanganeh Formations are widely distributed in the Iranian part of the Kopet Dagh Basin, extending from east to west. The present study concentrates on calcareous nannofossil content of a relatively poorly studied sequence of the Sarcheshmeh and Sanganeh Formations, which is located in the Takal Kuh section in the western part of the basin. The section measures about 1600 meters and consists of marl, limestone, marly limestone and shale. The distribution of the nannofloral assemblages of the Sarcheshmeh and Sanganeh sediments reveal the presence of Zones CC6 and CC7 of Sissingh (1977) indicating an Upper Barremian-Upper Aptian age that is well-correlated with the ammonites zonation in the lower parts.

Nannoconids are present throughout the section, but reach their maximum abundance in the upper parts, thus indicating warm, nutrient-depleted surface waters for the environment of deposition (Erba, 1994).

References

Sissingh, W. 1977. Biostratigraphy of Cretaceous calcareous nannoplankton. *Geol. Mijnbouw*, **56**: 37-65.

Erba, E. 1994. Nannofossils and superplumes: The early Aptian 'nannoconid crisis'. *Paleoceanography*, **9**: 483- 501.

MIS11 calcareous nannoplankton assemblages off western Iberia (MD01-2443): Paleoecological and paleoceanographic implications

Sara Marreco, Mário Cachão, Lúcia de Abreu, Vanda Brotas

Orbital parameters and greenhouse gas concentrations during Marine Isotope Stage (MIS) 11 (428 - 360 ka) are most similar to the Holocene, and thus MIS11 is considered a past analogue of the present day interglacial climatic system. For this study, a high-resolution set of 216 samples for a 61 kyr time-interval from the MIS 11 section of the core MD01 – 2443 (western Iberian margin; de Abreu *et al*., 2005) was analysed.

The main kenotic affinity associations of calcareous nannoplankton were identified and characterized by establishing possible linear correlations between certain coccolithophores and paleoecological and/or paleoclimatic proxies. Thus, possible paleoenvironmental and paleoproductivity forcing mechanisms are addressed by statistically matching our time-series against other micropaleontological (benthic and planktonic foraminifera) and geochemical ($\delta^{18}O$) proxies from de Abreu *et al*. (2005). Results will be presented and discussed, namely the possible existence of sub-Milankovitch cycles through the identification of meaningful frequencies for each taxon.

Reference

de Abreu, L., Abrantes, F., Shackleton, N.J., Tzedakis, P., McManus, J., Oppo, D. & Hall, M. 2005. Ocean climate variability in the eastern North Atlantic during interglacial marine isotope stage 11: A partial analogue to the Holocene. *Paleoceanography*, **20**: 1-15.

Nannofossil biostratigraphy of Miocene sections in two wells from the Gulf of Suez, Egypt

Akmal M. Marzouk

Calcareous nannofossils were studied in Miocene sediments (Early-Middle Miocene) of two wells (Gulf of Suez, Egypt). One of them is located in the extreme northern part of the Gulf of Suez (Darag 17-1A), at a latitude of 29˚30', and the second one (GS 148-1) is at a latitude of 29˚ (in the center of the Gulf of Suez). In the two studied sections, the abundance fluctuations of some nannofossil marker-species proved to be a very useful tool for correlation. However, the index species of calcareous nannofossils is not abundant, but common to few and continuous in the subsurface wells of the Miocene of the Gulf of Suez. The quantity of index species was determined by means of quantitative methods in order to test the reliability of biohorizons used in the recent literature dealing with a Mediterranean Neogene Nannoplankton Zonation (MNN1-6) (Fornaciari & Rio, 1996; Fornaciari *et al*., 1996). Some problems linked to stratigraphical boundaries through the Miocene are discussed, as well as some peculiarities of the Mediterranean calcareous nannofossil assemblages.

In the Middle Miocene sediments of the uppermost Rudeis, Kareem and Belayim Formations, calcareous nannofossils were not recorded in the northern part of the Gulf of Suez (Darag 17-1A) well, while they were deposited in the GS (148-1) well, which is located relatively southwards. The partial absence of the uppermost Rudeis, Kareem and Belayim nannofloral assemblages from the extreme northern part of the Gulf of Suez (Darag 17-1A) well, including zones MNN4, MNN5 and MNN6a, may be due to unfavorable environmental conditions that prevailed at the end of the deposition of the upper Rudeis Formation. This absence may also be related to tectonic movements, which caused an unconformity within the Rudeis Formation, likely related to an uplift of the northern part of the Gulf of Suez area. Due to the presence of most common helicoliths in the assemblage, the uppermost part of the Darag 17-1A well was referred to shallower-water, nearshore conditions. Moreover, the extremely thin Kareem section, and the lack of thick evaporites, in the northern part of the Gulf of Suez Darag 17-1A well, indicates a period of no subsidence and low deposition in the Middle Miocene.

Thoracospheres: the evolution of calcification in dinoflagellates

Sebastian Meier

Calcification has evolved multiple times in many different branches of the eukaryotic part of the tree of life, and also one small sprig within the dinoflagellates has acquired this character during its evolution. The timing of this event has long been unclear, as some isolated records of microfossils with morphological characters attributed to the calcareous dinoflagellates, so-called calcispheres, are known from the Upper Triassic, whereas an uninterrupted record of undoubted calcareous dinoflagellates exists only since the Upper Jurassic. Molecular clock calculations with alternative calibration points for the origin of calcareous dinoflagellates indicate that a Jurassic origin is more likely than a Triassic one (Gottschling *et al*., 2008). This is in good agreement with traditional morphological dinoflagellate taxonomy, as the Triassic calcispheres show no indication of tabulation, whereas the true calcdino tabulation is remarkably stable over their evolutionary history.

A major discrepancy between molecular and morphological classifications lies in the current concept of classifying calcareous dinoflagellates by the crystallographic orientation of the crystals within the wall. Calcification in calcdinos has evolved first in the diploid life-cycle phase, and the majority of species investigated today forms diploid calcareous cysts. Diploid calcification was lost in a subclade of the calcareous dinoflagellates in which the haploid life-cycle phase has diversified. Calcification was regained secondarily in two genera of this clade, and the vegetative calcareous coccoid cells are the dominant life-cycle phase. Therefore, one part of the taxonomic confusion in calcareous dinoflagellates seems to result from comparing non-homologous calcareous structures, *i.e*. diploid resting cysts and vegetative coccoid cells (Meier *et al*., 2007).

Reinvestigating the ultrastructure of the calcareous walls in calcdinos is therefore urgently needed for a better understanding of unifying molecular, morphological and fossil phylogenies. First results show that the three major clades in calcareous dinoflagellates may be represented also by three different biomineralisation modes. Unfortunately, the underlying biogeochemical processes are largely unknown. There are now first studies on the isotope chemistry of the calcareous wall of dinoflagellates representing different proposed biomineralisation modes, and all of them show a characteristic strong depletion in $\delta^{13}C$ against equilibrium conditions in modern and fossil species (Friedrich & Meier, 2003; Minoletti *et al*., 2004; Zonneveld *et al*., 2007), indicating highly specialized biomineralisation pathways in calcareous dinoflagellates that are maintained despite the evolution of different modes of biomineralisation.

References

Friedrich, O. & Meier, K.J.S. 2003. Stable isotopic indication for the cyst formation depth of Campanian/Maastrichtian calcareous dinoflagellates. *Micropaleontology*, **49**: 375-380.

Gottschling, M., Renner, S., Meier, K.J.S., Keupp, H. & Willems, H. 2008. Timing deep divergence events in calcareous dinoflagellates. *Journal of Phycology*, **44**: 429-438.

Meier, K.J.S., Young, J.R., Kirsch, M. & Feist-Burkhardt, S. 2007. Evolution of different life-cycle strategies in oceanic calcareous dinoflagellates. *European Journal of Phycology*, **42**: 81-89.

Minoletti, F., de Rafelis, M., Renard, M., Gardin, S. & Young, J. 2005. Changes in the pelagic fine fraction carbonate sedimentation during the Cretaceous-Paleocene transition: contribution of the separation technique to the study of Bidart section. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **216**: 119-137.

Zonneveld, K.A.F., Mackensen, A. & Baumann, K.-H. 2007. Stable oxygen isotopes of *Thoracosphaera heimii* (Dinophyceae) in relationship to temperature; a culture experiment. *Marine Micropaleontology*, **64**: 80-90.

Response of coccolithophores to atmospheric and oceanographic changes during the Holocene African Humid Period in the East Atlantic, NW Africa

Alejandra Mejía-Molina, José-Abel Flores, Francisco Javier Sierro, M. Ángeles Barcena, Francis Grousset, Elsa Jullien

Core MD03-2705 -DUST was recovered on a seamount at 18˚05'N and 21˚09'W at a water depth of 3085 m off Mauritania-Senegal (NW Africa) during the R/V *Marion Dufresne II* Cruise (PICABIA, summer/fall 2003). The continuous sediment sequence consists of foraminifer and nannofossil oozes. The age-model is based on the correlation of $\delta^{18}O$ record of the benthic foraminifer *Cibicides wuellerstorfii* to the SPECMAP and ODP Hole 658C records (Martinson *et al*., 1987; deMenocal *et al*., 2000). Additionally, these results were compared to ^{14}C analyses. Qualitative analyses, carried out on coccolithophores together with wind-transported microfossils (phytholiths and fresh-water diatoms) from continental NW African areas, allow us to interpret variations in the direction and intensity of winds and their relationship with superficial oceanographic dynamics during 14.5-5.5 ka cal. BP, associated with the African Humid Period (Sarnthein *et al*., 1982; deMenocal *et al*., 2000). The terrigenous record exhibits a well-defined period of low influx associated with the African Humid Period (AHP), when the Sahara was nearly completely covered by vegetation and supporting perennial lakes. This period has been attributed to a strengthening of the African monsoon, due to gradual orbital increases in summer insolation. Variations in the surface-water productivity of coccolithophores (variations in the nutricline/thermocline position) were monitored using the N ratio between Noelaerhabdaceae (inhabitants of the upper photic zone) *versus Florisphaera profunda* (a lower photic zone inhabitant). High values in the N ratio imply a relatively high nutricline/thermocline position. During the AHP, the high productivity conditions are related with high values in the N ratio with abundant specimens of Noelaerhabdaceae. The transition between the Younger Dryas and the Holocene is interpreted as a rapid shift to arid conditions. The end of this period is coincident with high abundance in fresh-water diatoms and phytholiths, and with a progressing positive pulse in the Ti/Al ratio, suggesting intensification in the wind regime. At this time, the coccolithophore assemblage shows a dramatic decrease in the cool-water species *Gephyrocapsa muellerae*, interpreted as a return to warmer conditions.

References

deMenocal, P., Ortiz, J., Guilderson, T., Adkins, J., Sarnthein, M., Baker, L. & Yarusinsky, M. 2000. Abrupt onset and termination of the African Humid Period: rapid climate responses to gradual insolation forcing. *Quaternary Science Review*, **19**: 347-361.

Martinson, D.G., Pisias, N.G., Hays, J.D., Imbrie, J., Moore, T.C. & Shackleton, N.J. 1987. Age dating and the orbital theory of the Ice Ages: development of a high-resolution 0 to 300, 000-year chronostratigraphy. *Quaternary Research*, **27**: 1-29.

Sarnthein, M., Thiede., J., Pflaumann, U., Erlenkeuser, H., Fütterer, D., Koopmann, B., Lange, H. & Seibol, E. 1982. Atmospheric and oceanic circulation patterns off Northwest Africa during the past 25 million years. *In*: U. Rad, I. Hinz, M. Sarnthein & E. Scibol (Eds). *Geology of the Northwest Africa continental margin*. Springer-Verlag, New York: 547-604.

Coccolithophore assemblages of the Early-Middle Miocene in the Colombian Caribbean Sea: A correlation between the Arroyo Alférez section and ODP Leg 165, Site 999

Alejandra Mejía-Molina, José-Abel Flores, Vladimir Torres Torres, Francisco Javier Sierro

Correlating onshore sequences and offshore-cored sections is often critical to develop an integrated biostratigraphic model. Here, we examine high-resolution records from ODP Leg 165, Site 999 in concert with an onshore section, Arroyo Alférez, from Colombia. We used the standard biozonations proposed by Martini (1971) and Bukry (1973, 1975) for detailed Miocene biostratigraphy. Those biozonations were established in detailed sequences from the Caribbean Sea. The base of the onshore Arroyo Alférez sequence studied here is lower Oligocene NP23 (CP18) to Middle Miocene NN5 (CN4), and provides a continuous record and an excellent preservation of coccolithophore assemblages. The analyses carried out from samples, collected from a core of ODP Site 999 in the Colombian Basin, covers a continuous Miocene-Pleistocene interval, revealing an irregular and intermediate preservation of the coccolithophore record. The most representative taxa identified in the interval studied are *Cyclicargolithus floridanus*, *Cyclicargolithus abisectus*, *Reticulofenestra minuta*, *Reticulofenestra minutula*, *Reticulofenestra pseudoumbilicus* and *Sphenolithus moriformis*. We note also that *Helicosphaera* spp. was abundant in some intervals, while discoasterids increase towards the top of the sections. Most of the classical biostratigraphic events have been identified in both sequences. The study of the Arroyo Alférez onshore sequence constitutes the first biostratigraphic scheme based upon calcareous nannofossils. This scheme provides a biochronologic frame for the Cenozoic of northern Colombia, which has direct applications for oil exploration in the offshore areas of the Colombian Caribbean Basin. Its correlation with the well-calibrated ODP Site 999 offshore record provides a robust biostratigraphic framework and represents a potential key for future paleoceanographic interpretations.

References

Bukry, D. 1973. Coccolith and silicoflagellate stratigraphy, Tasman Sea and Southern Pacific Ocean, Deep Sea Drilling Project Leg 21. *Initial Reports of the Deep Sea Drilling Project*, **21**: 885-893.

Bukry, D. 1975. Coccolith and silicoflagellate stratigraphy, northwestern Pacific Ocean, Deep Sea Drilling Project, Leg 32. *Initial Reports of the Deep Sea Drilling Project*, **32**: 677-701.

Martini, E. 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. *In*: A. Farinacci (Ed.). *Proceedings of the II Planktonic Conference, Roma, 1970*, **2**: 739-785.

Calcareous nannofossil extinction pattern across the Cretaceous/Tertiary boundary in the Tethyan Realm

Mihaela C. Melinte-Dobrinescu, Marcos A. Lamolda, Ana-Voica Bojar

This paper presents detailed calcareous nannofossil investigations carried out across the K/T boundary interval in sections from the Tethyan Realm (Caravaca from the Betic Cordilleras, SE Spain, and Pietroşiţa from the southern part of the Eastern Carpathians, Romania). The Caravaca section was the object of one of the first detailed calcareous nannoplankton investigations for the K/T boundary interval (Romein, 1977), as well as of more recent micropaleontological (foraminiferal and nannofloral) and isotope studies (Kaiho & Lamolda, 1999; Lamolda *et al*., 2005). In the Pietroşiţa section, isotope measurements and fluctuations were recently published (Bojar *et al*., accepted).

In the studied sections, calcareous nannofossil events are similar to those recorded everywhere in the Tethyan Realm across the K/T boundary (Aguado, 1993; Pospichal, 1995; Melinte, 1999; Gardin, 2002; Tantawy, 2003, among many others). Namely, the successive first occurrences (FOs) of *Micula murus*, *Nephrolithus frequens* and *M. prinsii*, followed by the extinction of most Cretaceous nannoplankton, as well as by 'blooms' of the calcareous dinoflagellate *Thoracosphaera operculata* and of the nannofossil *Braarudosphaera bigelowii*.

The oldest observed step in the decline of Upper Cretaceous nannofloras, both in terms of species richness (number of taxa per sample) and abundance (number of specimens per field of view), was identified in the Spanish and Romanian sections below the 'fallout' lamina of the K/T boundary, above the FO of *M. prinsii*. This decline is expressed by a decrease of 15-20% in species richness and up to 30% in abundance. Taking into account the sedimentation rate for each investigated section, the first nannofloral decline took place around 4.5 kyr prior to the K/T event. A second nannofloral decline (approximately 2 kyr prior to the K/T event) is recorded in the two studied sections, and is marked by an abundance decrease of 60-70%, while species richness has no relevant changes. We may assume that these two Upper Maastrichtian steps in nannofloral decline observed in both Tethyan sections mirror paleoenvironmental changes that took place contemporaneously in the two investigated regions, and therefore indicate a stepwise extinction. Alternatively, this pattern may be an artifact of preservation and/or of local palaeoecological conditions (the Signor-Lipps effect, a false extinction) reported also by Gardin (2002) around the K/T boundary at Elles, Tunisia.

At the K/T boundary, around 80% of Cretaceous nannofossils disappeared. The survivors (Cretaceous taxa which are believed to cross the K/T boundary, having a consistent and continuous occurrence in the Tertiary nannofossil assemblages) are *B. bigelowii*, *B. alta*, *Chiastozygus ultimus*, *Cyclagelosphaera reinhardtii*, *Markalius inversus*, *Neocrepidolithus neocrassus*, *Octolithus multiplus* and *Zeugrhabdotus sigmoides*. In both the studied sections, *Biantholithus sparsus* sporadically occurs from the topmost Maastrichtian.

Just above the K/T boundary (the Ir 'layer'), *T. operculata* significantly increases in abundance from 0.5% up to 5% and a 'bloom' of *Markalius inversus* occurred. The dominant components of the basal Paleocene nannofloral assemblages are *Watznaueria barnesiae* and *Micula decussata*, which together account for up to 80% of the total nannofloras. Notably, both taxa are the dominant components of Upper Maastrichtian nannofloras, representing together around 40-50% of the total assemblage, but they show a continuous decrease towards the top of the analyzed sections (in the lowermost Paleocene).

Within the basal Paleocene of the Spanish and Romanian sections, successive 'blooms' of *T. operculata* (up to 60%) and *B. bigelowii* (up to 25-30%) were observed. The isotope data show a negative correlation with the *Thoracosphaera* 'blooms' and a positive correlation with the *B. bigelowii* 'bloom' in the Romanian succession.

References

Aguado, R. 1993. *Nanofósiles del Cretácico de la Cordillera Bética, Bioestratigrafía*. Unpubl. PhD thesis, Universidad de Granada: 413pp.

Bojar, A.V., Melinte, M.C. & Bojar, H.P. Accepted. A continuous Cretaceous/Paleogene red bed section in the Romanian Carpathians. *SEPM Special Publication*.

Gardin, S. 2002. Late Maastrichtian to early Danian calcareous nannofossils at Elles (Northwest Tunisia). A tale of one million years across the K-T Boundary. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **178**: 211-231.

Kaiho, M.A.& Lamolda, M.A. 1999. Catastrophic extinction of planktonic foraminifera at the Cretaceous/Tertiary boundary evidenced by stable isotopes and foraminiferal abundance at Caravaca, Spain. *Geology*, **27**(4): 355-358.

Lamolda, M.A., Melinte, M.C. & Kaiho, K. 2005. Nannofloral extinction and survivorship across the K/T boundary at Caravaca, southeastern Spain. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **224**: 27-52.

Melinte, M.C. 1999. Cretaceous/Tertiary Boundary in the East Carpathians (Romania) based on nannofloral evidence. *Acta Paleontologica Rumaniae*, **II**: 269-273.

Pospichal, J.J. 1995. Cretaceous/Tertiary boundary calcareous nannofossils from Agost, Spain. *In*: J.-A. Flores & F.J. Sierro (Eds). *Proceedings of the 5th INA Conference, Salamanca*: 185-217.

Romein, A.J.T. 1977. Calcareous nannofossils from the Cretaceous/Tertiary boundary interval in the Barranco del Gredero (Caravaca, Prov. Murcia, SE Spain). *Proceedings of the Kon. Ned. Akad. van Wetensch., Amsterdam,* **B80**(4): 256-279.

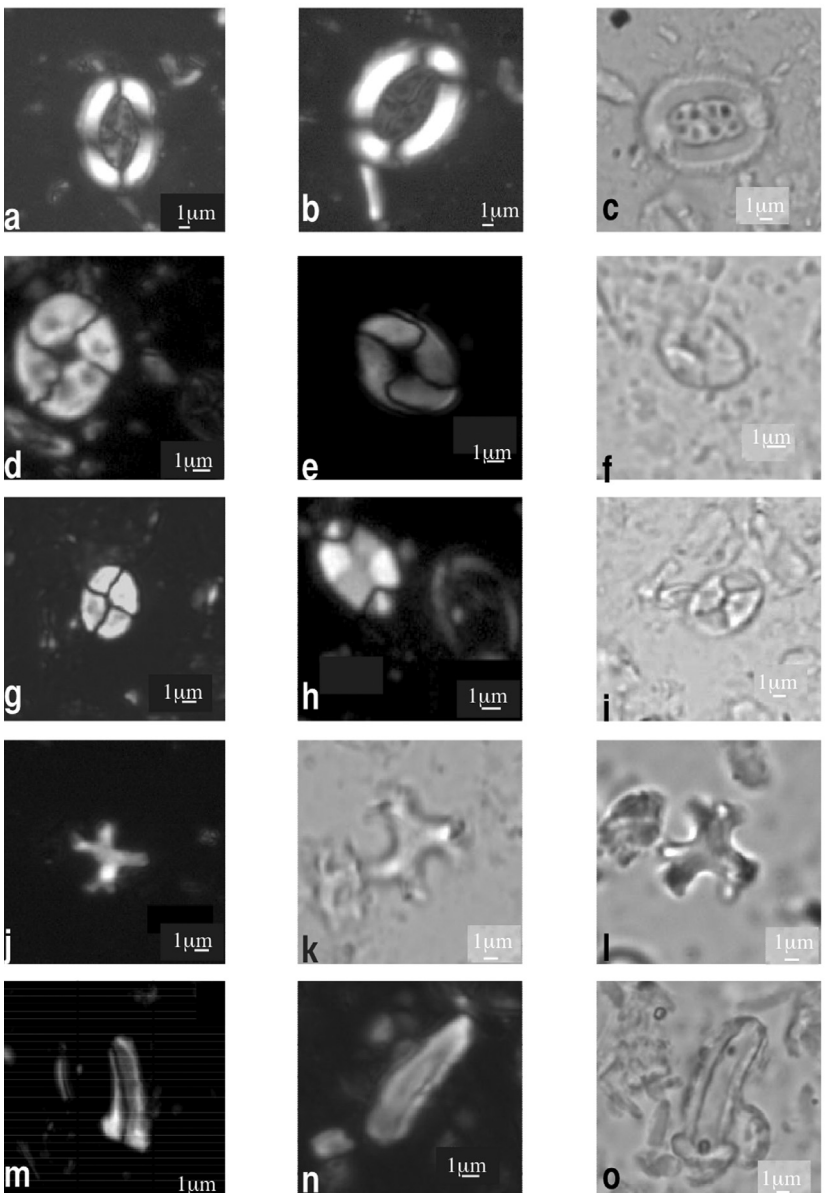
Tantawy, A.A.A.M. 2003. Calcareous nannofossil biostratigraphy and paleocecology of the Cretaceous-Tertiary transition in the central eastern desert of Egypt. *Marine Micropaleontology*, **47**: 323-356.

Reconstruction of the interregional Late Cretaceous sea-level record using nannofossil biostratigraphy

Svetlana F. Mizintseva

Biostratigraphy is a powerful tool in many different areas of stratigraphic reconstructions. Nannofossil biostratigraphy is an indispensable tool for a variety of stratigraphic work in many different regions. My studies have focused on the application of nannofossils biostratigraphy to Late Cretaceous sea-level reconstructions in the northern part of the Atlantic passive margin-New Jersey coastal plain. My approach has been to integrate sequence stratigraphy, paleobathymetry and biostratigraphy to derive a record of Late Cretaceous sea-level changes in the New Jersey coastal plain and establish firm biostratigraphy for interregional reconstructions. Use of calcareous nannoplankton biostratigraphy allows resolving the ages of the Santonian –Campanian sequences of New Jersey coastal plain. The ages are from 78.8 to 84.5 Ma and they correspond to CC16 (MeI sequence), CC17-18 (MeII sequence), CC18-19 (MeIII sequence) zone of calcareous nannoplankton biozonation of Sissingh (1977) and Perch-Nielsen (1985). The following markers are found on New Jersey coastal plain: the lowest occurrence (LO) of *Lucianorhabdus cayeuxii* identifies the base of Zone CC16, the LO of *Calculites obscurus* and the presence of *Calculites ovalis* identifies the base of Zone CC17, the LO of *Broinsonia parca parca* identifies the base of Zone CC18, and the highest occurrence (HO) of *Marthasterites furcatus* identifies the base of Zone CC19 (Fig 1).

This work provides a great potential for interregional sea-level reconstructions and evaluation of eustasy as a possible mechanism for New Jersey coastal plain sea-level changes. My future work is directed on interregional correlation of the Santonian–Campanian strata using nannofossils biostratigraphy.



All figured specimens are from the Millville, NJ corehole. Depths refer to the sample from which the figured specimen was taken. All species names follow Sissingh (1978) and Perch-Nielsen (1985). XPL = cross-polarized light, NL- normal light. **a-c**) *Broinsonia parca parca* (1228ft; 374.2m): **a**) XPL 0˚ rotated, **b**) XPL 45˚ rotated, **c**) NL. **d-f**) *Calculites ovalis* (1236ft; 376.7m): **d**) XPL 0˚ rotated, **e**) XPL 45˚ rotated, **f**) NL. **g-i**) *Calculites obscurus* (1251ft; 381.3m): **g**) XPL 0˚ rotated, **h**) XPL 45˚ rotated, **i**) NL; **j-l**) *Marthasterites furcatus* (1221ft; 372.1m): **j**) XPL 0˚ rotated, **k**) NL, **l**) NL; **m-o**) *Lucianorhabdus cayeuxii* (1251ft; 381.3m): **m**) XPL 0˚ rotated, **n**) XPL 45˚ rotated, **o**) NL

Reference

Perch-Nielsen, K. 1985. Mesozoic calcareous nannofossils. *In*: H.M. Bolli, K. Perch-Nielsen & J.B. Saunders (Eds). *Plankton stratigraphy*. Cambridge University Press, Cambridge: 427-554.

Sissingh, W. 1978. Biostratigraphy of Cretaceous calcareous nannoplankton. *Geologie en Mijnbouw*, **57**: 433-440.

New high-resolution calcareous nannofossil biostratigraphy and *Fasciculithus* evolutionary trend across the Danian-Selandian transition at ODP Site 1262, comparison with Zumaia (Spain) and the Qreiya (Egypt) sections

Simonetta Monechi, Viviana Reale, Gilen Bernaola, Barbara Balestra

High-resolution calcareous nannofossil analysis has been carried out on an expanded and continuous Paleocene sequence recovered during Leg 208 (Walvis Ridge, South Atlantic) at Site 1262. The detailed magnetostratigraphy and astronocyclostratigraphy of Westerhold *et al*. (2008) have allowed a precise calibration of the recognized bio-events. Twenty meters of the composite section across the nannofossil Zones NP4-NP5 have been studied in order to define the lowest occurrence (LO) of *Fasciculithus*, and the evolutionary trend of this genus until the LO of *Fasciculithus tympaniformis*.

The first specimens of *Fasciculithus* (*F. magnicordis* and *F. magnus*) have been observed in the middle part of Chron C27r, just above the LO of *Toweius pertusus*, and prior to the LO of the genus *Sphenolithus* (in agreement with Agnini *et al*., 2007). The distribution and abundance of *Fasciculithus* vary throughout the studied interval, and diaplay two radiation intervals. The first radiation of *Fasciculithus*, that involves the occurrence of *F. chowii* and related species, is recorded in the upper part of Chron C27n. The second one, characterized by the assemblage of *F. ulii* gr. and *F. janii* gr., occurs in the lower part of Chron 26r. The distribution of *Fasciculithus* is not continuous; in fact, between the two radiations, an interval barren of *Fasciculithus* has been detected. The LO of *F. tympaniformis* has been observed in the upper part of Chron C26r between the LO of *Neochiastozygus perfectus* and the LO of *Toweius eminens*.

A taxonomic review of the early species of *Fasciculithus*, and the detailed stratigraphic distribution of these taxa, have permitted the identification of new species and suggested a possible evolutionary trend. The succession of the events recognized at Site 1262 confirms the bio-events documented in the Zumaia section, proposed as stratotype (GSSP) of the Danian/Selandian boundary (Bernaola *et al*., 2008). In general, the observations made at the Qreiya section validate the succession of the events recognized by Rodriguez & Aubry (2006) in the same section, even if some inconsistencies have been observed, mainly related to the different taxonomic concept of a few *Fasciculithus* species.

References

Agnini, C., Fornaciari, E., Raffi, I., Rio, D., Röhl, U. & Westerhold, T. 2007. High-resolution nannofossil biochronology of middle Paleocene to early Eocene at ODP Site 1262: Implications for calcareous nannoplankton evolution, *Marine Micropaleontology*, **64**: 215–248. doi: 10.1016/j.marmicro.2007.05.003

Bernaola, G., Martín-Rubio, M. & Baceta, J.I. In press. New high resolution calcareous nannofossil analysis across the Danian-Selandian transition at the Zumaia section: comparisons with South Tethys and Danish sections. *Geologica Acta*.

Rodriguez, O. & Aubry, M-P. 2006. Lower to Middle (Danian-Selandian) Paleocene calcareous nannofossil stratigraphy of the Qreiya section (Egypt) *In*: F. Caballero *et al*. (Eds). *Climate and Biota of the Early Paleogene, 2006, abstracts*. Bilbao: 111.

Westerhold, T., Röhl, U., Raffi, I., Fornaciari, E., Monechi, S., Reale, V., Bowles J. & Evans, H.F. 2008. Astronomical calibration of the Paleocene time. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **257**: 377-403.

Sea-surface dynamics and coccolithophore behaviour during sapropel deposition of Marine Isotope Stages 7, 6 and 5 in the western Adriatic Sea

Áurea Narciso, José-Abel Flores, Mário Cachão, Francisco Javier Sierro, Elena Colmenero-Hidalgo, Andrea Piva, Alessandra Asioli

A detailed calcareous nannofossil analysis was performed on 234 samples from the core PRAD1-2, collected in the Mid-Adriatic Deep during the PROMESS1 Cruise. The selected sequence includes the Marine Isotope Stages 7, 6 and 5, crossing several sapropel layers (S8 to S3) (Piva *et al*., 2008). The main goal of the present study was to recognise changes in calcareous nannopankton distribution pattern during MIS 7, 6 and 5, and in particular across the associated sapropel layers.

Most of the sedimentological, geochemical and micropaleontological studies (*e.g*. Capozzi & Picotti, 2003; Arnaboldi & Meyers, 2003; Rio *et al*., 1997) refer that sapropels are dark-coloured organic-rich layers interbedded in the normal pelagic sediments of the Mediterranean Sea. They are related to climatic or oceanographic variations. Sapropel generation is also associated to orbital scale oscillations under conditions of maximum summer insolation, corresponding to a minimum of the precession component of Earth's orbit, with a periodicity of 21kyr (Hilgen, 1991; Lourens *et al*., 1996; Hilgen *et al*., 1997).

The results of this work indicate a decrease of the total coccolith abundance during most of the sapropels. A similar pattern was previously observed in others sectors of the Mediterranean (*e.g*., Negri &Villa, 2000; Negri & Giunta, 2001), while the reworked nannoliths exhibit an opposite pattern. The analysis of single species (namely, *C. pelagicus*, *H. carteri*, *Syracosphaera* spp., *R. clavigera*+*Calciosolenia* spp., *B. bigelowii* and small taxa) shows a decrease in abundance during MIS 7, while during MIS 6 and 5 the opposite pattern occurs. Another important feature of the studied samples is the significant increases in *Coccolithus pelagicus* and in *Helicosphaera carteri* at the beginning of MIS 7 sapropel layers, reflecting a phase characterized by cold and mixed waters (eutrophication). However, the same pattern is not so evident for the other interglacial stage (MIS 5). Our results also show important increments of *Syracosphaera*, *Rhabdosphaera*+*Calciosolenia*, and *Braarudosphaera* at the top or above the end of the sapropels; these increments are clearer for MIS 5. This phase is consistent with the end of dryer and cold conditions, and subsequent reestablishment of the general oligotrophy of surface waters. During MIS 7, between these phases and during most of the sapropel deposition, increases in reworked taxa are observed that reflect a more intense runoff. The consequences of this important fluvial erosion may have hampered the development of autochthonous species.

In general, our results indicate the existence of fluctuations in the calcareous nannofossil content between the interglacial stages 7 and 5, and also between these two and the glacial stage 6, revealing a transition of different paleoceanographic conditions across the analysed interval. A similarity in the environmental conditions occurring during sapropel deposition of each stage was also detected.

References

Arnaboldi, M. & Meyers, P. 2003. Geochemical evidence for paleoclimatic variations during deposition of two Late Pliocene sapropels from the Vrica section, Calabria. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **190**: 257-271.

Capozzi, R. & Picotti, V. 2003. Pliocene sequence stratigraphy, climatic trends and sapropel formation in the Northern Apennines (Italy). *Palaeogeography, Palaeoclimatology, Palaeoecology*, **190**: 349-371.

Hilgen, F.J. 1991. Astronomical calibration of Gauss to Matuyama sapropels in the Mediterranean and implication for the Geomagnetic Polarity Time Scale. *Earth Planetary Science Letters*, **104**: 226-244.

Hilgen, F.J., Krijgsman, W., Langereis, C.G. & Lourens, L.J. 1997. Breakthrough made in dating of the geological record. *EOS, Trans.-Am. Geophys. Union*, **78**: 286-289.

Lourens, L., Antonarakou, A., Hilgen, F.J., Van Hoof, A.A.M., Vergnaud Grazzini, C. & Zachariasse, W.J. 1996. Evaluation of the Plio-Pleistocene astronomical timescale. *Paleoceanography*, **11**: 391-413.

Negri, A. & Giunta, S. 2001. Calcareous nannofossil paleoecology in the sapropel S1 of the eastern Ionian sea: paleoceanography implications. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **169**: 101-112.

Negri, A. & Villa, G. 2000. Calcareous nannofossil biostratigraphy, biochronology and paleoecology at the Tortonian/Messinian boundary of the Faneromeni section (Crete). *Palaeogeography, Palaeoclimatology, Palaeoecology*, **156**: 195-209.

Piva, A., Asioli, A., Schneider, R., Trincardi, F., Andersen, N., Colmenero-Hidalgo, E., Dennielou, B., Flores, J.-A. & Vigliotti, L. 2008. Climatic cycles as expressed in sediments of the PROMESS1 borehole PRAD1-2, central Adriatic, for the last 370ka: 1. Integrated stratigraphy. *Geochem., Geophys., Geosyst.*, **9**: 1-21.

Rio, D., Channell, J., Bertoldi, R., Poli, M., Vergerio, P., Raffi, I., Srovieri, R. & Thunell, R. 1997. Pliocene sapropels in the northern Adriatic area: chronology and paleoenvironmental significance. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **135**: 1-25.

Late Eocene-Late Oligocene nannofossil paleoecology at Site 1090 (Agulhas Ridge, South Atlantic)

Laura Pea, Chiara Fioroni, Davide Persico, Silvia Palandri, Giuliana Villa

Climate changes occurred between the Paleogene and the Neogene, marking the transition between Greenhouse to Icehouse conditions. The Paleogene time is characterized by a general cooling trend, culminating in the Early Oligocene Oi-1 event (~ 33.5 Ma) (Miller *et al*., 1991; Zachos *et al*., 1996; Lear *et al*., 2000; Zachos *et al*., 2001). This trend is actually punctuated by several short warming phases, recorded by foraminifera carbon and oxygen isotopes (Kennet & Stott, 1990; Zachos *et al*., 2001; Bohaty & Zachos, 2003), and by nannofossil communities at several high-latitude (Bralower, 2002; Persico & Villa, 2004; Villa & Persico, 2006; Villa *et al*., subm.) and mid-latitude sites (Agnini *et al*., 2006; Gibbs *et al*., 2006). The Late Eocene shows a strong climatic instability, with periodicity of warming and cooling phases. The Eocene/Oligocene boundary and the next Oi-1 event represent the most abrupt climatic change, followed by a long, cool period spanning most of the Oligocene.

A paleoecological study of the nannofossil assemblages has been carried out at Hole 1090B, based on a quantitative analysis of high-resolution samples. The studied interval spans from the Late Eocene to the Late Oligocene. This Hole is located on the southern flank of the Agulhas Ridge on the Subantarctic sector of the Atlantic Ocean (42°54'S). It lies along the boundary between the North Atlantic Deep Water and the Circumpolar Deep Water. Thanks to its position above the Carbonate Compensation Depth (3702 m), the nannofossil assemblage preservation is from poor to good in most of the section, even thought some intervals are barren. A well-preserved magnetostratigraphic signal through all of the section, and nannofossil biostratigraphy, provided the time framework essential for interpreting the assemblage variations.

Methodology used in previous works (Persico & Villa, 2004; Villa *et al*., subm.) were applied here to the dataset to obtain the total abundance and the Shannon–Weaver species diversity index; furthermore, for each species, abundance curves were plotted as percentages, and also R-mode principal component analysis (PCA), and R-mode cluster analysis were performed. PCA, allowed us to identify the major components of the nannofossil assemblage, and to plot the factors that explain the maximum variance, here interpreted in a paleoecological view.

Once compared, the results derived from the two methods allowed us to obtain a paleoecological classification of the nannofossil assemblages, interpreted in terms of paleoecological changes (cool, temperate, and warm-water taxa). Using this classification, we identified abundance changes of each specific group of taxa, here interpreted mainly as related to sea-surface temperature variations. Importantly, the Oi-1 cooling event, previously recognized in other Southern Ocean sites as occurring just after the Eocene-Oligocene boundary, has been identified at about 257 mcd. This datum reinforces the position of the epoch boundary proposed by Channell *et al*. (2003), on the basis of the magnetostratigraphy, rather than the boundary proposed on the basis of foraminifer biostratigraphy.

The results obtained in this study are compared with data from some Southern Ocean sites (689, 738, 744, 748) (Persico & Villa, 2004; Villa & Persico, 2006; Villa *et al*., subm.), in order to obtain an ideal latitudinal transect along the Indian and Atlantic oceans. Compared to southernmost locations, at Site 1090, warm-water taxa are more abundant and temperate-water taxa have a more constant pattern; this is plausibly linked to the lower-latitude position of this site, north of the subantarctic front, where temperate forms thrive and are less affected by climatic changes.

As it is shown here, as well as in numerous, previous studies from different areas, nannofossils resulted to be useful tools for paleoclimatic and paleoceanographic reconstructions.

References

Agnini, C., Fornaciari, E., Rio, D., Tateo, F., Backman, J. & Giusberti, L. 2006. Responses of calcareous nannofossil assemblages, mineralogy and geochemistry to the environmental perturbations across the Paleocene/Eocene boundary in the Venetian Pre-Alps. *Marine Micropaleontology*, **63**: 19-38. doi:10.1016/j.marmicro.2006.10.002.

Bohaty, S.M. & Zachos, J.C. 2003. Significant Southern Ocean warming event in the late middle Eocene. *Geology*, **31**: 1017-1020.

Bralower, T.J. 2002. Evidence of surface water oligotrophy during the Paleocene–Eocene thermal maximum: nannofossil assemblage data from Ocean Drilling Program Site 690, Maud Rise, Weddell Sea. *Paleoceanography*, **17**: 13.1-13.13.

Channell, J.E.T., Galeotti, S., Martin, E.E., Billups, K., Scher, H. & Stoner, J.S. 2003. Eocene to Miocene magnetostratigraphy, biostratigraphy, and chemostratigraphy at ODP Site 1090 (sub-Antarctic South Atlantic). *Geological Society of America Bulletin*, **115**: 607-623.

Gibbs, S.J., Bralower, T.J., Bown, P.R., Zachos, J.C. & Bybell, L.M. 2006. Shelf and open-ocean calcareous phytoplankton assemblages across the Paleocene-Eocene Thermal Maximum: Implications for global productivity gradients. *Geology*, **34**: 233–236. doi: 10.1130/G22381.1.

Kennett, J.P. & Stott, L.D. 1990. Proteus and proto-Oceanus: ancestral Paleogene oceans as revealed from Antarctic stable isotopic results; ODP Leg 113. *In*: P.F. Barker, J.P. Kennett *et al*. (Eds). *Proceedings ODP, Scientific Results*, *113*: 865– 880.

Lear, C.H., Elderfield, H. & Wilson, P.A. 2000. Cenozoic deep-sea temperatures and global ice volume from Mg/Ca in benthic foraminiferal calcite. *Science*, **287**: 269–272.

Miller, K.G., Wright, J.D. & Fairbanks, R.G. 1991. Unlocking the ice house: Oligocene-Miocene oxygen isotopes, eustasy, and margin erosion. *Journal of Geophysical Research*, **96**: 6829–6848.

Persico, D. & Villa, G. 2004. Eocene-Oligocene calcareous nan-

nofossils from Maud Rise and Kerguelen Plateau (Antarctica): Palaeoecological and palaeoceanographic implications. *Marine Micropaleontology*, doi: 10.1016/j.marmicro.2004.05.002.

Villa, G., Fioroni, C., Pea, L., Bohaty, S. & Persico, D. Submitted. Middle Eocene-Late Oligocene climate variability: calcareous nannofossil response at Kerguelen Plateau, Site 748. *Marine Micropaleontology*.

Villa, G. & Persico, D. 2006. Late Oligocene climatic changes: Evidence from calcareous nannofossils at Kerguelen Plateau Site 748 (Southern Ocean). *Palaeoceanography, Palaeoclimatology, Palaeoecology*, **231**: 110-119.

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

Zachos, J.C., Quinn, T.M. & Salamy, K.A. 1996. High-resolution (10^4 years) deep-sea foraminiferal stable isotope records of the Eocene – Oligocene climate transition. *Paleoceanography*, **11**: 251–266.

Calcareous nannofossils as paleoproductivity indicators in sediments from the southeastern Sulu Sea

Alyssa M. Peleo-Alampay, Deborah N. Tangunan

This study investigates calcareous nannofossils from two sediment cores collected from the Sulu Sea in the southwestern Philippines during Philex cruise Leg 2 onboard R/V *Melville* in December 2007. These two core sites from the southeastern Sulu Sea sub-basin were chosen for their difference in productivity, based on present-day chlorophyll data. The high productivity site, Core MC10, is located closer to the coast of Zamboanga Peninsula at 8˚23.10'N, 122˚09.15'E and 4022m water depth, while Core MC8 is located in the central portion of the sub-basin at 8˚38.97'N, 121˚31.83'E and 4492m water depth.

Sulu Sea is a marginal, enclosed oceanic basin that is unique in its warm and oxygen-deficient bottom waters. It exchanges waters with the South China Sea, Sulawesi Sea *via* the Sibutu Strait, and with the Pacific through the Bohol Sea. Today, it is one of the most productive fishery areas of the Philippines that is increasingly exposed to anthropogenic activities. High chlorophyll-*a* maxima have been observed during the northeast monsoon in recent times in Sulu Sea waters off the coast of Zamboanga. Studying the sediment core in this area is a good opportunity to trace the upwelling history through time and compare it with the other study site.

Previous nannofossil studies show that some species can be used as paleoproductivity indicators. This research utilizes the lower photic-zone dweller, *Florisphaera profunda* as a proxy for non-upwelling or low-productivity events. Higher abundances of upper photic zone species, such as *Gephyrocapsa oceanica*, common in marginal sea sediments, are used as upwelling or higher-productivity indicators.

Nannofossil and environmental changes across the Sinemurian/Pliensbachian boundary in the Lusitanian Basin (S. Pedro de Moel, Portugal)

Julien Plancq, Stefano Palmerini, Vincent Grossi, Emanuela Mattioli, Bernard Pittet, George Yordanof, François Fourel, Luis Vitor Duarte, François Baudin

The Sinemurian/Pliensbachian boundary is characterized by an important event in the history of coccolith diversification, namely the first occurrence of *Similiscutum* (placolith coccoliths). However, nannofossil assemblages from this time interval are still poorly studied. In this work, an integrated study of calcareous nannofossils (absolute and relative abundance), inorganic (carbon and oxygen isotopes) and organic geochemistry (biomarkers) is presented. Nannofossil preservation is moderate to good in the studied samples. Delicate structures, such as the long spine of *Parhabdolithus liasicus liasicus*, are commonly preserved. Some bio-events are reported from San Pedro de Moel. The first occurrences of *Mitrolithus lenticularis* and *Crepidolithus crassus* are recorded in the Late Sinemurian, respectively ~20 and ~15 m below the Sinemurian/Pliensbachian boundary, as defined by ammonites. The first occurrence of *Similiscutum* is observed ~3 meters above the Sinemurian/Pliensbachian boundary. Few specimens of *Mazaganella* are recorded from the base of the section.

Sedimentological data indicate a sea-level drop close to the Sinemurian/Pliensbachian boundary at the studied site. Nannofossil abundances per gram of rock are the lowest during the sea-level low, probably because of the reduction of the ecospace for the development of a well-diversified nannoplankton community. Although *Schizosphaerella* spp. (a probable calcareous dinoflagellate) is always dominant in the analysed samples, coccolith proportion progressively increases in the basal Pliensbachian. The percentage of *Parhabdolithus liasicus liasicus* and *P. liasicus distinctus* that are very common in the assemblage seem to be inversely correlated. Average relative abundance of *Mitrolithus jansae* is 10% in the Upper Sinemurian samples, but increases up to 30% in the Lower Pliensbachian. Our results are similar to those presented for the same section by N. Perilli *in* Duarte *et al*. (2006), although this work only deals with qualitative nannofossil data.

Environmental conditions favorable to organic matter (OM) accumulation occurred in the Late Sinemurian (*Raricostatum* Zone), but OM-poor sediments are recorded in the Early Pliensbachian. The changes observed in the nannofossil assemblage composition may be the response of the nannoplankton community to environmental changes occurring across the Sinemurian/Pliensbachian. However, because of the scarcity of works dealing with ecological preferences of Lower Jurassic nannofossil taxa, we are at present unable to interpret them. The comparison of nannofossil assemblage composition and data derived from inorganic and organic geochemistry should enable us to better understand the ecology of some of the most ancient coccolithophorids.

Reference

Duarte, L.V., Perilli, N., Antonioli, L., Rodrigues, R., Cabral, M.C., Dino, R. & Azerêdo, M.C. 2006. Evidências sedimentologicas, geoquimicas (COT) e micropaleontologicas nas facies bituminosas do Sinemuriano termianl de Agua de Madeiros (Portugal). *VII Congresso Nacional de geologia, 2006, Universidade de Evora*: 633-636.

Productivity response to the SST and hydrography change in the Tagus prodelta during the Younger Dryas and the Holocene

Channarayapattana Prabhu, Teresa Rodrigues, Jose-Abel Flores, Antje Voelker, Fatima Abrantes

A sediment core recovered from the Tagus prodelta (90 m water depth) in the Portuguese Margin has been analysed for the coccolithophore assemblage, planktonic and benthic foraminifera oxygen isotopes and the biomarkers, for reconstructing the primary productivity variations during the Holocene. The chronology, based on 10 AMS ^{14}C dates, suggests that the sediment sequence extends up to the last 13.5 cal yr BP.

The alkenone-based SST, and the $\delta^{18}O$ of *G. bulloides,* suggest cooler surface water (~8˚C) conditions during the Younger Dryas (YD). This period was also characterised by low primary productivity as indicated by the *G. muellerae* abundance and low coccolithophore accumulation rates. However, the $\delta^{18}O$ of benthic foraminifera species *A. beccari* shows that the bottom water conditions were different from surface conditions.

Termination 1B is associated with 1 ‰ *G. bulloides* $\delta^{18}O$ and 10˚C SST shifts. The primary productivity increases with rising temperature. The dominance of the coccolithophore species *Gephyrocapsa oceanica* and small *Gephyrocapsa* is recorded for this period and also the Holocene. The Holocene, particularly the last 8 cal kyr BP, witnesses a decrease in SST from 19˚C to 15˚C. A gradual increase in coccolithophore accumulation rate indicates that, in spite of decreasing SST, primary productivity increased. The fresh water influx from the Tagus River could have changed the surface water hydrography and triggered higher primary production because the river water discharges important amounts of nutrients to the prodelta.

The sudden shift in $\delta^{18}O$ of *G. bulloides* around 10, 8.2 and 5.6 cal kyr BP, could correspond to the abrupt cooling events recorded in different parts of the Atlantic Ocean. This suggests that the study area is influenced not only by the river estuarine condition but also by the Atlantic Ocean circulation.

Lower Jurassic (Domerian) calcareous nannoplankton biogeography in the western Mediterranean area

Letizia Reggiani, Emanuela Mattioli

Quantitative studies have been carried out on Lower Jurassic calcareous nannofossils in order to assess a biogeographical distribution pattern within the western Mediterranean area. Four sections have been studied in different paleogeographic settings, namely Peniche in the Lusitanian Basin, Marcoux in the French Subalpine Basin, Burano in the Umbria-Marche Basin, and Trionto in the Ligurian-Piedmont Basin.

A total of 118 samples were analyzed for absolute and relative abundance, Shannon diversity index, and wt%$CaCO_3$. Correlations between the sections have been done by means of well-established nannofossil and ammonite integrated biostratigraphy. A careful checking of preservation state has been performed in each analyzed sample.

In the Lower Jurassic, calcareous nannoplankton species are commonly considered to be cosmopolitan. However, significant changes in relative abundance of species can be observed in different localities. Our study indicates that *Schizosphaerella* spp. (a probable calcareous dynocyst) dominates the assemblages in all studied sections, with percentage attaining 85%. This taxon is eurytopic but its relative abundance is systematically higher in the Umbria-Marche Basin (Burano and Trionto sections) than in the Lusitanian and Vocontian Basins. Within the coccoliths, the taxa showing the most significant biogeographic differences are: *Crepidolithus crassus* and *Mitrolithus jansae*. *Crepidolithus crassus* exhibits higher relative abundances within the Lusitanian and Vocontian basins testifying to an affinity for the NW European settings. Conversely, *Mitrolithus jansae* dominates the assemblages in the Burano and Trionto sections, and is therefore associated with the Mediterranean domain.

Lower Jurassic palaeogeographic reconstructions indicate the existence of seaway connections between the NW European and Mediterranean domains. Therefore, differences in relative and absolute abundances of specific taxa within the studied area suggest a control of environmental conditions on nannoplankton distribution. Several parameters may control nannoplankton distribution in the water column. However, the most important parameter in the studied localities seems to be related to nutrient supply in the different paleogeographic settings.

The Mediterranean domain was characterized by perioceanic carbonate platforms, without surrounding emerged lands. This region was therefore characterized by generally oligotrophic conditions in the considered time interval. Conversely, the NW European domain was represented by shelves and shallow epi-continental basins, where more or less constant nutrient supplies were provided by surrounding emerged lands.

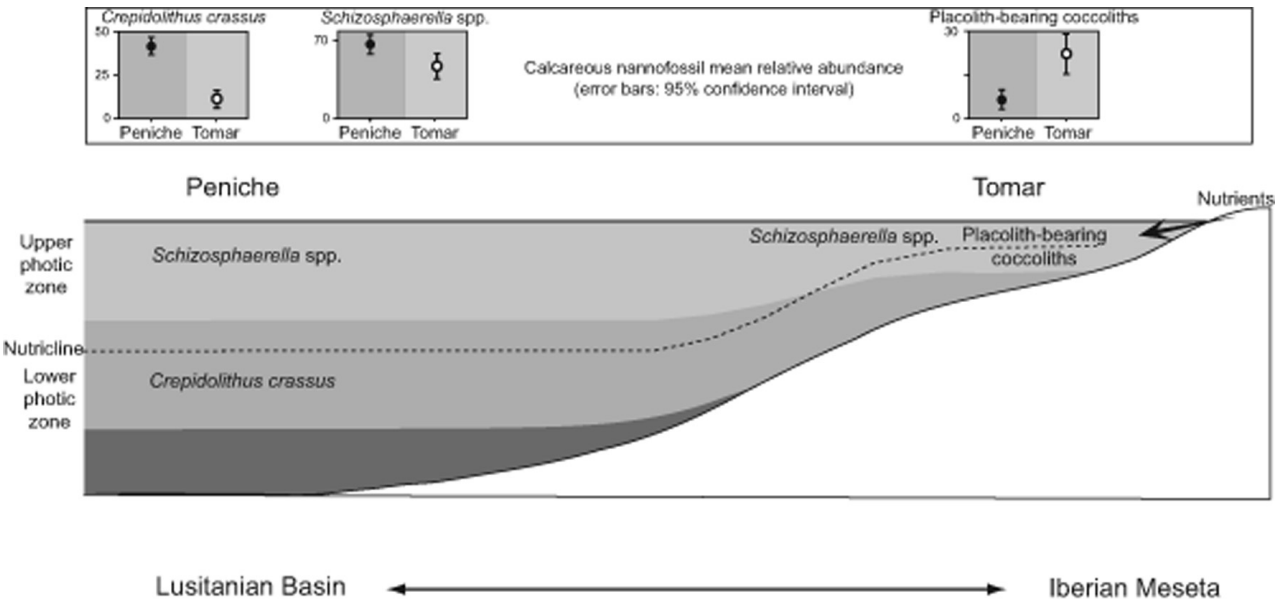
Spatial distribution of Pliensbachian (Lower Jurassic) calcareous nannofossils within the Lusitanian Basin (Portugal)

Letizia Reggiani, Emanuela Mattioli, Bernard Pittet

Quantitative analysis of Pliensbachian calcareous nannofossils have been carried out on a proximal-distal transect in the Lusitanian Basin (Portugal). The studied sections, Tomar and Peniche, respectively represent the proximal and the distal environments with respect to the emerged land of the Iberian Meseta (to the east). The upper portion of the Vale das Fontes Fm (*P. davoei* and *A. margaritatus* ammonite Zones) was studied in both sections and correlated by means of well-established ammonite and nannofossil integrated biostratigraphy. A careful analysis of the preservation state of nannofossils was performed in the studied samples. Preservation state is moderate to good in the two settings, changes in nannofossil assemblages are therefore considered as primary.

A total of 51 samples was analyzed for nannofossil absolute and relative abundances, wt%$CaCO_3$ and species diversity. The analysis of calcareous nannofossil quantities (absolute abundance, percentage, average-abundance) shows changes in the community structure in the space (*i.e.*, from proximal to distal), and vertically within the water column. This record suggests a partitioning of habitats within the photic zone, and with respect to emerged lands. Proximal environments within the Lusitanian Basin were probably more eutrophic, because of the presence of emerged lands to the east (Iberian Meseta). This was the source area for nutrients delivered into the basin. Distal environments were likely characterized by a relatively deeper photic zone.

The assemblages recorded in the proximal setting exhibit high mean relative abundance of placolith-bearing coccoliths (*Lotharingius* spp., *Biscutum* spp. and *Similiscutum* spp.) and of *Schizosphaerella* spp., while distal assemblages are dominated by *Crepidolithus crassus* and *Schizospharella* spp. *C. crassus* is interpreted as a deep-dweller coccolithophorid, inhabiting preferentially distal and deeper settings in the Lusitanian Basin. Placolith-bearing coccoliths were more abundant under elevated trophic conditions, and were more common in proximal settings, with respect to emerged lands. The probable calcareous dinocyst *Schizosphaerella* spp. proliferated in surface waters of both proximal and distal environments.



Calcareous nannofossils in petroleum exploration: improving correlations using palaeoecological events

Frédéric Ricciardi

Calcareous nannofossils in petroleum research are powerful tools for high-resolution chronostratigraphy and calibration of seismic horizons. Nevertheless, standard studies mainly focus on the chronostratigraphic aspect and only little attention is paid to potentially correlatable paleoecological and/or paleoclimatic nanno-events. For example, the relatively long-lasting Miocene nannozone NN4 (2.5Myr; 15.7Ma to 18.2Ma) is only characterized by the LAD (Last Occurrence Datum) of *H. ampliaperta* and the FAD (First Occurrence Datum) of *S. heteromorphus*. Using the modified classification of Wei & Wise (1990) on datasets of 3 offshore Angola wells, the CTW variations (Cool to Temperate/Warm species) suggest four synchronous warm events in agreement with the foraminiferal planktic blooms usually recognized in the area. A first event is recorded at the NN2/NN3 transition while NN4 can be subdivided into three intervals using two intra-NN4 events. A last correlatable warm event characterizes the NN4/NN5 transition. The paleoenvironmental characterization of nannoflora can hence be used, at least regionally, as a powerful tool that may refine the standard chronostratigraphic zonation.

Reference

Wei, W. & Wise, S.W. 1990. Biogeographic gradients of middle Eocene-Oligocene calcareous nannoplankton in the South Atlantic Ocean. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **79**: 29-61.

Multi-species coccolithophore response to an anthropogenically-modified ocean

R.E.M. Rickaby, P.R. Halloran, I.R. Hall, E. Colmenero-Hidalgo, J. Henderiks

Coccolithophores are one of the most important pelagic calcifying organisms in the present ocean to contribute to the organic carbon and carbonate pump of pCO_2 from the atmosphere into the deep ocean. As a major primary producer in the ocean, coccolithophores are responsible for fixation and drawdown of dissolved inorganic carbon into the deep ocean *via* the biological pump. Coccolithophores also calcify, and the production and export of calcium carbonate releases CO_2. The net influence of coccolithophores on pCO_2 depends partly on the particulate inorganic:organic carbon ratio (PIC/POC).

Major questions surround the species-specific nature of coccolithophore calcification in response to rising atmospheric CO_2 levels and the likely biogeochemical feedback on future climate. Here we investigate the assemblage - wide coccolithophore response to anthropogenically elevated pCO_2 using both culture experiments and field evidence from a North Atlantic core. The particle volume distribution data from the coccolith size-fraction of a rapidly accumulating North Atlantic sediment core appear to indicate that coccoliths produced by the larger coccolithophore species present at this location increase in mass in parallel with anthropogenic CO_2 release, in contrast to those of the smaller size, which decrease in mass. This contrasting behaviour is consistent with the results of our culture experiments of different species under conditions of carbonate chemistry which is decoupled from pCO_2. A divergence between the calcification response of these two coccolithophore size-groups could reflect contrasting physiological controls and evolutionary adaptation to pCO_2. This has significant implications for the realistic representation of an assemblage-wide CO_2-calcification response in numerical models.

Paleocene calcareous nannofossil analysis of the Qreiya section (Egypt) and the Eastern Venezuelan Basin

Olga M. Rodríguez V., Marie-Pierre Aubry

The present study focuses on the comparison of the zonal schemes based on calcareous nannofossils from two differents localities: the Qreiya section (Egypt) and the Eastern Venezuelan Basin. In the first locality, calcareous nannofossil assemblages were analyzed in order to establish the geochronological frame of a 20m-thick interval of the Dahkla Formation, which is exposed in the Qreiya section. This section lies at the southern end of Gebel Abu Had, ~50 km NE of Qena (N Egypt). Seventy samples were qualitatively and quantitatively analyzed in smear slides. Preservation is good and coccoliths are abundant. The section is comprised in the Zones NP4 (-4-12.3 m) and NP5 (12.6-16 m).

A biostratigraphic study was carried out in 10 wells in the Eastern Venezuelan basin. All the samples were taken from the Vidoño Formation. Fifty samples were analized in smear slides. The Vidoño Formation belongs to the Zones NP5 to NP9, preservation is poor and coccoliths are rare. According to Pindell *et al*. (1998), during the Early Paleocene this area was exposed, forming part of the forebulge related to the Paleogene foreland basin. In the Late Paleocene a marine sedimentation occurred again.

References

Pindell, J.L., Higgs, R. & Dewey, J.F. 1998. Cenozoic palinspastic reconstruction, paleogeographic evolution, and hydrocarbon setting of the northern margin of South America. *In*: J.L. Pindell & C.L. Drake (Eds). *Paleogeographic Evolution and Non-glacial Eustacy of Northern South America, SEPM Special Publication*: 45-86.

Evolution of the coccolithophore assemblages during the Last Deglaciation in ODP Site 1233 (southeastern Pacific Ocean)

Mariem Saavedra-Pellitero, José-Abel Flores, Francisco Javier Sierro

ODP Site 1233 is located 40 km offshore southern Chile (41˚0.01'S, 74˚26.99'W at 838 m water depth) in a small fore-arc basin on the upper continental slope isolated from turbidity currents. At this location, the mean sedimentation rates were extremely high (*ca*. 100cm/kyr) during the Holocene, and the records show a pronounced variability (in compositional changes, and in marine and oceanic paleoenvironments; Lamy *et al*., 2004) on multi-centennial to millennial timescales (Mix *et al*., 2003). Given these characteristics, this ODP site is very sensitive to even small past oceanographic changes.

The lack of high resolution paleoceanographic records from the South Pacific during the last glacial period and the following deglaciation, led us to study the biological responses to climatic events in this region over the last 70kyr using coccolithophores.

The coccolith record has been shown to be responsive to millenial-scale oscillations and variations in the position of current systems. Smear slides were prepared to assess the relative abundance of coccolithophore taxa and coccolith fluxes using the Flores & Sierro technique (1997), using a petrographic microscope (1000X). Additional studies were performed under scanning electron microscope, using a combined technique of filtration and dilution (Andruleit, 1996).

One of the objectives of this work was the study of the Last Deglaciation and Termination I. Given this objective, the resolution was increased during the time interval from ~24kyr to ~10kyr. High productivity was recorded during the Last Glacial Maximum (23 to 19 kyr), while a marked decrease occurred during the deglaciation, based on coccolith fluxes (NAR, Nannofossil Acumulation Rate). Variations in the coccolithophore assemblage point out cold and warm consecutive episodes.

References

Andruleit, H. 1996. A filtration technique for quantitative studies of coccoliths. *Micropaleontology*, **42**: 403-406.

Flores J.-A. & Sierro, F.J. 1997. Revised technique for calculation of calcareous nannofossil accumulation rates. *Micropaleontology*, **4**: 21-324.

Lamy, F., Kaiser, J., Ninnemann, U., Hebbeln, D., Arz, H.W. & Stoner, J. 2004. Antarctic timing of surface water changes off Chile and Patagonian ice-sheet response. *Science*, **304**: 1959-1964.

Mix, A.C., Tiedemann, R., Blum, P. & Shipboard Scientific Party 2003. Leg 202 Summary. *Proceedings of the Ocean Drilling Program, Initial Reports*, **202**: 145pp. College Station TX.

A revised calcareous nannofossil biostratigraphic framework for the Campanian-Maastrichtian interval recovered by ODP Leg 207 on Demerara Rise, western equatorial Atlantic

Anatoliy Shumnyk, Sherwood W. Wise, Jr.

Ocean Drilling Program (ODP) Leg 207 to Demerara Rise, a submarine plateau off Suriname, South America, recovered Cretaceous and Paleogene sediments to help elucidate the paleoceanography of the equatorial Atlantic (Erbacher *et al*., 2004; Mosher *et al*., 2007). In doing so, it recovered a Campanian-Maastrichtian sequence at all five of the sites drilled (1257-1261) that records the opening of the Equatorial Atlantic Gateway that accompanied the final separation of South America from Africa and the continuous deepening of the study area that followed.

Oxic conditions were well established by the late Campanian, when sedimentation on Demerara Rise changed from hemipelagic to pelagic, and clayey chalk was being deposited. In general, carbonate contents are initially about 35wt% and diagenetic calcite, carbonate debris, trace fossils, barite and pyrite crystals are abundant. Radiolarians are well preserved, indicating high surface-water productivity, although planktonic foraminifers are absent or poorly preserved. The lower Campanian-lower Maastrichtian zeolitic nannofossil claystone, however, gives way to Upper Maastrichtian greenish gray nannofossil chalk with foraminfers and clay.

The Campanian-Maastrichtian nannofossil chalks, clays and claystones show a reasonably diversified assemblage of calcareous nannofossils, although most holococcoliths are missing due to bathyal paleowater-depths. Well-preserved nannofossils are abundant in the section, and their distribution patterns provide a number of biostratigraphic nannofossil events that allow revision of the calcareous nannofossil zonation for equatorial regions such as this. The major biostratigraphic events illustrated in Figure 1 consist of the following first and last occurrences (FOs and LOs): *Micula prinsii*, *Lithraphidites quadratus*, *Reinhardtites levis-Tranolithus orionatus*, *Uniplanarius trifidus*, *Broinsonia parca constricta*, *Eiffellithus eximius*, and *B. parca parca*.

Equally important, however, secondary index species have been delineated *via* quantitative and qualitative nannofossil data from Holes 1258A, 1259A and 1260A, and these can be correlated throughout the study area. These events (Fig. 1) are: acmes of *Lithraphidites quadratus*, *Bukryaster hayi* and *Lithastrinus quadricuspis*; LO of acmes of *Kamptnerius magnificus*, *Gartnerago segmentatum*, *Ahmuellerella octoradiata* and *Zeugrhabdotus bicrescenticus*; FO of acmes of *Pseudomicula quadrata*, *Prediscosphaera incohatus*, *Ahmuellerella regularis*, *Lithraphidites praequadratus*, *Micula praemurus* and *K. magnificus*; LO of *Quadrum gartneri* and *Zeugrhabdotus diplogrammus*; FO of *Ceratolithoides amplector*; and significant increases in *C. amplector* and *Staurolithites mielnicensis*. The study has shown that no previously developed stratigraphic schemes can be strictly applied to this sequence. Instead, this example shows that a mix of quantitative and qualitative approaches provides broader opportunities for the application of Cretaceous calcareous nannofossil biostratigraphies.

References

Erbacher, J., Mosher, D.C., Malone, M.J. *et al*. 2004. *Proc. ODP, Init. Repts*., **207**. College Station, TX (Ocean Drilling Program). doi:10.2973/odp.proc.ir.207.2004

Mosher, D.C., Erbacher, J. & Malone, M.J. (Eds). 2007. *Proc. ODP, Sci. Results*, **207**. College Station, TX (Ocean Drilling Program). doi:10.2973/odp.proc.sr.207.2007

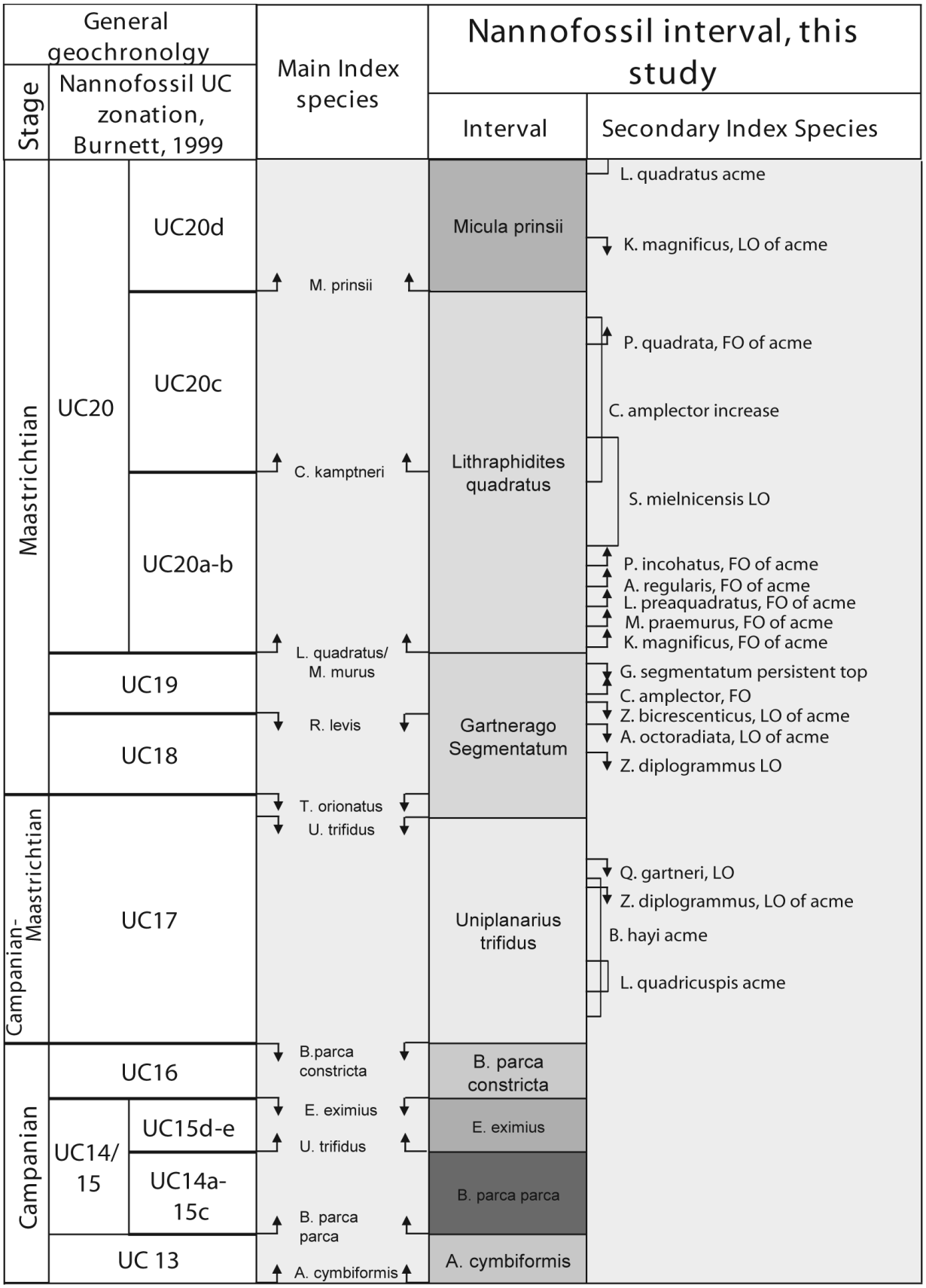


Figure 1: Campanian-Maastrichtian biostratigraphic framework for Demerara Rise based on ODP Leg 207 cores

Variations in abundance and morphology of *Watznaueria britannica* and *W. barnesiae* coccoliths in the Volgian sediments of the Ivkino section, Russian Platform

Ekaterina Shcherbinina

Volgian black shales (Upper Jurassic) are documented in many areas of the Russian Platform. The widely known Gorodishche and Kashpir sections display many short hiatuses in this interval. The Ivkino section (Unzha River, left tributary of Volga River, Kostroma Oblast) seems to be more complete and shows sedimentary contrasts. Middle Volgian deposits (6 m) are made up of a rhythmical alternation of black shale (BS) and claystone/marlstone layers. Nannofossil assemblages of the Ivkino section significantly differ from those of the Gorodishche and Kashpir sections, where boreal *Stephanolithion atmetos* and *Crucibiscutum salebrosum* and high-fertility *Biscutum constans* and *Zeugrhabdotus erectus* are found (Kessels *et al*., 2003). In the section studied, the two first species are absent; the other species are common in underlying Kimmeridgian sediment (up to 28 and 12% respectively), but become almost absent in Volgian deposits (<1%). Nannofossil assemblages are mainly composed of *Watznaueria* spp. (*W. barnesiae/fossacincta*, *W. britannica/communis*, *W. ovata*, *W. manivitiae*) forming up to 70% of the total nannofossil assemblage in the lower part of the sequence and up to 98% in its upper part. The occurrence of this oligospecific assemblage, showing moderate preservation, seems to be caused by primary effect rather than by diagenetic impact. Successive occurrence of unique specimens of *Conusphaera mexicana*, *Polycostella beckmannii* and Helenea chiastia approximately mark the NJ20A-B and NJKA zones.

W. britannica quantities strongly decrease at the base of the Volgian sediments (from 40-50 to 15-20%), but its abundance slightly increases in isolated BSs and toward the top of the sequence, while *W. barnesiae* shows an inverse trend, reaching 85% of the total assemblage in the lower part of the sequence and decreasing in the BSs. To define morphological variation in different *Watznaueria* groups as a response to paleoecological changes during BSs accumulation, biometric measurements, including lengths and widths of coccoliths and of central opening, were made on 100 specimens of *W. barnesiae* and *W. britannica* groups, using digitally-captured images in light microscope. There are no significant changes in *W. barnesiae* size and ellipticity from the Kimmeridgian toward the top of the Volgian sediments. This implies an extreme r-selection mode for this taxon. *W. britannica* displays a rather narrow continuum of both coccolith length (Lc = 5.0-8.2 μm) and proportion of coccolith and central opening lengths (Lc/Lo = 2.8-5.5) in Kimmeridgian sediments. This continuum is interrupted in Volgian sediments, where two different *W. britannica* morphotypes occur. One of them is represented by small coccoliths (Lc = 3.5-5.0 μm) with narrow central openings (Lc/Lo = 5.0-7.7); the second morphotype is represented by large coccoliths (Lc = 6.0-9.8 μm) with a large central opening (Lc/Lo = 2.2-4.1). Ellipticity of *W. britannica* does not change significantly from Kimmeridgian to Volgian sediments. The lack of transitional forms between the two morphotypes likely indicates their different life-strategies or the affinity for different habitats, *e.g*. different depths in a stratified water column. Relative increase in number of *W. britannica* group toward the top of the BS sequence implies its high adaptive potential under increased fertilization during BS accumulation.

References

Kessels, K., Mutterlose, J. & Ruffell, A. 2003. Calcareous nannofossils from late Jurassic sediments of the Volga Basin (Russian Platform): evidence for productivity-controlled black shale deposition. *International Journal of Earth Sciences*, **92**(5): 743-757.

Late Maastrichtian short-term warming events in the Boreal Realm: nannofossil evidence from Denmark

Emma Sheldon

The climate of the Late Cretaceous was probably one of the warmest in the history of the Earth, and global sea levels were high, resulting in marine transgression over large continental masses (Surlyk *et al*., 2003; Lykke-Andersen & Surlyk, 2004). However the Maastrichtian was characterised by a long-term global cooling and the Upper Cretaceous – Danian chalk succession of Denmark represents part of one of the largest and longest-lived cool-water carbonate platform deposits in the stratigraphic record. Based on foraminifera, nannofossils and oxygen isotope data from low-latitude and southern high-latitude sites (*e.g*. Huber & Watkins, 1992; Li & Keller, 1998; Thibault & Gardin, 2006, 2007), it is inferred that the overall cooling in the Maastrichtian was superimposed by two short-term intervals of increased temperature, followed by a global cooling just prior to the K/T event.

Sparse published material exists concerning Maastrichtian nannofossil palaeoecology of the Boreal Realm. However, a temperature increase in the Late Maastrichtian is inferred based on warm-water planktonic foraminifera incursions reported from the North Sea Basin and the Faeroe-Shetland Basin (*e.g*. King *et al*., 1989; Bergen & Sikora, 1999; Akker *et al*., 2000) and from Northern Jutland and Stevns Klint in Denmark (Troelsen, 1955; Hart *et al*., 2005).

Due to extensive hydrocarbon exploration in the chalks of the North Sea, a plethora of routine nannofossil and microfossil biostratigraphy has been carried out on the Upper Maastrichtian reservoir sections, but the nature of the hydrocarbon industry dictates that most data is highly confidential and remains unpublished. This study presents nannofossil data from the Boreal Realm which ties in with global studies on the Late Maastrichtian palaeoclimatic fluctuations. A high-resolution quantitative nannofossil study of 8 Upper Maastrichtian chalk cores from the Danish Central Graben and Danish Basin reveal small but significant shifts in taxa thought to have been sensitive to temperature fluctuations (*Watznaueria barnesiae*, *Kamptnerius magnificus*, *Nephrolithus frequens*). Two short-term warming events are inferred in the Late Maastrichtian, one in UC20b^{BP} and one in UC20d^{BP}, followed by a terminal Cretaceous cooling.

References

van den Akker, T.J.H.A., Kaminski, M.A., Gradstein, F.M. & Wood, J. 2000. Campanian to Palaeocene biostratigraphy and palaeoenvironments in the Foula Sub-basin, west of Shetland Islands, UK. *Journal of Micropalaeontology*, **19**: 23-43.

Bergen, J.A. & Sikora, P.J. 1998. Microfossil diachronism in southern Norwegian North Sea chalks: Valhall and Hod Fields. *In*: R.W. Jones & M.D. Simmons (Eds). *Biostratigraphy in Production and Development Geology. Geological Society, London, Special Publications*, **152**: 85–111.

Hart, M.B., Feist, S.E., Håkansson, E., Heinberg, C., Price, G.D., Leng, M.J. & Watkinson, P. 2005. The Cretaceous–Palaeogene boundary succession at Stevns Klint, Denmark: Foraminifers and stable isotope stratigraphy. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **224**: 6–26.

Huber, B.T. & Watkins, D.K. 1992. Biogeography of Campanian–Maastrichtian calcareous nannoplankton in the region of the Southern Ocean: paleogeographic and paleoclimatic implications. *In*: *The Antarctic paleoenvironment: a perspective on global change*. *Antarctic Research Series*, **56**: 31–60.

King, C., Bailey, H.W., Burton, C.A. & King, A.D. 1989. Cretaceous of the North Sea. *In*: D.G. Jenkins & J.W. Murray (Eds). *Stratigraphical Atlas of Fossil Foraminifera*. Ellis Horwood Ltd, Chichester: 372-417.

Li, L. & Keller, G. 1998. Maastrichtian climate, productivity and faunal turnovers in planktic foraminifera in South Atlantic DSDP Sites 525A and 21. *Marine Micropaleontology,* **33**: 55–86.

Lykke-Andersen, H. & Surlyk, F. 2004. The Cretaceous–Palaeogene boundary at Stevns Klint, Denmark: inversion tectonics or sea-floor topography? *Journal of the Geological Society, London*, **161**: 343–352.

Surlyk, F., Dons, T., Clausen, C.K. & Higham, J. 2003. Upper Cretaceous. *In*: D. Evans, C. Graham, A. Armour & P. Bathurst (Eds). *The Millennium Atlas: Petroleum Geology of the Central and Northern North Sea*. *The Geological Society of London*: 213–233.

Thibault, N. & Gardin, S. 2006. Maastrichtian calcareous nannofossil biostratigraphy and palaeoceology in the Equatorial Atlantic (Demerera Rise, ODP Leg 207 Hole 1258A). *Revue de Micropaléontologie*, **49**: 199-214.

Thibault, N. & Gardin, S. 2007. The Late Maastrichtian nannofossil record of climate change in the South Atlantic DSDP Hole 525A. *Marine Micropaleontology*, **65**: 163-184.

Troelsen, J.C. 1955. *Globotruncana contusa* in the White Chalk of Denmark. *Micropaleontology*, **1**: 76–82.

Campanian-Maastrichtian nannofossil biostratigraphy of the Boreal Realm (Danish Basin chalks)

Emma Sheldon

Recently, two boreholes were drilled in the Danish Basin (Stevns-1 and Stevns-2), close to the well-known K/T boundary section at Stevns Klint; the aims included sedimentology, isotopes, biostratigraphy and palaeoecology of the chalks. The Danish Basin chalks comprise a system sculpted by energetic, long-lasting contour currents into ridge, drift, moat and valley systems (Lykke-Andersen & Surlyk, 2004; Surlyk & Lykke-Andersen, 2007). This presentation focuses on the Campanian to uppermost Maastrichtian biostratigraphy of the Stevns-1 well (Sheldon, in press).

The succession consists broadly of Upper Campanian–lowermost Maastrichtian bioturbated chalk succeeded by Lower Maastrichtian alternating chalks and marls. The Upper Maastrichtian part comprises almost pure chalk with some intervals of flint-rich chalk and marly horizons (Stemmerik *et al*., 2006).

The Stevns-1 well (with 100% core recovery) was drilled on a Maastrichtian positive ridge structure within the ridge, moat and valley complex. The Stevns-1 well is the thickest completely cored section (456 m) through the Upper Campanian–Maastrichtian in northwestern Europe. It therefore constitutes a significant biostratigraphic and palaeoecological reference for this interval.

The core from the Stevns-1 well comprises 'Campanian–Maastrichtian boundary interval', Maastrichtian and Danian chalk. The 'Campanian–Maastrichtian boundary interval' is referred to subzones UC16d^{BP} to UC16a^{BP} and the Maastrichtian (Tor Formation) spans UC20d^{BP} to UC17 (after Burnett *et al*., 1998 and Network Stratigraphic Consultancy Ltd *in* Fritsen, 1999). The only apparent missing section appears to be Zone UC18, probably explained by the presence of minor firmgrounds, which were revealed by the lithological study.

A total of 64 species were encountered for the Maastrichtian and 71 for the 'Campanian/Maastrichtian boundary interval'. Nannofossil preservation compares favourably with that of North Sea chalks (Sheldon, 2006). Previously unreported nannofossil events include the extinction of *Helicolithus trabeculatus* and increase in abundance of *Prediscosphaera grandis* in the Upper Maastrichtian, and extinction of *Zeugrhabdotus praesigmoides* in the 'Campanian/Maastrichtian boundary interval'. Additional nannofossil events, which appear to contradict those of the established schemes, are discussed.

References

Burnett, J.A. with contributions from Gallagher, L.T. & Hampton, M.J. 1998. Upper Cretaceous. *In*: P.R. Bown (Ed.). *Calcareous Nannofossil Biostratigraphy*. British Micropalaeontological Society Series. Chapman & Hall/Kluwer Academic: 132–199.

Fritsen, A. 1999. *A Joint Chalk Stratigraphic Framework. Volume 1. Joint Chalk Research Program Topic V*. Norwegian Petroleum Directorate: 206pp.

Lykke-Andersen, H. & Surlyk, F. 2004. The Cretaceous–Palaeogene boundary at Stevns Klint, Denmark: inversion tectonics or sea-floor topography? *Journal of the Geological Society, London*, **161**: 343–352.

Sheldon, E. 2006. *Upper Maastrichtian-Danian nannofossils of the Danish Central Graben and the Danish Basin: a combined biostratigraphic-palaeoecological approach*. Unpubl. PhD thesis, Univ. College London, London: 354pp.

Sheldon, E. In press. Upper Campanian – Maastrichtian calcareous nannofossil biostratigraphy of the Stevns-1 borehole, Denmark. *Journal of Nannoplankton Research*.

Stemmerik, L., Surlyk, F., Klitten, K., Rasmussen, S.L. & Schovsbo, N. 2006. Shallow core drilling of the Upper Cretaceous Chalk at Stevns Klint, Denmark. *Geological Survey of Denmark and Greenland Bulletin*, **10**: 13-16.

Surlyk, F. & Lykke-Andersen, H. 2007. Contourite drifts, moats and channels in the Upper Cretaceous chalk of the Danish Basin. *Sedimentology*, **54**: 405–422.

Nannolithofacies: an alternative method, using minerals and calcareous nannofossils, for hydrocarbon reservoir characterization and stratigraphic correlation

Seirin Shimabukuro, Armando Antônio Scarparo Cunha

Nannolithofacies is proposed as an alternative sediment analysis method, combining two previously known, independent sediment analyses: calcareous nannofossils and heavy minerals. The method consists of the analysis and interpretation of the calcareous nannofossil and mineral content of smear-slides by means of a petrographic microscope. The use of a high-resolution calcareous nannofossil biostratigraphic framework, coupled with mineral analysis, allows us to distinguish different sandstone bodies and seal rocks in turbiditic systems. Our experience has shown that authigenic minerals, such as anatase, dolomite and pyrite are suitable for this purpose. Other common allochthonous heavy minerals in sediments, such as zircon, tourmaline, granade, biotite and rutile, are recognizable in smear-slides and they are considered good indicators to characterize the individual reservoir and its provenance. Although qualitative, this method constitutes a useful tool in specific horizontal-well drilling operations (geo- and biosteering). Provided that time and precision are critical parameters in petroleum exploration, we stress that the nannolithofacies method, along with several independent studies, such as mineralostratigraphy, litho- and biostratigraphy could be a valuable alternative, at low cost.

The last 20kyr reconstruction of the western Mediterranean Sea and north-western African margin from coccolith chemistry

Débora Simón-Baile, Patrizia Ziveri, Heather Stoll, José-Abel Flores, Francisco Javier Sierro

The Alboran Sea is situated within a transition zone between the Mediterranean Sea and the Atlantic Ocean; this exceptional location is particularly sensitive to record the connections between both areas. It records and amplifies the smallest climatic changes occurring at the mid-latitude regions, however, there are few data about the primary production pattern in the area and the influence of the Atlantic Ocean as the major source of nutrients.

The present work concerns the study of two high-resolution calipso piston cores obtained during *Marion Dufresne* cruises. MD95-2043 was recovered from the Alboran Sea (WM) at 36˚N-2˚W and 1841m water depth, and MD03-2705 DUST was recovered from 3100 m water depth at 18˚N-21˚W off Mauritania-Senegal (NWA).

Restricted coccolith fractions were analyzed for Sr/Ca ratio and stable isotopes to reconstruct productivity and sea surface temperature during the last 20kyr, and to assess the interactions and latitudinal gradient between the western Mediterranean Sea (WM) and the north-western African margin (NWA).

Repeated decanting and microfiltering techniques allow separation and concentration of sediment fractions dominated to high degrees by the coccolith-carbonate from a single species. The cosmopolitan *Emiliania huxleyi* and the surface dwellers *Helicosphaera carteri* and *Calcidiscus leptoporus* were isolated from every sample, even when their abundances in the original sample were low.

Different fractions from the same sample showed an offset in the isotopic ratios that is in agreement with the non-equilibrium effects obtained from previous culture experiments. The Mediterranean core shows a wider range of isotopic values related to a greater sensibility of the area to climatic and oceanographic variations.

Variations in surface-water conditions at the NW Iberian margin during the last ~50kyr, as revealed by coccoliths

Katharina Stolz, Karl-Heinz Baumann, Till J.J. Hanebuth

We present results from a Late Glacial and Holocene sediment sequence from the Northeast Atlantic. The studied gravity Core GeoB 11035-1 spanning 505 cm sediment recovery was taken at the north-western Iberian Margin off the Galician coast during the cruise P-342 in 2006. The site is located at 42˚10'N/9˚39'W in a water depth of 2045 m. The area is dominated by wind-driven upwelling during summer, downwelling in winter and, furthermore, terrestrial sediment input by rivers (Schmidt *et al*., 2002). Therewith the thickness of the surface water is subject to seasonality and shows strong variations between the winter and summer seasons (Fiúza *et al*., 1998).

The investigations cover the study of coccolith assemblages, as well as the analysis of fine-fraction (<20 μm) stable isotopes, assuming that the carbonate of the fine fraction is mainly build up by coccoliths.

In the lowermost 400 cm, probably spanning MIS 3 and MIS 2, the coccolith assemblage is dominated by the species *Emiliania huxleyi* and *Gephyrocapsa muellerae*. Coccolith numbers vary between *c*. 1000 and 3000 x10^6 coccoliths/g sediment. Few thermophilic species, such as *Syracosphaera* or *Helicosphaera*, seem to prevail in phases of the influence of warmer surface waters. This pattern changes with the onset of the Holocene, which is indicated by a sharp increase in total coccolith numbers to more than 16 000 x10^6 coccoliths/g sediment pointing to an enhanced productivity.

Fine-fraction $\delta^{18}O$ values vary between 1.5 and -2.5 during the Last Glacial, showing a slight trend towards lighter values. With the beginning of the Holocene, fine-fraction oxygen isotope values increase from -2.5 towards heavier values around 1.5. Studies of Dudley *et al*. (1986) have already shown that coccolith $\delta^{18}O$ shows a positive correlation of lighter values with increasing water temperatures, as it is also known and succesfully used in palaeoceanographic studies on planktic foraminifera. In our studies, we see, in contrast, an inverse trend to planktic foraminifera oxygen isotope values from this area.

In near future, we will look for an explanation on this problem and extend our study on this site by using other proxies for the reconstruction of surface water conditions.

References

Dudley, W.C., Blackwelder, P., Brand, L. & Duplessy, J.-C. 1986. Stable isotopic composition of coccoliths. *Marine Micropaleontology*, **10**: 1-8.

Fiúza, A.F.G., Hamann, M., Ambar, I., Díaz del Río, G., González, N. & Cabanas, J.M. 1998. Water masses and their circulation off western Iberia during May 1993. *Deep-Sea Research I: Oceanographic Research Papers*, **45**(7): 1127-1160.

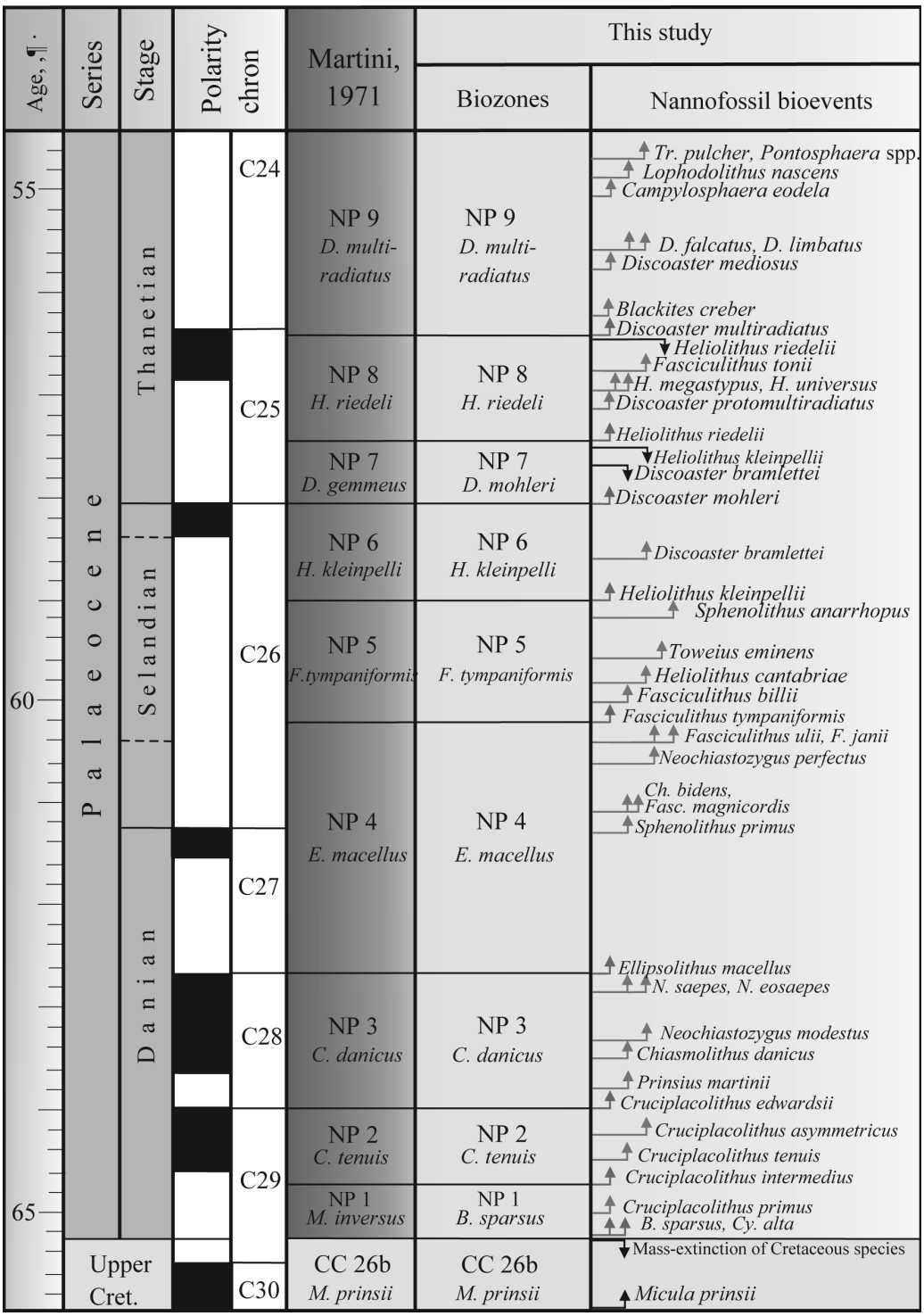
Schmidt, S., van Weering, T.C.E., Reyss, J.-L. & van Beek, P. 2002. Seasonal deposition and reworking at the sediment-water interface on the northwestern Iberian margin. *Progress in Oceanography*, **52**: 331-348.

Paleocene-Lower Eocene calcareous nannofossil biostratigraphy of Bulgaria

Kristalina Stoykova

Outcrop samples from 50 sections spread all over the territory of Bulgaria, as well as core samples from five offshore wells (W Black Sea shelf) were analyzed for biostratigraphy, using calcareous nannofossils. Martini's (1971) work serves as a reference standard scheme for subdivision and correlation of the studied sections. A complete sequence of nine Paleocene and five Lower Eocene biozones is recorded. Within each biozone, a sequence of successive bioevents of first and/or last occurrences of stratigraphically reliable nannofossil taxa is observed. They are utilized as additional markers in particular parts of the zone.

This detailed study has provided a total of 38 bioevents in the Paleocene and 17 bioevents in the Lower Eocene (Figs 1A, B). The selected bioevents during the present study are among the most significant nannofossil biohorizons, recently used to refine Paleocene and Lower Eocene calcareous nannofossil biostratigraphic framework (Agnini *et al*., 2007; Westerhold *et al*., 2008). Their recognition in the studied sections allows the reliable correlation between the Bulgarian sections and the sedimentary successions from other parts of the world. The produced biostratigraphy is based on the palaeontological identification of 212 species, belonging to 62 calcareous nannofossil genera, besides the



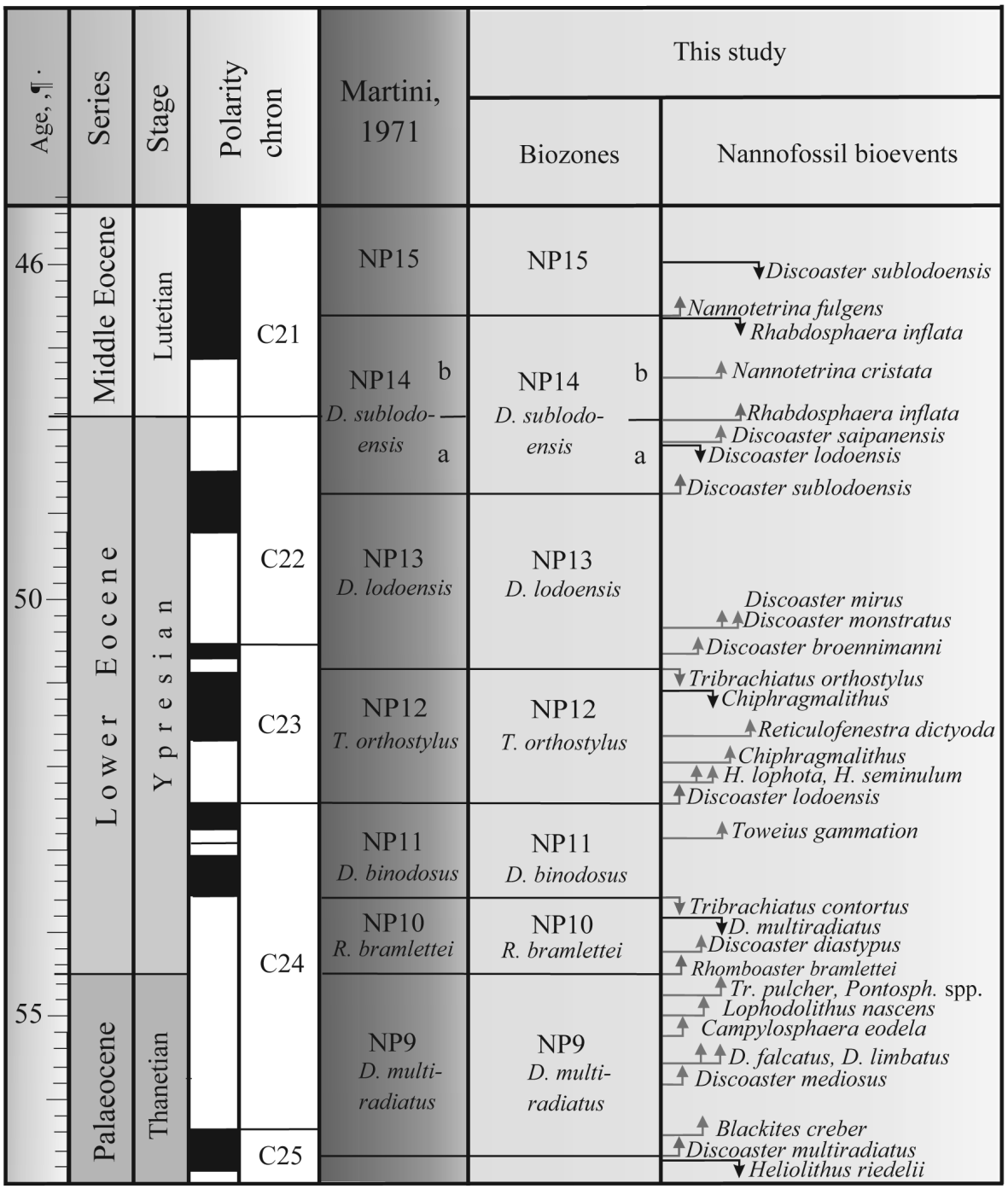
range of many species is refined.

References

Agnini, C., Fornaciari, E., Raffi, I., Rio, D., Röhl, U. & Westerhold, T. 2007. High-resolution nannofossil biochronology of middle Paleocene to early Eocene at ODP Site 1262: Implications for calcareous nannoplankton evolution. *Marine Micropaleontology*, **64**(3-4): 215-248.

Martini, E. 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. *In*: A. Farinacci (Ed.). *Proc. II Plankt. Conference. Roma, 1970. Tecnoscienza*, **2**: 739-785.

Westerhold, T., Röhl, U., Raffi, I., Forniaciari, E., Monechi, S., Reale, Bowles, V.J. & Evans, H. 2008. Astronomical calibration of the Paleocene time. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **257**(4): 377-403.



Paleocene hyperthermal events evidenced by calcareous nannofossils in Bulgarian sections

Kristalina Stoykova, Marin Ivanov

We have carried out a detailed, purposeful study of calcareous nannofossil assemblages of many Paleocene sections, located in northern Bulgaria. During this study, we have chanced upon some trustworthy evidences about the record of two Paleocene hyperthermal events – the mid-Paleocene biotic event (MPBE) and the Paleocene-Eocene thermal maximum (PETM).

MPBE. Until 2007, the MPBE was documented in the oceanic sections Shatsky Rise and Walvis Ridge only (Bralower *et al*., 2003; Zachos *et al*., 2004). The first land-based locality has been recently described by Bernaola *et al*. (2007) at Zumaia section (W Pyrenees). According to the last authors, the MPBE is positioned within the nannofossil zone NP6, at 4.5 m above the first occurrence of *Heliolithus kleinpellii* and 2 m below the C26r-C26n boundary. The nannoplankton response to this short-lived warming event suggests a shift from cooler mesotrophic to warmer oligotrophic conditions, as evidenced by relative abundance of selected calcareous nannofossil taxa (Bernaola *et al*., 2007).

We report here the presence of particular clay-rich interval in two Bulgarian sections, at Kladorub (NW Bulgaria) and Byala (NE Bulgaria), characterized by significant calcareous nannofossil changes. At Kladorub section, the distinct reddish clay layer (7-10 cm thick) occurred. It is situated within the upper part of NP 6 zone, above the first occurrence of *Discoaster bramlettei*, and is supposed to represent the sedimentary response of the MPBE. Calcareous nannofossil assemblage in the reddish layer is characterized by the abundance of *Heliolithus kleinpellii*, *Coccolithus pelagicus* and *Toweius eminens*. At Byala section, the clay interval is grayish, dominated by *Heliolithus kleinpellii*, *H. cantabriae*, *Toweius tovae* and *Ericsonia subpertusa*. Further isotope ($\delta^{13}C$) and paleomagnetic studies are needed to perform in mid-Paleocene sequences of both sections, in order to prove undoubtedly the presence of MPBE.

PETM. First biostratigraphic evidences about the expression of the PETM in three Bulgarian sections, Kladorub, Riben and Bozhuritsa, have been recently produced (Stoykova & Ivanov, 2005; Stoykova *et al*., 2005). Later on, it has been identified in the offshore section Yury Shimanov, W Black sea shelf. The PETM is marked by substantial lithological turnover – sharp decrease of the carbonate content, as well as by major calcareous nannofossil change across the Paleocene-Eocene boundary interval.

Samples have been collected usually at 0.5 m, but within the PETM interval the sampling resolution has been increased to 0.2 m. Calcareous nannofossils are common to abundant in all sections; only a few samples in the clay-dominated carbon dissolution interval contained rare, dissolution-resistant taxa or are barren of nannofossils. Preservation varies from very good to moderate.

The interval investigated spans from the upper part of NP9 zone to the lower part of NP10 zone. Calcareous nannofossil assemblages show a major turnover across the PETM interval. The P/E boundary coincides with the boundary between NP9/NP10 zones, which is placed at the first occurrence of *Rhomboaster bramlettei*. In all studied sections, this boundary is drawn clearly above the onset of the event (Fig. 1).

The upper part of NP9 zone reveals an extremely diverse and abundant nannofloral assemblage, comprising more than 30 species. It is characterized by the species having their first occurrence here, such as *Campylosphaera eodela*, *Lophodolithus nascens* and *Transversopontis pulcher*. The first occurrences of *Discoaster mediosus*, *D. falcatus* and *D. limbatus* are documented immediately below the PETM in Bulgarian sections, along with the last occurrence of *Scapholithus rhombiformis*. Across the P/E boundary interval, a series of extinctions is recorded. The most prominent is that of the genus *Fasciculithus*, which extinction is just below the onset of the PETM in NP9 zone.

Above the P/E boundary, *i.e*. in the Eocene part of PETM interval, the nannofossil association is dominated by *Rhomboaster bramlettei* (including *R. cuspis*), *R. spineus*, *Discoaster mediosus*, *D. falcatus*, *D. limbatus*, *D. araneus*, *D.* sp. aff. *anartios*. This association, called *Rhomboaster* spp.-*D. araneus* (RD) association, was recently distinguished and proposed as reliable stratigraphic proxy for the carbon isotope excursion at the PETM (Khan & Aubry, 2004).

The first occurrence of *Discoaster diastypus* is well above the PETM interval, in the middle part of NP10 zone. Neither *Tribrachiatus digitalis*, nor *Rhomboaster contortus* were recorded in our sections, which indicate the absence of the upper part of NP10 zone.

References

Bernaola, G., Baceta, J.I., Orue-Extebarria, X., Alegert, L., Martin-Rubio, M., Arostegui, J. & Dinares-Turell, J. 2007. Evidence of an abrupt environmental disruption during the mid-Paleocene biotic event (Zumaya section, western Pyrenees). *GSA Bulletin*, **119**(7-8): 785-795.

Bralower, T.J., Röhl, U., Petrizzo, M.R., Zachos, J., Premoli-Silva, I., Thomas, D. 2003. Constraining the control on carbonate accumulation in deep sea sequences: a global dissolution event in the early late Paleocene. *GSA Abstracts*, **35**(6): 205.

Khan, A. & Aubry, M.-P. 2004. Provincialism associated with the Paleocene/Eocene thermal maximum: temporal constraint. *Marine Micropaleontology*, **52**: 117-131.

Stoykova, K. & Ivanov, M. 2005. First data on the presence of the Paleocene-Eocene Thermal Maximum in Bulgaria. *C. R. Acad. Bulg. Sci*, **58**(3): 297-302.

Stoykova, K., Ivanov, M., Dinares-Turell, J. & Spirovelli, M. 2005. Paleocene-Eocene Thermal Maximum – biostratigraphic and stable isotope data in Bulgarian sections. *Bulg. Geol. Soc., 80th Anniversary, Ann. Conf.*: 21-23.

Zachos, J.C., Kroon, D. *et al*. 2004. Early Cenozoic extreme climates: the Walvis Ridge transect. *Proceedings ODP, Initial Reports,* **208** [online].

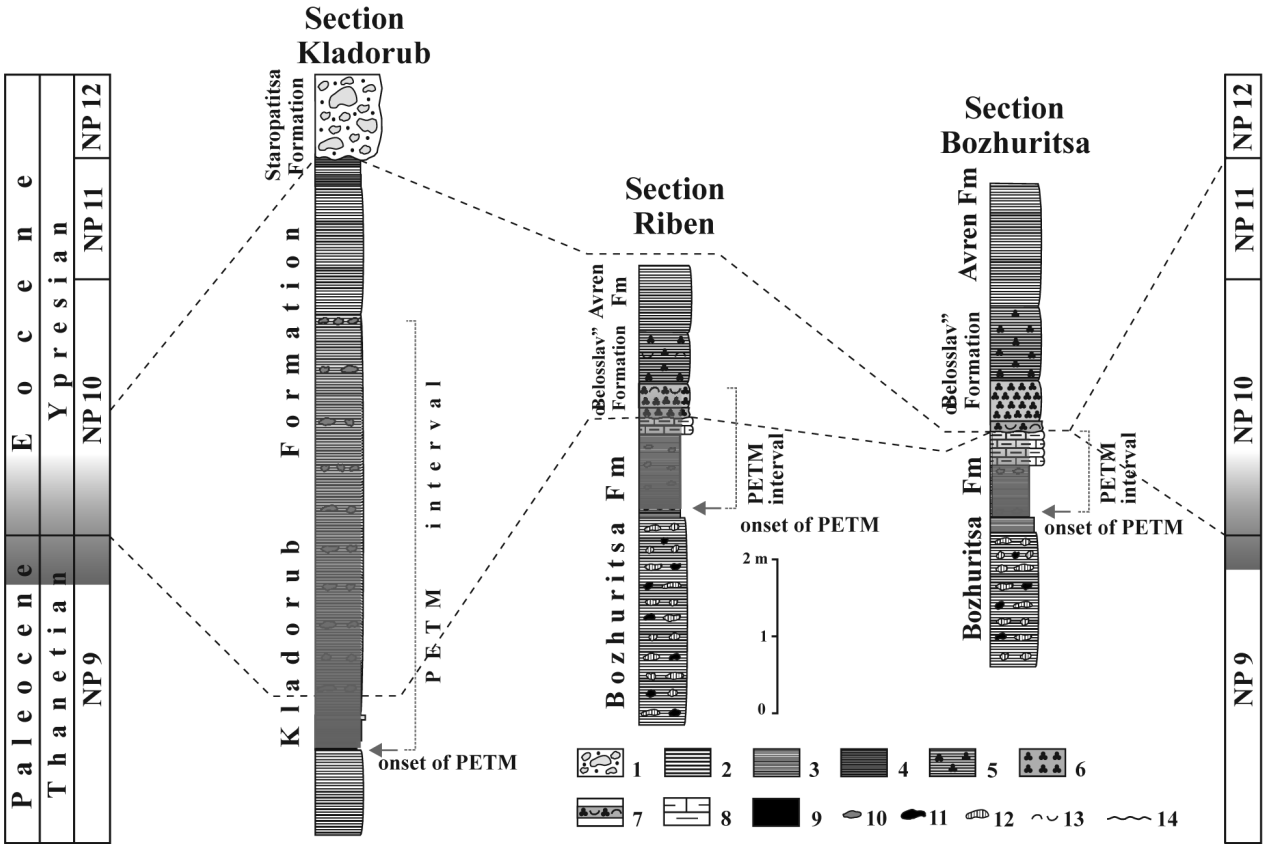


Figure 1: Correlation of the Bulgarian sections across the PETM interval: 1 – conglomerates; 2 – marls; 3 – clayey marls; 4 - rusty Fe-hydroxides-enriched marls; 5 – glauconitic marls; 6 – glauconites; 7 – glauconites with *Ostrea* shells (condensed level); 8 – marly limestones; 9 – dark-grey to black clays; 10 – Fe-hydroxide concretions; 11 – cherty concretions; 12 – carbonate concretions; 13 – *Ostrea* shells and shell detritus; 14 – wash-out surface

Changes in size distribution of the Early Jurassic nannofossil *Schizosphaerella* sp.: a new proxy for paleoenvironmental reconstructions?

Guillaume Suan, Emanuela Mattioli, Bernard Pittet

Experimental studies suggest that increasing carbon dioxide concentrations due to anthropogenic emissions will likely decrease the saturation state of the ocean with respect to calcium carbonate. This in turn should affect calcification of calcareous phytoplankton and could have profound and detrimental consequences for marine ecosystems (Orr *et al*., 2005). However, relationships between environmental conditions and phytoplankton calcification are still unclear, and remain, furthermore, largely untested in the geological record. *Schizosphaerella incertae sedis*, a probable calcareous dinoflagellate, whose range is earliest Jurassic to Late Jurassic, was one of the most important carbonate pelagic producers during the Jurassic period and thus represents an ideal nannofossil taxon to address the response of calcareous phytoplankton to past environmental changes.

Here we report size distribution measurements of *Schizosphaerella*, calcium carbonate contents, and stable isotopic compositions ($\delta^{18}O$ and $\delta^{13}C$) of well-preserved brachiopod shells from Lower Pliensbachian to Lower Toarcian hemipelagic deposits of the reference section of Peniche, Portugal. Nannofossil quantification indicates that most of the carbonate mud was not produced by nannofossils and was thus most likely imported from adjacent shallow-water platforms. The carbonate content and the size variations of *Schizosphaerella* both show a close parallelism all along the studied interval, and largely co-vary with the oxygen isotopic compositions of brachiopod shells. Maximum mean diameters of *Schizosphaerella* are recorded in the Late Pliensbachian, a period of cool climatic conditions, characterized by low carbon dioxide concentrations, while minimum sizes are recorded during the Early Toarcian oceanic anoxic event, which is commonly interpreted as a time of elevated seawater temperatures and exceptionally high carbon dioxide concentrations (McElwain *et al*., 2005). Though it is tempting to attribute these size variations in terms of changes in carbon dioxide concentrations and calcium carbonate saturation, it is still unclear if carbon dioxide directly controlled the biocalcification of this genus *via* carbonate saturation decrease, or indirectly via CO_2-induced changes in environmental conditions (*e.g*., temperature, salinity, runoff and nutrient input).

References

McElwain, J.C., Wade-Murphy, J. & Hesselbo, S.P. 2005. Changes in carbon dioxide during an anoxic event linked to intrusion of Gondwana coals. *Nature*, **435**: 479–482. doi:10.1038/nature03618.

Orr, J.C. *et al*. 2005. Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. *Nature*, **437**: 681–686.

How did orbital cycles influence coccolith size fluctuations? An example from the Early Pliensbachien (Early Jurassic) of Peniche (Portugal)

Baptiste Suchéras-Marx, Emanuela Mattioli, Bernard Pittet, Gilles Escarguel, Guillaume Suan

Though climate and environmental changes influence coccolithophorid (unicellular photoautotrophic algae) diversity, the relationships between fluctuation of size of coccoliths (small calcite plates produced by coccolithophorids) and environmental parameters remain unclear. In order to understand possible interactions between coccolith size variations and climate, a high-resolution (every 5 cm) biometric study of *Crepidolithus crassus* coccoliths has been performed in the Early Pliensbachian (Early Jurassic) hemipelagic deposits of Peniche (Portugal). Four of the six measured parameters have cyclic patterns that appear to be in phase opposition with calcium carbonate contents of the sediments. Spectral analyses performed on both size measurements and calcium carbonate contents show that the size variations of *C. crassus* coccoliths are related to Earth's eccentricity and precession orbital cycles. A closer analysis of morphologic disparity within the measured specimens through 'mixture analysis' reveals the existence of two distinct groups: a group called here 'small *crassus*' with a mean size of ~6.5 μm, and a group called 'large *crassus*' that averages a size of ~8.5 μm and dominates the assemblages during the studied interval.

C. crassus is generally interpreted as a deep-dweller (living in the lower photic zone) and its development could have been greatly dependant on light supply. Accordingly, the two morphotypes could have lived at different water-depths due to differential buoyancy capacities. To test this hypothesis, a geometrical coccosphere reconstruction model, based on coccolith biometry, was built and reveals a linear relationship between coccolith size and coccosphere mass, thus confirming that smaller coccoliths may have had overall higher buoyancies than larger ones. Consequently, it is suggested that changes in the water-column transparency may have been an important controlling factor on replacement between the two groups, and hence the resulting coccolith mean size. This transparency may have been mainly controlled by both carbonate platform input and storm recycled particulates in the photic zone, which could thus explain the inverse relationship between calcium carbonate contents and *C. crassus* size. Though, the 'small *crassus*' group appears to be more abundant in organic matter-rich levels, suggesting a preference for nutrient-rich water bodies.

Diachroneic first occurrence of *Marthasterites furcatus* in the Tethyan foreland basins (Outer Western Carpathians)

Lilian Švábenická

The depositional area of Tethyan foreland basins was situated along the SE margin of the NW European Platform, SE from its present location in the outer group of nappes, Western Carpathians. This area was probably connected with the epicontinental sea of the NW European Plate, as it is the case for the Boreal-Tethyan transitional path (Švábenická *et al*., 2002).

Here, the first occurrence (FO) of *Marthasterites furcatus* was observed at two differrent stratigraphic levels (Figure 1):

1. Lower Turonian, zone UC6b, Silesian Unit. *M. furcatus* appears between FO *Eprolithus moratus* and FO *Quadrum gartneri*.
2. Middle Turonian, zone UC9a, Waschberg Zone and Ždánice-Subsilesian Unit. Rare *M. furcatus* occurs approximately at the same level as *Lithastrinus septenarius*, after FO *Eiffellithus eximius* and before FO *Zeugrhabdotus biperforatus*.

The first occurrence of *M. furcatus* in the Middle Turonian was also observed in the epicontinental platform sediments of the Bohemian Cretaceous Basin. A seaway between this area and the Ždánice-Subsilesian Unit existed during the Cenomanian-Coniacian (Stráník *et al*., 1996). The depositional area of the Silesian Unit was situated further northern (Golonka *et al*., 2006).

References

Golonka, J., Gahagan, L., Krobicki, M., Marko, F., Oszczypko, N. & Slaczka, A. 2006. Plate Tectonic Evolution and Paleogeography of the Circum-Carpathian Region. *In*: J. Golonka & F. Picha (Eds). *The Carpathians and their foreland. Geology and hydrocarbon resources. AAPG Memoir*, **84**: 11-46.

Stráník, Z., Bubík, M., Čech, S. & Švábenická, L. 1996. The Upper Cretaceous in South Moravia. *Věstník Českého geologického ústavu*, **71**(1): 1-30.

Švábenická, L., Wagreich, M. & Egger, J. 2002. Upper Cretaceous calcareous nannofossil assemblages at a transect from the Northern Tethys to temperate realm in Central Europe. *In*: J. Michalík (Ed.). *Tethyan/Boreal Cretaceous Correlation*. Veda, Bratislava: 187-212.

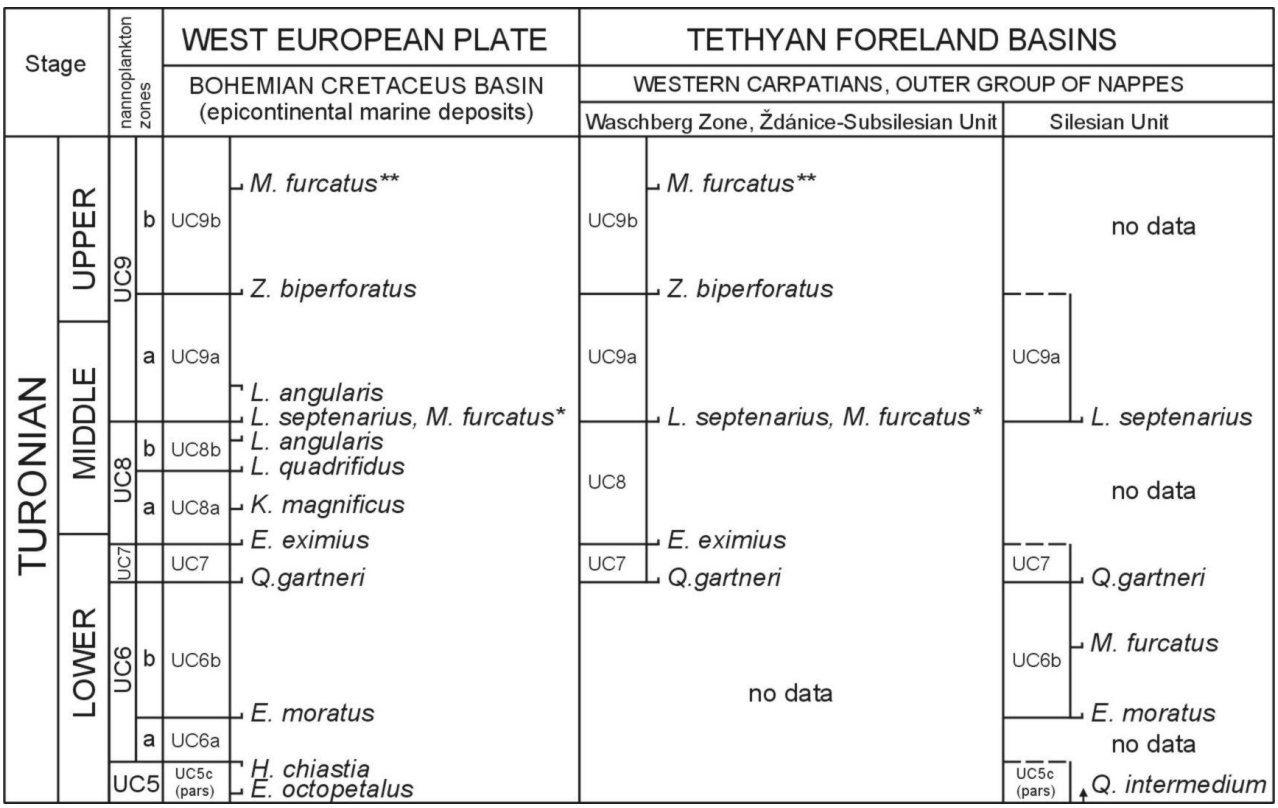


Figure 1: FO *Marthasterites furcatus* in the Outer Western Carpathians and Bohemian Cretaceous Basin. Data compiled by Stráník *et al*. (1996), Švábenická *et al*. (2002) and this work. *rare, **common

Campanian-Maastrichtian nannofossil palaeoecology in the Boreal Realm (Stevns-1 well, Danish Basin chalks)

Nicolas Thibault, Niels Schovsbo, Emma Sheldon, Lars Stemmerik, Finn Surlyk

To date, very few studies have documented the distribution of Campanian–Maastrichtian boreal nannofossil assemblages (Friedrich *et al*., 2005; Sheldon, 2006). A comparison of these studies with our knowledge from the Tropical Realm suggest that nannofossil species did not respond the same way in both realms to climate change. For instance, in the Tropical Realm, cool-water taxa seem to highlight the distinct climatic modes of the Maastrichtian (Thibault & Gardin, 2006, 2007), whereas no changes were noticed in their distribution in the Boreal Realm, with respect to climate change. This suggests that we need to better understand the palaeoecology of latest Cretaceous nannofossil taxa and especially that more data are needed from the Boreal Realm.

Recently, two boreholes (Stevns-1 and Stevns-2) were cored close to the famous K/T boundary section at Stevns Klint (Denmark), in order to investigate the sedimentology, biostratigraphy and geochemistry of the Upper Campanian-Maastrichtian chalk succession (Stemmerik *et al*., 2006; Schovsbo *et al*., in press). Drilled on a palaeo–seafloor high, the Stevns-1 well recovered 456 m of Upper Campanian to basal Danian sediments with 100% recovery. The nannofossil biostratigraphy of this core has recently been investigated by Sheldon (in press, a). A nearly complete biozonation was documented from the Upper Campanian to the K/T boundary, aside from the apparent absence of zone UC18 (Sheldon, in press, a). To date, Stevns-1 therefore represents the first continuous section in northwest Europe through the uppermost Cretaceous and the most expanded section worldwide. It is hoped that its study will constitute a reference in the Boreal realm for extensive biostratigraphy, chemostratigraphy and palaeoceanography. The succession consists of Upper Campanian–lowermost Maastrichtian bioturbated chalk with rare, thin clay beds succeeded by interbedded lower Maastrichtian chalk and marl. The Upper Maastrichtian part comprises almost pure chalk with some intervals of flint-rich chalk and few marly horizons (Stemmerik *et al*., 2006). The Stevns area has been buried to less than 600–700 m during post-Danian time and the lack of extensive-burial diagenetic overprinting makes these sediments highly suitable for geochemical and nannofossil palaeoecological analysis. The sites offer a unique opportunity to document the evolution of boreal nannofossil assemblage distribution with respect to climatic and environmental changes.

This study will focus on the distribution of calcareous nannofossil assemblages in Stevns-1 at two different timescales. At the sub-Milankovitch range, the distribution of nannofossils in marl and chalk will be examined in order to help deciphering the distinct conditions leading to the deposition of these alternating cycles (primary *vs*. diagenetic origin). At the million-year range, the evolution of the distribution of nannofossil assemblages are being compared to that of stable isotopes in order to unravel the palaeoecological response of these fossil organisms to climatic modes in the latest Cretaceous Boreal Sea.

References

Schovsbo, N.H., Rasmussen, S.L., Sheldon, E. & Stemmerik, L. In press. Correlation of carbon-isotope events in the Upper Cretaceous chalk. *Geological Survey of Denmark and Greenland Bulletin*.

Sheldon, E. 2006. *Upper Maastrichtian-Danian nannofossils of the Danish Central Graben and the Danish Basin: a combined biostratigraphic-palaeoecological approach*. Unpubl. PhD thesis, Univ. College London, London: 354pp.

Sheldon, E. In press, a. Upper Campanian-Maastrichtian calcareous nannofossil biostratigraphy of the Stevns-1 borehole, Denmark. *Journal of Nannoplankton Research*.

Sheldon, E. In press, b. Campanian-Maastrichtian nannofossil biostratigraphy of the Boreal Realm (Danish Basin chalks). 12th International Nannoplankton Association Meeting, Lyon, 7–10 September, 2008, abstracts volume. Cambridge University Press, Cambridge.

Stemmerik, L., Surlyk, F., Klitten, K., Rasmussen, S.L. & Schovsbo, N. 2006. Shallow core drilling of the Upper Cretaceous chalk at Stevns Klint, Denmark. *Geological Survey of Denmark and Greenland Bulletin*, **10**: 13–16.

Thibault, N., & Gardin, S. 2006. Maastrichtian calcareous nannofossil biostratigraphy and palaeoecology in the Equatorial Atlantic (Demerara Rise, ODP Leg 207 Hole 1258A). *Revue de Micropaléontologie*, **49**: 199–214.

Thibault, N. & Gardin, S. 2007. The late Maastrichtian nannofossil record of climate change in the South Atlantic DSDP Hole 525A. *Marine Micropaleontology*, **65**: 163–184.

Calcareous nannofossil biostratigraphy (Upper Bajocian–Lower Bathonian) of the Ravin du Bès section (Bas Auran, Subalpine Basin, SE France), evolutionary trends of *Watznaueria barnesiae* and new enigmatic morphotypes of the genus *Rucinolithus*

Daniele Tiraboschi, Elisabetta Erba

A biostratigraphic and evolutionary study based on calcareous nannofossils was performed on the Ravin du Bès section (Bas Auran area, SE France), proposed as formal candidate of Global Boundary Stratotype Section and Point (GSSP) for the base of the Bathonian stage (Fernàndez-Lòpez *et al*., 2007). Semiquantitative estimates of total nannofloral abundance and single species abundance were carried out. The following biohorizons were identified and calibrated to ammonite biostratigraphy: the first occurrence (FO) of *Watznaueria* aff. *W. barnesiae*, the FO of *Pseudoconus enigma*; the FO of *Rucinolithus* sp.; the last occurrence (LO) of *Hexalithus magharensis*; the FO of *Stephanolithion speciosum octum* and the FO of *Watznaueria barnesiae*. These results, consistent with biostratigraphic schemes previously proposed (Erba, 1988, 1990; de Kaenel & Bergen, 1993; de Kaenel *et al*., 1996; Bown & Cooper, 1998; Mattioli & Erba, 1999) confirm that calcareous nannofossils are good biostratigraphic markers for the Bajocian/Bathonian boundary interval. Moreover, the finding of *P. enigma* within the sub-Mediterranean province allows a direct calibration between Tethyan and Boreal nannofossil events and biozones.

This study showed an evolutionary trend from *Watznaueria communis* to *Watznaueria barnesiae* that seems to support the theory of punctuated equilibrium rather than a phyletic gradualism.

We also documented the occurrence of new morphotypes of uncertain polycycloliths. These enigmatic nannoliths are very similar to specimens of the Cretaceous taxon *R. terebrodentarius*, whose peculiar structure arises doubts on its origin. In fact, as previously speculated (Tremola & Erba, 2002; Erba, 2004), *R. terebrodentarius* nannoliths might be the result of $CaCO_3$ precipitates or biocalcification by bacteria under peculiar oceanographic conditions, rather than products of coccolithophorid algae.

References

Bown, P.R. & Cooper, M.K.E. 1998. Jurassic. *In*: P.R. Bown (Ed.). *Calcareous Nannofossil Biostratigraphy*. British Micropalaeont. Soc. Publ. Series. Kluwer Academic Publishers, London: 34-85.

de Kaenel, E. & Bergen, J.A. 1993. New early and Middle Jurassic coccolith taxa and biostratigraphy from the eastern proto-Atlantic (Morocco, Portugal and DSDP Site 547B). *Eclogae Geol. Helv*., **86**: 861-907.

de Kaenel, E., Bergen, J.A. & von Salis Perch Nielsen, K. 1996. Jurassic calcareous nannofossil biostratigraphy of western Europe. Compilation of recent studies and calibration of bio-events. *Bull. Soc. Geol. Fr*., **167**: 15-28.

Erba, E. 1988. Calcareous nannofossils from the Bas Auran section. *In*: M. Innocenti, C. Mangold, G. Pavia & H. Torrens (Eds). *A proposal for the formal ratification of the basal boundary stratotype of the Bathonian stage based on a Bas Auran section (S.E. France). 2nd International Symposium on Jurassic Stratigraphy*: 333-346.

Erba, E. 1990. Calcareous nannofossil biostratigraphy of some Bajocian sections from Digne area (SE France). *Mem. Descr. Carta geol. Ital*., **40**: 237-356.

Erba, E. 2004. Calcareous nannofossils and Mesozoic Oceanic Anoxic Events. *Marine Micropaleontology*, **52**: 85-106.

Fernàndez-Lòpez, S.R., Pavia, G., Erba, E., Guiomar, M., Henriques, M.H., Lanza, R., Mangold, ?, Morton, N., Olivero, D. & Tiraboschi, D. 2007. Formal proposal for the Global Boundary Stratotype Section and Point (GSSP) of the Bathonian Stage, at the base of the Zigzag Zone in the Ravin du Bès Section (Bas-Auran, Sudalpine Basin, SE France). *International Subcommission of Jurassic Stratigraphy. Bathonian Working Group Ballot*: 1-43.

Mattioli, E. & Erba, E. 1999. Synthesis of calcareous nannofossil events in Tethyan Lower and Middle Jurassic successions. *Riv. Ital. Paleontol. Stratigr*., **105**: 373- 376.

Tremolada, F. & Erba, E. 2002. Morphometric analyses of Aptian *Assipetra infracretacea* and *Rucinolithus terebrodentarius* nannoliths: Implications for taxonomy, biostratigraphy and paleoceanography. *Marine Micropaleontology*, **44**: 77-92.

Quaternary calcareous nannofossil biostratigraphy and stable isotope stratigraphy (C and O) from middle slope, northern portion of Campos Basin, Brazil

Felipe Antonio de Lima Toledo, Lucio Riogi Tokutake

This work presents paleoenvironmental interpretations for the last 130 kyr in one middle slope core located in the northern portion of the Campos Basin. We used the method of triangular co-ordinate diagram applied to calcareous nannofossils. This method is used to estimate environmental characters by plotting nannofossil quantitative data (Tokutake & Toledo, 2007; Toledo *et al*., 2005). It can be useful for paleoceanographic and paleoproductivity studies. The same samples were collected for calcareous nannofossils and stable isotopes (C and O).

Calcareous nannofossil results show an absolute predominance of three taxa: *Florisphaera profunda*, *Emiliania huxleyi* and *Gephyrocapsa* spp. Some estimates were made by means of comparisons between the same species plotted in Okada's triangle (Okada, 1992) in order to compare the effect of temperature, depth and nutrient availability on coccolithophore community.

Isotope stratigraphy reveals a good correlation with $\delta^{18}O$ isotopic stages. The carbon isotope stratigraphy data shows a good correlation with abundance variations of *Gephyrocapsa* spp., indicating variations in the nutrient availability.

References

Okada, H. 1992. Biogeographic control of modern nannofossil assemblages in surface sediments of Ise Bay, Mikawa Bay and Kumano-Nada, off coast of central Japan. *Memorie Di Scienze Geologiche*, **43**: 431-449.

Tokutake, L.R. & Toledo, F.A.L. 2007. Bioestratigrafia de nanofósseis calcários e Estratigrafia de Isótopos (C e O) do Talude médio, Quaternário, porção N da Bacia de Campos, Brasil. *In*: Ismar Carvalho, Rita Cassab, Cibele Schwanke, Marcelo Carvalho, Antonio Fernandes, Maria Rodrigues, Marise Carvalho, Mitsuru Arai & Maria Emília Oliveira (Eds). *Paleontologia: Cenários da Vida*, **2**. Interciência Ltda., Rio de Janeiro: 395-410.

Toledo, F.A.L., Quadros, J.P., Santos, E.C. & Costa, K.B. 2005. Análise paleoambiental em estudos quantitativos de nanofósseis calcários: aplicação do diagrama triangular de coordenadas para o sudoeste do oceano atlântico. *10th ABEQUA Congress, Gurapari*, **1**.

Seasonal control on *Emiliania huxleyi* coccolith calcification in the Aegean Sea (E Mediterranean)

Maria V. Triantaphyllou, Margarita D. Dimiza, Eva Krasakopoulou, Elisa Malinverno, Valia Avgoustidi, Valia Lianou

Morphometric analysis has been performed on *Emiliania huxleyi* coccoliths from different locations of the Aegean Sea (water and sediment trap samples). The modern Aegean Sea is one of the most oligotrophic parts in the eastern Mediterranean Sea and a major area for deep water formation (Zervakis *et al*., 2000; Lykousis *et al*., 2002).

A seasonal morphological variation has been observed in several *E. huxleyi* type A specimens, collected from discrete water samples in the Aegean Sea. The pattern revealed displays an increase in the size of coccoliths and coccospheres, including a thicker inner tube-cycle (INT) of the distal shield, during winter and early spring months, when the lowest SSTs (15-18˚C) are occurring and higher HCO_3^- concentrations have been recorded.

The morphology of *E. huxleyi* shows considerable variation associated with size increase and, more specifically, exhibiting overcalcified specimens.

Analogous highly-calcified specimens have been recorded during Holocene colder intervals, and have been considered to represent a primary feature of the Aegean Sea.

Our initial results hint at a possible link between higher bicarbonate ion concentration, lower temperatures and stronger coccolithophore calcification in the field.

Since a number of other factors such as nutrients and light intensity affect coccolithophore calcification, the above evidence still remains to be further investigated.

References

Lykousis, V., Chronis, G., Tselepides, A., Price, N.B., Theocharis, A., Siokou-Fragou, I., Wambeke, F. van, Danovaro, R., Stavrakakis, S., Duineveld, G., Georgopoulos, D., Ignatiades, L., Souvermezoglou, A. & Voutsinou-Taliadouri, F. 2002. Major outputs of the recent multidisciplinary biogeochemical researches undertaken in the Aegean Sea. *J. Mar. Syst*., **33-34**: 313-334.

Zervakis, V., Georgopoulos, D. & Drakopoulos, P.G. 2000. The role of the North Aegean in triggering the recent Eastern Mediterranean climatic changes. *J. Geophys. Res*., **105**: 26103-26116.

Calcareous nannofossil evidence for Marine Isotopic Stage 31 (1Ma) in ANDRILL MIS Core (western Ross Sea, Antarctica)

Giuliana Villa, Davide Persico, Sherwood S. Wise, Alessia Gadaleta

During the austral summer 2006, the ANDRILL Program recovered a 1285-m-long succession of cyclic glaciomarine sediments from the McMurdo Ice Shelf (MIS). The aim of the MIS Project was to obtain continuous Neogene (*c*.0-10Ma) glacial, glaciomarine, volcanic and biogenic sediments that have accumulated in the region of the MIS (Ross Sea), nourished by ice flowing from the East Antarctic Ice Sheet (EAIS) outlet glaciers in the Transantarctic Mountains.

The MIS AND-1B drill core represents the longest and most complete (98% recovery) geological record from the Antarctic continental margin to date, and will provide a key reference record of climate and ice-sheet variability through the Late Neogene; detailed investigations of this record will contribute for improving our knowledge of Antarctica's influence on global climate.

Preliminary on-ice analysis of the smear slides of the Andrill core revealed calcareous microfossils (dinoflagellates, calciosponge spicula and small foraminifera) occurring with variable concentrations. The presence of thoracosphaerid fragments in the smear slides of the first 600mbsf (Quaternary), probably belong to the species *Thoracosphaera saxea* (Stradner, 1961) and *T. heimi* (Kamptner, 1941) and other, potentially undescribed, species (Villa & Wise, 1998), suggesting either a peculiar adaptation to this environment, due to their ability to develop cysts, or warmer conditions at the time of their deposition, or a combination of both. However, they represent an additional element to use, along with the other proxies for inferring palaeoenvironmental conditions of the core.

Subsequent shore-based analyses of 100 samples from 86-96mbsf revealed for the first time the presence of Pleistocene coccolithophorids at these high southern latitudes (77˚S), including: *Cocco. pelagicus*, small *Gephyrocapsa*, *Retic. asanoi*, *Pseudoemil. lacunosa*, *Dictyo. productus*, *Retic.* sp., *R. minutula*, *Thoraco.* spp. Tertiary reworked species include: *Discoaster* sp., *Retic. hampdenensis*, *R. pseudoumbilica*, *Dictyo. antarcticus*, *Cyclicargo. floridanus*, *Geminilith. rotula*, *Transverso. sigmoidalis* and the Upper Cretaceous *Rein. levis*. As the lower temperature limit for living calcareous nannoplankton is 2.5˚C, the presence of nannofossils from 86 to 96mbsf, though rare, is an indication of ice-free conditions and sea surface temperatures warmer than today in the Ross Sea. The presence of numerous volcaniclastic units and bio-siliceous sediments from 86.6 to 92.5mbsf indicate an extended period of open-water conditions, with no sea ice beyond the calving line.

An $^{40}Ar/^{39}Ar$ age of 1.015±0.004Myr on pumice at 85.20mbsf confirms the age assignment given by diatom biostratigraphy (1.07Ma) for this interval. Accordingly, the short normal magnetozone between 84.97 and 91.13mbsf is correlated with the Jaramillo Subchron (C1r.1n; Wilson *et al*., 2006).

The presence of nannofossils in the biogenic interglacial sediments is consistent with a warm episode of surface waters and open-marine conditions during the Jaramillo Subchron, at ~1Ma, which corresponds with Marine Isotope Stage 31 (Naish *et al*., 2007). The 'superinterglacial' associated with Marine Isotope Stage 31 was the last significant warm interglacial of the obliquity-dominated world, and may represent a precursor to the high-amplitude, eccentricity-dominated cycles that followed the mid-Pleistocene climate shift. Climate proxies from other studies around Antarctica, like nannofossils and oxygen isotope stratigraphy at ODP Site 1165 (Villa *et al*., 2008), and the presence of *Thoracosphaera* in a shelly carbonate sequence at Cape Roberts 1 (Villa & Wise, 1998), also support the idea of a warming event during this time, suggesting that it was areally extended around the Antarctic Continent, implying a total or partial collapse of the MIS. The warm interval during the Jaramillo Subchron shows that these areas were more climatically dynamic than previously thought and calls into question the notion that the EAIS has remained in a stable polar condition since the late Neogene. The warm surface water event reported here is especially significant, given its proximal position to the Antarctic ice sheet.

References

Kamptner, E. 1941. Die Coccolithineen der Südwestküste von Istrien. *Annalen des Naturhistorischen Museums in Wien*, **51**: 54–149.

Naish, T., Powell, R., Levy, R., Henrys, S., Krissek, L., Niessen, F., Pompilio, M., Scherer, R., Wilson, G. & the ANDRILL-MIS Science Team 2007. Synthesis of the Initial Scientific Results of the MIS Project (AND-1B Core), Victoria Land Basin, Antarctica. *Terra Antarctica*, **14**(3): 317-327.

Stradner, H. 1961. Vorkommen von Nannofossilien im Mesozoikum und Alttertiär. *Erdöl-Zeitschrift*, **77**: 77–88.

Villa, G. & Wise, S.W. 1998. Quaternary calcareous nannofossils from the Antarctic region. *Terra Antarctica*, **5**(3): 479-484.

Villa, G., Fioroni, C., Pea, L., Bohaty, S. & Persico, D. Submitted. Middle Eocene-Late Oligocene climate variability: calcareous nannofossil response at Kerguelen Plateau, Site 748. *Marine Micropaleontology*.

Wilson, G., Levy, R., Browne, G., Dunbar, N., Florindo, F., Henrys, S., Graham, I., McIntosh, W., McKay, R., Naish, T., Ohneiser, C., Powell, R., Ross, J., Sagnotti, L., Scherer, R., Sjunneskog, C., Strong, C.P., Taviani, M., Winter, D. & the ANDRILL MIS-Science Team 2007. Preliminary Integrated Chronostratigraphy of AND-1B Drill Core, ANDRILL McMurdo Ice Shelf Project, Antarctica. *Terra Antarctica*, **14**(3): 297-316.

Paleocene nannofossils from the Odessa Shelf (south-western Black Sea region)

Dennis Daniel Waga, Aida Sergeivna Andreeva-Grigorovich

In 2006 -2007, two boreholes (Odeska-6 and Odeska-20) were drilled on the south-western part of the Ukrainian sector of the Black Sea. According to the geophysical well-log data, borehole Odeska-20 recovered sediments of the Paleocene (1151-1621 m) and Eocene (692-1151 m).

We studied nannofossils from the Paleocene interval of both boreholes. The identified nannofossils had a moderate to bad preservation. Four nannofossil zones of Martini (1971) and Okada & Bukry (1980) were identified: combined *Cruciplacolithus tenuis-Chiasmolithus danicus* zone (NP2-NP3/CP1b-CP2), *Fasciculithus tympaniformis* (NP5/CP4), *Heliolithus kleinpellii* (NP6/CP5) and *Heliolithus riedelii* (NP8/CP7).

The combined *C. tenuis-C. danicus* zone (NP2-NP3/CP1b-CP2) was distinguished only in borehole Odeska-6 (int. 1544-1635 m). The most common species are: *Coccolithus pelagicus*, *Neochiastozygus* sp., *Toweius* sp., *Thoracosphaera* sp., *Sphenolithus* sp., *Zygodiscus* sp., fragments of *Braarudosphaera*, *Cruciplacolithus* cf. *C. tenuis*, *Coccolithus* sp., *Chiasmolithus* aff. *C. danicus*. The interval is also characterized by a large number of reworked Cretaceous species: *Watznaueria barnesiae*, *Arkhangelskiella cymbiformis*, *Micula staurophora*, *Broinsonia parca*, *Kamptnerius*? sp., *Eiffellithus* sp., *Gartnerago* sp., *etc*. The lower two samples (3232, 3284) from the interval 1625.1-1625.2 m are assigned to the *C. tenuis-C. danicus* zone, based on the presence of *C. pelagicus* and *Neochiastozygus* sp.

The *F. tympaniformis* (NP5/CP4) is present in both boreholes: Odeska-6 (int. 1477.55-1548 m) and Odeska-20 (int. 1544-1563.1 m). The typical species are: *F. tympaniformis*, *F.* cf. *F. ulii*, *Ellipsolithus* cf. *E. macellus*, *Prinsius* sp., *Braarudosphaera bigelowii*, *C. pelagicus*, *F.* cf. *F. involutus*, *Toweius* sp., *T. pertusus* (*craticulus*), *T. eminens*, *Ericsonia subpertusa*, *F. pileatus*?, *Fascic.* sp. The intervals are also characterized by the same reworked species as in the previous zone, but they are much rarer.

The *H. kleinpellii* (NP6/CP5) zone in Odeska-6 (1475.55) and Odeska-20 (1513.22-1544 m) is identified thanks to the FO of *H.* cf. *H. kleinpellii*. The nannofossil assemblage of the zone is characterized by *Fascic.* sp., *F.* cf. *F. ulii*, *F.* cf. *F. shaubii*, *Heliolithus* sp., *C. pelagicus*, *Toweius* sp., *Thoracosphaera* sp., *Ericsonia robusta*, *Prinsius* sp., *Markalius inversus*?, *Chiasmolithus bidens*, *Coccolithus eopelagicus*, *Chiasmolithus consuetus*. The upper limit of the zone was not identified. It was set within the lower limit of the subsequent *H. riedelii* (NP8/CP7) zone.

H. riedelii (NP8/CP7) zone was established in both boreholes Odeska-6 (int. 1424.21419.2 m) and Odeska-20 (int. 1513.22-1457.95 m). Its lower limit was determined through the FO of *H. riedelii*. In borehole Odeska-20, it is established within sample 5 (1457.95 m) where only four species were identified: *Thoracosphaera* sp., *Toweius* sp., *C. pelagicus* and reworked species *W. barnesiae*. Sample 5 was collected from a interval (1452.25-1469.25 m) that is presented by non-carbonate grey sandstones and siltstones. The identified zone is presented by an assemblage of *T. craticulus*, *Prinsius* sp., *C. pelagicus*, *Thoracosphaera* sp., *Heliolithus conicus*, *Sphenolithus* cf. *S. anarrhopus*, *Prinsius bisulcus*, *C. eopelagicus*, *H. kleinpellii*, *Discoaster* cf. *D. elegans*, *Fascic.* sp., *F. tympaniformis*, *Heliolithus cantabriae*, *Zygodiscus sigmoides*, *Pontosphaera* sp., *Ericsonia robusta*, *Chiasmolithus* cf. *C. consuetus*, *M. inversus*, *Fascic.* cf. *F. billii*, *Chiasmolithus danicus*, *Sphenolithus primus*, *Discoaster* sp. In the *H. riedelii* zone, the number of reworked species decreases; they are represented by *W. barnesiae*, *M. staurophora*, *Micula* sp., *Gartnerago* sp., *Eiffellithus* sp., *Cretarhabdus conicus*?

According to the Stratigraphic Scheme of Southern Ukraine (Makarenko *et al*., 1993) the combined *C. tenuis-C. danicus* (NP2-NP3/CP1b-CP2) zone correlates with the lower part of the Bilokamian stage (Danian of the Geological Time Scale of Gradstein *et al*., 2004). The *F. tympaniformis* (NP5/CP4), *H. kleinpellii* (NP6/CP5) and *H. riedelii* (NP8/CP7) zones correlate with the Kachian (Selandian-Thanetian) stage.

Based on nannofossil research it is possible to suggest that there are two unconformities. One is present within the Bilokamian stage (borehole Odeska-6) and corresponds to the zones *E. macellus* (NP4) and lower part of the *F. tympaniformis* (NP5/CP4) that are missing. The second one is present within the Kachian stage and corresponds to the absence of the *Discoaster mohleri* zone (NP7/CP6). With the help of the Geological Time Scale (Gradstein *et al*., 2004) the relative duration for the first unconformity is estimated to about 3.2 Myr; the second one lasted around 0.7 Myr.

References

Gradstein, F.M., Ogg, J.G. & Smith, A.G. 2004. The Paleogene Period. *A Geological Time Scale*. Cambridge University Press, Cambridge: 310-322.

Martini, E. 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. *Proceedings II Plankton Conference, Roma*. *Tecnoscienza*, **2**: 739-785.

Makarenko, D.E., Zelinskaya, V.A., Zernetskiy, B.F. *et al*. 1993. *Stratigraphic Scheme of Paleogene sediments of Ukraine for the geological maps of the new generation*. Graphic additions, Kiev.

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.

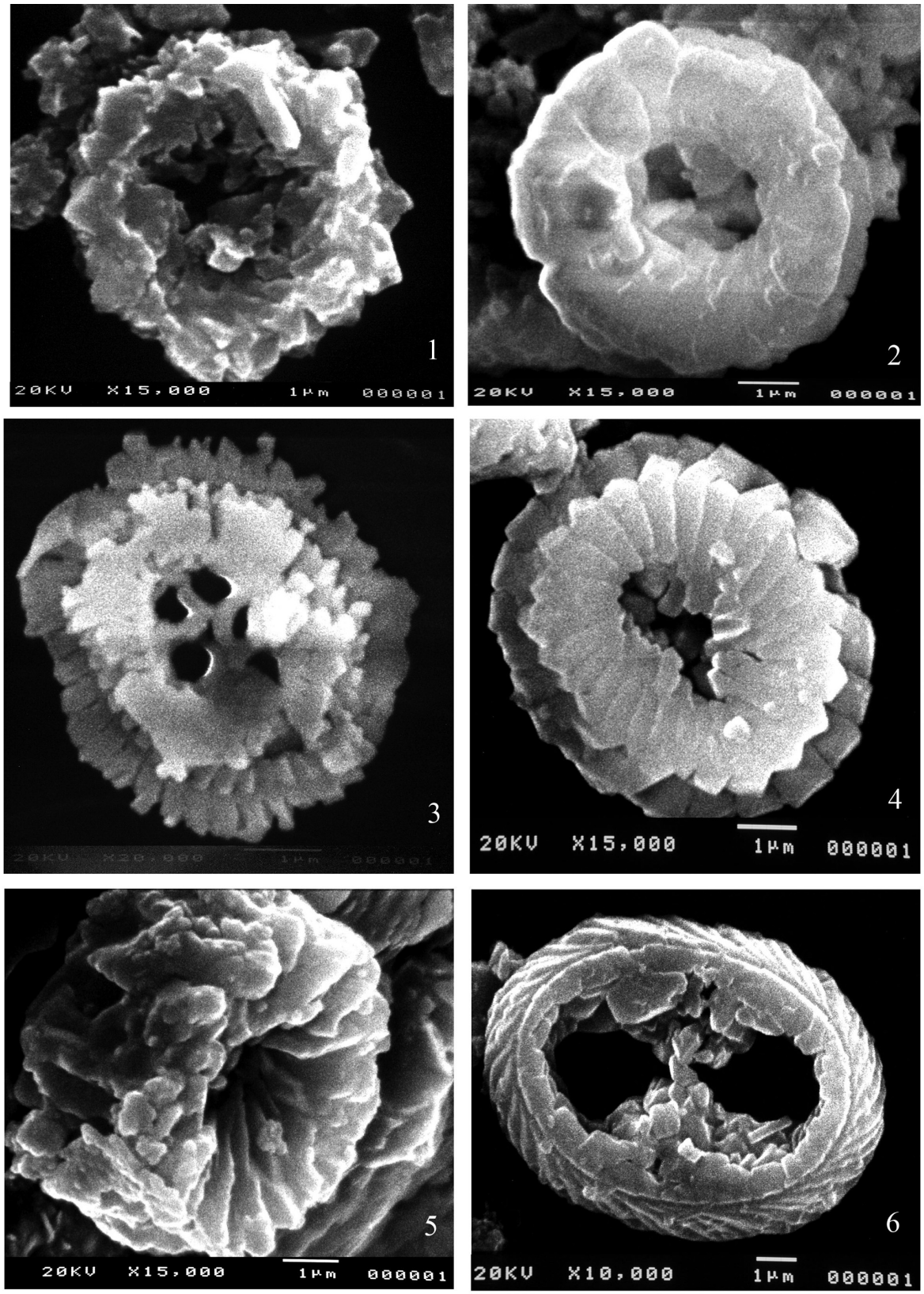


Figure 1: SEM photographs of nannofossils from the Odeska Gas Field.
1. *Heliolithus* sp. (Borehole Odeska-20, 1489m); 2. *Ericsonia* sp. (Borehole Odeska-6, 1424.2m); 3. *Toweius tovae* (Borehole Odeska-6, 1424.2m); 4. *Prinsius bisulcus*? (Odeska-6, 1424.2m); 5. *Fasciculithus tympaniformis* (Borehole Odeska-20, 1489m); 6. *Neochiastozygus* sp. (Borehole Odeska-6,, 1424.2m)

Calcareous nannofossil biostratigraphy of the Buchak and Kiev Formations (Middle Eocene) of the central part of the Ukrainian Shield

Dennis Daniel Waga, Aida Sergeivna Andreeva-Grigorovich

Paleogene sediments are widely distributed above the crystalline rocks of the Ukrainian Shield. The most complete section of the Paleogene is located in the Southern Krivbass (Inguletsk quarry). The Middle Eocene is represented here by the Voikovska, Rahmanivska, Malynivska, Staroinguletska and Borisfenska suites (Berezovskiy, 2000). The first three correspond to the Buchak Formation of the Lutetian stage; the Staroinguletska suite is equivalent with the Kiev Formation of the Bartonian stage. The Borisfenska suite is assigned to the Lower Oligocene (Berezovskiy, 2000). Despite a long period of paleontological research within this area, the age of most of the suites remains equivocal. Doubts mostly concern the age of the upper part of the Staroinguletska suite (Berezovskiy, 2000).

We studied nannofossils from sediments of the Malynivska (samples 1-9) and Staroingiletska (samples 10-19) suites (Andreeva-Grigorovich *et al*., 2003; Waga, 2007). Both formations are represented by terrigeneous (sandstone-clayey) and clayey (silty-mudstone) sediments and constitute a total thickness of about 40m. Samples 1-4 from the lower half of the Malynivska suite did not contain any nannofossils. Nannofossils appear in the upper part of the suite (samples 5-7) where they are represented by an association of moderate- towell-preserved species: *Coccolithus pelagicus*, *Coccolithus eopelagicus*, *Ericsonia formosa*, *Ericsonia fenestrata*, *Reticulofenestra minuta*, *Discoaster germanicus*, *Discoaster deflandrei*, *Discoaster barbadiensis*, *Discoaster elegans*, *Discoaster kuepperi*, *Nannotetrina* sp., *Nannotetrina fulgens*, *Chiasmolithus solitus*, *Rhabdosphaera* sp., *Transversopontis pulcheroides*, *Neococcolithus dubius*, *Discoaster binodosus binodosus*, *Discoaster distinctus*, *Reticulofenestra dictyoda* (Waga, 2007). These samples were assigned to the *Nannotetrina fulgens* (NP15) of Martini (1971) or *Nannotetrina cristata* (CP13) of Okada & Bukry (1980) zonation.

The lower part of the Staroinguletska suite (samples 8-14) is characterized by similar species, but with the FO of *Rhabdosphaera truncata*, *Chiasmolithus consuetus*, *Chiphragmalithus cristatus*, *Rhomboaster* sp., *Coronocyclus nitescens*, *Zygrhablithus bijugatus*, *Rhabdosphaera creber* (Waga, 2007). This section was correlated with the upper part of the *Nannotetrina fulgens* (NP15) zone of Martini (1971).

Based on the FO of *Discoaster bifax*, the following interval (samples 15-19) was assigned to the *Discoaster bifax* (CP14a) Subzone of Okada & Bukry (1980). Apart from the zonal marker the most common species are: *Transversopontis pulcheroides*, *Neococcolithus dubius*, *Reticulofenestra dictyoda*, *Discoaster tanii nodifer*, *Coccolithus pelagicus*, *Reticulofenestra umbilica*, *Chiasmolithus grandis*, *Reticulofenestra hilliae*.

In the paleoecological aspect, within the study area during the Middle Eocene existed a shallow to moderately-deep paleobasin with warm to tropical conditions. Both nannofossil zones contain species which, according to the classification of Dmitrenko (1993), are typical for tropical ecological zone (*Discoaster deflandrei*, *Sphenolithus moriformis*, *Cyclicargolithus formosus*, *Discoaster barbadiensis*, *Discoaster binodosus binodosus*, *Chiasmolithus grandis*, *etc*.). On the basis of the paleobionomical classification (Baldi-Beke, 1983), nannofossil assemblages are characteristic of an open-ocean (*Coccolithus*, *Cyclicargolithus*, *Zygrhablithus*, *Discoaster tanii nodifer*) to a shallow-water (*Rhabdosphaera*, *Pontosphaera*) environment (Waga, 2007).

These results allow us to conclude that the sediments of the Staroinguletska suite (Kiev Formation), which were earlier believed to be equivalents of the Bartonian stage, can be correlated indeed with both the Lutetian and the Bartonian stages of the Geological Time Scale (2004).

References

Andreeva-Grigorovich, A.S., Berezovskiy, A.A. & Waga, D.D.O. 2003. *Nannoplankton and Mollusks from the Eocene deposits of the Kryvoy Rog Iron Basin. Theoretical and practical aspects of the modern stratigraphy of the Phanerozoic of Ukraine*. Kiev: 3-5.

Baldi-Beke, M. 1984. The nannoplankton of the Transdanubian Paleogene formations. *Inst. Geol. Hungaricum., Pal*., **43**: 153-222.

Berezovskiy, A.A. 2000. Local stratigraphic scheme of Paleogene of the Kryvoy Rog Basin. *Biostratigraphical and paleoecological aspects of event stratigraphy*. Kiev: 43-45.

Dmitrenko, O.B. 1993. *Biogeography of the Atlantic and Indian Oceans in Cainozoic based on nannoplankton*. Nedra, Moscow: 175pp.

Gradstein, F.M., Ogg, J.G. & Smith, A.G. 2004. The Paleogene Period. *A Geological Time Scale*. Cambridge University Press, Cambridge: 310-322.

Martini, E. 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. *Proceedings II Plankton Conference, Roma. Tecnoscienza*, **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.

Waga, D.D.O. 2007. *The Paleocene-Eocene nannoplankton of the East European Platform: Paleontology and Stratigraphy*. PhD thesis, Nation. Acad. of Science of Ukraine, Inst. of Geol. Sciences, Kiev: 268pp.

Electronic nannoplankton, version #4: a demonstration

Sherwood W. Wise, Jr., Matthew Olney, Mitchener Covington, Theodore Bibby, Victoria M. Egerton, Shijun Jiang, Denise Kulhanek, Sarah Ramdeen, Patricia A. Sims, Audra Wood, Alexander Davis, David R. Davenport, Nicole Doepler, William Falcon, Carlos Lopez, C. T. Pressley, Hans M. Schrader, Olivia Swedberg, David M. Harwood & many others

Since its release at INA9 in Parma, Italy, INA CD-ROM Series, No. 1, then entitled *Electronic Calcareous Nannofossils*, has sold out with some 150 copies distributed. All proceeds go to the INA. The original motivation behind the product was to provide an electronic package that could be used by micropaleontologists at sea and in remote locations such as Antarctica and elsewhere where hard-copy literature resources are limited. As such, various versions have been used aboard the Integrated Ocean Drilling Program's *JOIDES Resolution* for the past 15 years, and additional databases have been added (see descriptions below in Wise *et al*., 2002, 2003, 2004). The product is now used as well for classroom teaching and by industry professionals, including lab-based or well-site paleontologists making or refining taxonomic identifications at the microscope. The interactive databases are displayed *via* a custom software program called *BugCam* written in Visual Basic for use on PCs. No other program is needed to run the databases, hence they are stand-alone, self-contained packages as provided on the CD.

Version 4 will be released and demonstrated at INA12 in Lyon, France. In addition to the packages and databases already incorporated in previous versions, it will include the prototype of an interactive electronic database for Cenozoic Antarctic Marine Diatoms (called '*DiatomWare*') along with a bibliography for that literature. Diatom specialists have long noted that their fossils also extend down into the 'nanno' size range, hence we are pleased to accommodate them with the inclusion of this database on this latest *NannoWare* CD. Over 500 taxa, grouped into 23 families or 'family groups' and 105 genera are included to date in *DiatomWare*, which has been described in some detail along with a picture of the interface by Wise *et al*. (2007). Biogeographic coverage lies within the present-day Southern Ocean, extending from the interior seas and continental shelves of Antarctica to the deep sea as far north as the Subtropical Front, which separates surface waters originating in the tropics from those of Antarctic origin.

Holders of the earlier Versions 1, 2, or 3 of *Electronic Calcareous Nannofossils* may exchange them through the Treasurers of the INA for Version 4 without charge. Copies of these earlier versions received in exchange will be made available with the compliments of the INA to individuals and institutions that have not been able to meet the purchase price.

References

Wise, S.W., Covington, J.M., Ladner, B.C. & Wei, W. (Compilers) 2002. *Electronic Calcareous Nannofossils, Version 1*. International Nannoplankton Association, CD-ROM Series, No. 1. [Several databases plus the NannoWare/BugCam package, an interactive, icon-driven digital-image catalog of over 600 Cenozoic taxa authored by Wise, S.W., Bybell, L.M, Covington, J.M., de Kaenel, E., Maiorano, P. *et al*.]

Wise, S.W., Covington, J.M., Ladner, B.C. & Wei, W. (Compilers) 2003. *Electronic Calcareous Nannofossils, Version 2*. International Nannoplankton Association, CD-ROM Series, No. 1. [As above, but with the addition of the *Calcareous Nannoplankton Taxonomic Index* (in 3 parts), scanned as necessary and converted to MS Excel format by J. Ford, R. Hartman, J. Lara, V. Regalado & A. Stant]

Wise, S.W., Covington, J.M., Ladner, B.C. & Wei, W. (Compilers) 2004. *Electronic Calcareous Nannofossils, Version 3*. International Nannoplankton Association, CD-ROM Series, No. 1. [As above, but with the addition by several teams of contributors of *Modern NannoWare* (an interactive digital-image catalog); *The Consolidated Calcareous Nannoplankton Taxonomic Index* in MS Excel Format; *The Consolidated INA Calcisphere Taxonomic Index* in MS Excel Format; *Augmented Cenozoic and Mesozoic Calcareous Nannoplankton Bibliography* [over 10 000 entries, and *The Silicoflagellate Bibliography*]

Wise, S.W., Olney, M., Covington, J.M., Egerton, V.M. Jiang, S., Kulhanek, D.K., Ramdeen, S., Schrader, H.J., Sims, P.A., Wood, A.S., Davis, A., Davenport, D.R., Doepler, N., Falcon, W,. Lopez, C., Pressley, T., Swedberg, O.L. & Harwood, D.M. 2007. *Cenozoic Antarctic DiatomWare/BugCam: An aid for research and teaching*. *In*: A.K. Cooper & C.R. Raymond *et al*. (Eds). *Antarctica: A Keystone in a Changing World – Online Proceedings of the 10th ISAES, USGS Open-File Report 2007-1047, Short Research Paper*, **017**: 4pp. doi: 10.3133/of2007-1047.srp017.

Nannotax

www.nannotax.org

Nannotax is a website being developed to allow online documentation of nannofossil taxonomy, broadcasting of images of nannofossils, and comment on them.

It uses the content management system Drupal, as implemented within EDIT (**European Distributed Institute of Taxonomy**), as a Taxonomy Information System - Scratch-pads. The strengths of this system are that diverse information can be uploaded and dynamically linked to individual taxa (*i.e.* it can grow organically), that the commenting system allows users to readily share their own observations, and that contributors can edit and add to the content.

Or rather, this sort of web 2.0 accessibility is what the strength of the site is *intended* to be. So far, there has not been much uptake on the participation side, although there has been a lot of good feedback. So, the main strength at present is that the system has allowed me to develop, relatively rapidly, a useful online guide to **Neogene nannofossils**.

The site contains pages for all the well-established Neogene species, using the taxonomy from Young (1998). For each species, there are currently **brief descriptions** and other comments, together with a varying number of **images**. Linking the species pages are pages on the **higher taxa**, with **longer descriptions**, and **tabular guides** to the next level in the taxonomy. Hopefully, the site can already be used, both as a **reference source** for experienced workers and as a **tool for learning** nannofossil taxonomy. There is a lot of potential for developing the site, including extending the coverage in terms of taxa and including additional content on the species.

I look forward to discussing it at INA12 (Lyon)
or why not get online, and start the taxonomic discussion now?!

Jeremy Young

Nannotax - a web-based system for documenting nannofossil taxonomy

Jeremy R. Young

I have recently established an online guide to nannofossil taxonomy using the content management system DruPal. This has been facilitated by IT support from the European Distributed Institute of Taxonomy (EDIT) project, and by encouragement from many colleagues especially Mike Styzen (Shell) and the site is supported/endorsed by the INA and the Gulf Coast section of SEPM.

The prime objective of the current phase of development of the Nannotax site was to produce an online version of Young (1998) - the Neogene chapter of *Calcareous Nannofossil Biostratigraphy*. This has been successfully achieved and the site is a useful demonstration of the potential for a site covering a wider range of nannofossil taxa. In this talk, I will demonstrate the current state of the Nannotax system, show how users can contribute to it, and discuss the potential for expansion.

References

Young, J.R. 1998. Neogene. *In*: P.R. Bown (Ed.). *Calcareous Nannofossil Biostratigraphy*. British Micropalaeontological Society Publications Series. Chapman & Hall, London: 225-265.

The complex discovery of coccolithophores, from Ehrenberg to Lohmann *via* Sorby, Wallich and Huxley

Jeremy R. Young

Coccolithophores are the smallest of routinely studied microfossils, only a few microns in diameter, in consequence the nineteenth century history of their study is not a tale of dedicated descriptive work by heroic pioneers. Instead it is a complex history of slow discovery and controversy, involving many of the greatest microscopists of the era. It is in part a well-documented story, with different aspects being covered by Gould (1978), Rehbock (1975), Rice *et al*. (1975), Rupke (1976) and Siesser (1994), especially as a result of the *Bathybius* controversy. However, re-examination of original material and manuscripts allows new perspectives to be given.

Like many other microfossils, coccoliths and discoasters were first described by the 'founder of micropalaeontology' Christian Gottfried Ehrenberg, and they are figured in many of the plates of his magnum opus *Mikrogeologie* (Ehrenberg, 1854). However, they were at the limit of resolution of his microscopes and he regarded them as inorganic precipitates – kalk-morpholithien and crystalldrusen. Subsequently, they were rediscovered in ocean bottom sediments by Thomas Huxley (1858), who coined the name 'coccolith' for them on the basis of fine experimental observations that they were calcareous (hence '–lith'), and a rather less impressive misinterpretation of them as spherical structures similar to '*Protococcus*' cells (hence 'Cocco-'). He also sent some of the sediment to Henry Clifton Sorby, the founder of petrographic microscopy. Sorby had previously observed that the chalk is largely composed of Ehrenberg's calc-morpholiths and had inferred that they were organic in origin. He rapidly established (Sorby, 1861) that Huxley's coccoliths were the same as Ehrenbergs calc-morpholiths, and so that deep-sea oozes provided an analog for the chalk.

The story then gets complex, as agglutinating foraminifera and inorganic precipitates lead the prime protagonists Wallich (a retired army doctor with scientific ambitions) and Huxley to infer that coccoliths were formed by the larvae of foraminifera (Wallich, 1861) or by a primordial slime covering the entire ocean bottom – *Bathybius haeckelii* (Huxley, 1868). The latter theory sounds like implausible fantasy, but in fact stemmed from predictions of Lorenz Okel, and especially Haeckel, and it briefly became a major scientific discovery, before being debunked by the observations of the *Challenger* expeditions' shipboard scientists in 1875. In parallel, Wallich became increasingly embittered at the lack of recognition of his contributions; his annotated reprint collection, archived in the NHM, provides spectacular evidence of his multiple grievances. Nonetheless, he first demonstrated that coccoliths are components of coccospheres (a term he coined in 1861) and, rather belatedly (Wallich, 1877), he documented that coccospheres were planktonic and described the first two species – *Coccosphaera pelagica* and *C. carteri*. However, the numerous nineteenth century publications on coccoliths did little beyond establishing their basic nature. The first truly heroic study of them only occurred in the early twentieth century, with the remarkable work of Hans Lohmann, who coined the terms coccolithophore and nannoplankton, identified them as a major component of the phytoplankton, developed techniques for sampling them, and documented their taxonomy and biogeography (Lohmann, 1902, 1919).

References

Ehrenberg, C.G. 1854. *Mikrogeologie: Das Erden und Felsen schaffende Wirken des unsichtbar kleinen selbständigen Lebens auf der Erde*. Leopold Voss, Leipzig.

Gould, S.J. 1978. *Bathybius* meets *Eozoon*. *Natural History*, **87**(4), 16-22. [Reprinted in *The Panda's Thumb: More Reflections in Natural History*, 1980]

Huxley, T. 1858. Appendix A. *In*: J. Dayman (Ed.). *Deep sea soundings in the North Atlantic Ocean between Ireland and Newfoundland made in H.M.S. Cyclops*. The Admiralty Commissioners, London: 63-68.

Huxley, T.H. 1868. On some organisms living at great depths in the North Atlantic Ocean. *Quarterly Journal of Microscopical Science*, **8**: 203-212.

Lohmann, H. 1902. Die Coccolithophoridae, eine Monographie der Coccolithen bildenden Flagellaten, zugleich ein Beitrag zur Kenntnis des Mittelmeerauftriebs. *Archiv für Protistenkunde*, **1**: 89-165.

Lohmann, H. 1919. Die Bevölkerung des Ozeans mit Plankton nach den Ergebnissen des Zentrifugenfänge während der Ausreise der "Deutschland" 1911. Zugleich ein Beitrag zur Biologie des Atlantischen Ozeans. Archiv für Biontologie, 4(3), 1-617.

Rehbock, P.F. 1975. Huxley, Haeckel and the oceanographers: the case of *Bathybius haeckelii*. *Isis*, **66**(4): 504-533.

Rice, A.L., Burstyn, H.L., Jones, A.G.E. 1976. G.C. Wallich M.D. - Megalomaniac or mis-used oceanographic genius? *Journal of the Society for the Bibliography of Natural History*, *7*(4): 423-450.

Rupke, N. 1976. *Bathybius haeckelii* and the psychology of scientific discovery. *Studies in the History and Philosophy of Science*, **7**: 53-62.

Siesser, W.G. 1994. Historical background of coccolithophore studies. *In*: A. Winter & W.G. Siesser (Eds). *Coccolithophores*. Cambridge University Press, Cambridge: 1-11.

Sorby, H.C. 1861. On the organic origin of the so-called crystaloids of the chalk. *Annals and Magazine of Natural History*, **8**: 193-200.

Wallich, G.C. 1861. Remarks on some novel phases of organic life, and on the boring powers of minute annelids, at great depths in the sea. *Annals and Magazine of Natural History*, **8**: 52-58.

Wallich, G.C. 1877. Observations on the coccosphere. *Annals and Magazine of Natural History*, **19**: 342-350.

The role of coccolithophores in dimethylsulphide production and their potential impact on climate

Jeremy R. Young, Dan Franklin, Gill Malin, Alex Poulton, Ian Probert

Charlson *et al*. (1987) noted that cloud formation over the oceans is significantly influenced by the supply of cloud condensation nuclei, the predominant source of which appeared to be dimethylsulphide (DMS), which is produced by planktonic algae in sea water. Hence, increased phytoplankton productivity is liable to increase cloud cover and so global albedo. This system, commonly termed the CLAW hypothesis, was envisaged as acting as a significant negative feedback to the global warming effects of changed insolation regimes and so as a partial global thermostat. Subsequent research and modeling has confirmed the importance of DMS as a source of CCN, especially in the Southern Hemisphere, indeed potential global temperature impacts of up to 3.8 degrees centigrade have been calculated (Watson & Liss, 1998). However, research and modeling since Charlson (1987) has also shown that the system is more complex and harder to predict than initially thought. Indeed, it is not even clear whether the effect is likely to act as a positive or negative feedback to anthropogenic global change.

Complicating factors include that DMS is produced from a precursor molecule dimethylsulphoniopropionate (DMSP), and the pathway from intracellular DMSP to atmospheric DMS is convoluted, with strong influences from the food-chain dynamics. Moreover the DMSP content of phytoplankton varies greatly between species (Keller *et al*., 1989). Presumably as result of these two factors, there is often only a poor correlation between phytoplankton biomass or productivity and DMS levels.

The pioneering work of Keller *et al*. (1989) suggested that coccolithophores and dinoflagellates had much higher DMSP contents than other phytoplankton, especially diatoms. Hence it is possible that varying abundances of these phytoplankon groups may be a significant factor controlling DMS production. To test this we have carried out a combination of laboratory and cruisework investigations of the role of coccolithophores in DMS production. The laboratory investigations looked at variability in cellular DMSP content across the phylogenetic diversity of coccolithophores. This revealed a remarkably consistent pattern, with all coccolithophores maintaining similar concentrations of DMSP in their cells, supporting the interpretation that it plays a key role in cellular physiology, probably as a compatible solute. The cruise-based work consisted of parallel investigation of phytoplankton populations and the DMS-DLA-DMSP system during a transect through the Mauretanian upwelling system.

References

Charlson, R., Lovelock, J., Andreae, M. & Warren, S. 1987. Oceanic phytoplankton, atmospheric sulphur, cloud albedo and climate. *Nature*, **326**: 655-661.

Keller, M.D., Bellows, W.K. & Guillard, R.R.L. 1989. Dimethyl sulphide production in marine phytoplankton. *In*: E.D. Saltzmann & W.J. Cooper (Eds). *Biogenic sulfur in the environment. ACS Symposium Series No. 393*: 167-182.

Watson, A.J. & Liss, P.S. 1998. Marine biological controls on climte via the carbon and sulphur geochemical cycles. *Philosophical Transactions of the Royal Society of London*, **B353**: 41-51.

Adaptation of coccolith calcification to sea-water carbonate chemistry

Patrizia Ziveri, Gerald Langer, Ian Probert, Jeremy Young

Coccolithophores are major calcifiers and through calcification cause feedbacks to atmospheric CO_2 cycling. The formation of $CaCO_3$ in seawater, in fact, causes a shift of the carbonate system towards CO_2, which in turn affects atmosphere/ocean CO_2 exchange. A change in marine calcification provides a concomitant feedback in organic carbon export and would lead to a change in the drawdown of atmospheric CO_2.

Coccolithophore culture experiments and field observations showed controversial results regarding the response of calcification to high CO_2. The three strains of *Emiliania huxleyi* (the most abundant living coccolithophore species) tested so far show both increased and decreased calcification at high CO_2 levels (lower pH).

Living *E. huxleyi* is known to have a large variability in both size and degree of calcification content, resulting in very large variation in coccolith mass, from about 1 to 5 pg. Recent field observations have suggested that the distribution of *E. huxleyi* coccolith morphotypes is related to carbonate saturation state, even though the morphotypes are known to be under strong genotypic control. This hypothesis can be tested by comparing the morphology of coccolith strains, and especially their degree of calcification, with the sea-water carbonate chemistry from which they were isolated. We selected 25 strains of *E. huxleyi* maintained at the Roscoff culture collection, collected from different oceanographic settings with different carbon speciation. Although the strains are maintained at similar temperature and carbonate chemistry, they still preserve a morphology similar to the one of the original ocean samples. The selected strains have been grown at the same carbonate chemistry. The culture temperatures mimicked the temperatures of the sites from where the strains were collected. With these experiments, we test the importance of the calcification strain adaptation to carbonate chemistry. Size and possibly different responses to carbonate chemistry variations will also be discussed.

INA12 authors' addresses

Fatima **Abrantes** - Dept. of Marine Geology, INETI, 2720 Alfragide, Amadora, Portugal
Claudia **Agnini** - Dipt. di Geoscienze, Via Giotto, 1, 35137 Padova, Italy
F. **Aguirre-Bahena** - Centro Interdisciplinario de Ciencias Marinas, Inst. Politécnico Nacional, México
Javier **Alcántara-Carrió** - Inst. de Investigación en Medio Ambiente y Ciencia Marina, Univ. Católica de Valencia, 46003 Valencia, Spain; javier.alcantara@ucv.es
Belén **Alonso** - Inst. de Ciencias del Mar (CSIC), Passeig Marítim de la Barceloneta, 37-49, E-08003 Barcelona, Spain; belen@icm.csic.es
M. Carmen **Álvarez** - Inst. de Investigación en Medio Ambiente y Ciencia Marina, Universidad Católica de Valencia, 46003 Valencia, Spain; carmen.alvarez@ucv.es
Cleber Fernandes **Alves** - Fundação Gorceix/Petrobras, CENPES, Brazil
David **Amblas** - GRC Geociències Marines, Universidad de Barcelona, 08028 Barcelona, Spain
Aida Sergeivna **Andreeva-Grigorovich** - Inst. of Geosciences, Academy of Sciences of Ukraine, Kiev-54, 01054, Gonchara Street 55b, Kiev, Ukraine
Gloria **Andreini** - Dipt. di Scienze della Terra, Univ. di Perugia, Italy
Harald **Andruleit** - Bundesanstalt für Geowissenschaften & Rohstoffe, Stilleweg 2, D-30655 Hannover, Germany; h.andruleit@bgr.de
Alessandra **Asioli** - ISMAR, Consiglio Nazionale delle Ricerche, Via Gobetti 101, I-40129 Bologna, Italy
Marie-Pierre **Aubry** - Dept. of Geology, Rutgers Univ., 610 Taylor Road, Piscataway, New Jersey, USA
Lia **Auliaherliaty** - Dept. of Paleoclimatology & Geomorphology, Fac. of Earth & Life Sciences, Vrije Univ. Amsterdam, De Boelelaan 1085, 1081HV, Amsterdam, The Netherlands
Valia **Avgoustidi** - Hellenic Centre for Marine Research, Inst. of Oceanography, 19013 Anavyssos, Greece
F. **Azzaro** - IAMC-CNR, U.O. di Messina, Italy

Jan **Backman** - Dept. of Geology & Geochemistry, Stockholm Univ., SE-106 91 Stockholm, Sweden
T. **Bahri** - FAO MedSudMed Project, Roma, Italy
Ramona **Balc** - Babes-Bolyai Univ., Fac. of Biology & Geology, Dept. of Geology, 1 Kogalniceanu St., Cluj-Napoca, 400084, Romania
Barbara **Balestra** - Dipt. di Scienze della Terra, Via G. La Pira 4, 50121 Firenze, Italy
Anne-Marie **Ballegeer** - Dept. de Geología, Univ. de Salamanca, 37008 Salamanca, Spain; amballegeer@usal.es
M. Ángeles **Barcena** - Univ. de Salamanca, Dept. de Geología, Fac. de Ciencias, 37008 Salamanca, Spain; mbarcena@usal.es
Milos **Bartol** - Ivan Rakovec Inst. of Paleontology, ZRC SAZU, Novi trg 2, PO Box 306, 1001 Ljubljana, Slovenia
Gretta **Bartoli** - Geological Inst., ETH Zürich, Universitätstraße 6, CH-8092 Zürich, Switzerland; gretta.bartoli@erdw.ethz.ch
G. **Basilone** - IAMC-CNR, U.O. di Mazara del Vallo, Italy
François **Baudin** - Univ. Pierre et Marie Curie, Paris 6 & UMR 7072 Tectonique, CNRS, CP 117, 4 Place Jussieu, 75252 Paris, Cedex 05, France
Karl-Heinz **Baumann** - Dept. of Geosciences, University of Bremen, Klagenfurterstr., 28334 Bremen, Germany; baumann@uni-bremen.de
Luc **Beaufort** - CEREGE, CNRS & Aix-Marseille Univ., Aix en Provence, France
Ana **Bento** - Dept. of Geology, Fac. of Sciences, Univ. of Lisbon, Campo Grande, 1749-016 Lisbon, Portugal
James **Bergen** - BP America, 200 West Lake Park Blvd., Houston, TX 77079, USA
Gilen **Bernaola** - Dept. of Mining & Metallurgic Engineering, Univ. of the Basque Country, E-48901 Barakaldo, Spain
Serge **Berné** - Géosciences Marines, IFREMER, BP 70, 29280 Plouzané, France
Adele **Bertini** - Dipt. di Scienze della Terra, Univ. degli Studi di Firenze, Via G. La Pira 4, 50100, Firenze, Italy
Theodore **Bibby** - Dept. of Geological Sciences, Florida State University, Tallahassee, FL 32306-4100, USA
Teodora **Blaj** - Dept. of Geology & Geochemistry, Stockholm Univ., SE-106 91 Stockholm, Sweden; teodora@geo.su.se
Babette **Boeckel** - FB5 Geowissenschaften, Universität Bremen, Klagenfurterstr., 28359 Bremen, Germany
Ana-Voica **Bojar** - Karl-Fränzens Univ., Inst. für Erdwissenschaften, 26 Heinrichstraße, A-8010 Graz, Austria; ana-voica.bojar@uni-graz.at
Jörg **Bollmann** - Geology Dept., Univ. of Toronto, Canada
A. **Bonanno** - IAMC-CNR, U.O. di Mazara del Vallo, Italy
Sergio **Bonomo** - Univ. di Palermo, Dipt. di Geologia e Geodesia, Via Archirafi 22, 90134 Palermo, Italy & IAMC-CNR, U.O. di Mazara del Vallo, Italy
David **Bord** - Dept. of Earth & Planetary Sciences, Rutgers Univ., USA
Cinzia **Bottini** - Dept. of Earth Sciences, Univ. of Milan, Milan, Italy; cinzia.bottini@unimi.it
Andrew R. **Bowman** - StatoilHydro, INT GEX GOM Regional Team, 2103 CityWest Boulevard, Houston, TX 77042, USA
Paul R. **Bown** - Dept. of Earth Sciences, Univ. College London, Gower Street, London, WC1E 6BT, UK
Vanda **Brotas** - Dept. Veg. Biology, Fac. of Sciences, Univ. of Lisbon, Campo Grande 1749-016, Lisboa, Portugal
Colin **Brownlee** - Marine Biological Association, The Laboratory, Citadel Hill, Plymouth, PL1 2PB, UK
Margarita **Buitrago-Reina** - Dept. de Geología, Univ. de Salamanca, Plaza de la Merced s/n, 37008 Salamanca, Spain: margaritab@usal.es
G. **Buscaino** - IAMC-CNR, U.O. di Mazara del Vallo, Italy

Andrea **Caburlotto** - Ist. Nazionale di Oceanografia e di Geofisica Sperimentale, Trieste, Italy
Mário **Cachão** - Centre for Geology, Univ. of Lisbon, 1749-016 Lisboa, Portugal & Dept. of Geology, Fac. of Sciences, Univ. of Lisbon, Campo Grande, 1749-016 Lisboa, Portugal; mcachao@fc.ul.pt
Isabel **Cacho** - GRC Geociències Marines, Universidad de Barcelona, 08028 Barcelona, Spain
Antonio **Calafat** - GRC Geociències Marines, Universidad de Barcelona, 08028 Barcelona, Spain
Angelo **Camerlenghi** - ICREA, c/o GRC Geociències Marines, Universidad de Barcelona, 08028 Barcelona, Spain
Miquel **Canals** - GRC Geociències Marines, Univ. de Barcelona, 08028 Barcelona, Spain
Damien **Carcel** - UMR CNRS 5125 PEPS, Univ. Claude Bernard, Lyon 1, 69622 Villeurbanne cedex, France
Jose Luis **Casamor** - GRC Geociències Marines, Universidad de

Barcelona, 08028 Barcelona, Spain
Cristina Emanuela **Casellato** - Dipt. di Scienze della Terra 'A.Desio', Univ. degli Studi di Milano, Italy
Simona **Cavagna** - Dipt. di Scienze della Terra, Univ. di Torino, Via V. Caluso 35, 10125 Torino, Italy
James E.T. **Channell** - Dept. of Geological Sciences, Univ. of Florida, Gainesville, Florida 32611, USA
Carmen Mariana **Chira** - Babes-Bolyai Univ., Fac. of Biology & Geology, Dept. of Geology, 1 Kogalniceanu St., Cluj-Napoca, 400084, Romania; mcchira@bioge.ubbcluj.ro
Abul **Chrachri** - Marine Biological Association, The Laboratory, Citadel Hill, Plymouth, PL1 2PB, UK
Pierangelo **Clari** - Dipt. di Scienze della Terra, Univ. di Torino, Via V. Caluso 35, 10125 Torino, Italy
Miriam **Cobianchi** - Dipt. di Scienze della Terra, Univ. degli Studi di Pavia, Via Ferrata 1, 27100 Pavia, Italy
Elena **Colmenero-Hidalgo** - Dept. de Geología, Univ. de Salamanca, 37008 Salamanca, Spain & Dept. of Earth & Ocean Sciences, Cardiff University, Cardiff, UK; elecolme@usal.es
Claude **Colombié** - UMR CNRS 5125 PEPS, Univ. Claude Bernard Lyon 1, 69622 Villeurbanne cedex, France
María José **Comas-Rengifo** - Dept. y UEI de Paleontología, Fac. de Ciencias Geológicas e Inst. de Geología Económica (CSIC-UCM), Calle José Antonio Novais, 2, 28040 Madrid, Spain; mjcomas@geo.ucm.es
Stjepan **Coriç** - Geological Survey of Austria, Neulinggasse 38, A-1030 Vienna, Austria; stjepan.coric@geologie.ac.at
Mara Y. **Cortés** - Dept. Geología Marina, Univ. Autónoma de Baja California Sur, A.P. 19-B, CP 23080, La Paz, BCS, México; mycortes@uabcs.mx
Sergio **Costa** - GRC Geociències Marines, Universidad de Barcelona, 08028 Barcelona, Spain
Martine J.J. **Couapel** - CEREGE, Aix-Marseille Univ. CNRS, IRD; Europôle Méditerrenéen de l'Arbois, BP80, 13545 Aix en Provence, France
Mitchener **Covington** - BugWare, Inc., 4027 Bobbin Brook East, Tallahassee, FL 32312, USA
Lluïsa **Cros** - Inst. de Ciencias del Mar (CSIC), Passeig Marítim de la Barceloneta, 37-49, E-08003 Barcelona, Spain; lluisa@icm.csic.es
A. **Cuttitta** - IAMC-CNR, U.O. di Mazara del Vallo, Italy

David R. **Davenport** - Dept. of Geological Sciences, Florida State Univ., Tallahassee, FL 32306-4100, USA
Alexander **Davis** - Dept. of Geological Sciences, Florida State Univ., Tallahassee, FL 32306-4100, USA
Lúcia **de Abreu** - Godwin Lab., Univ. Cambridge, Cambridge, CB2 3SA, UK
Bianca **De Bernardi** - Dept. of Earth Sciences 'Ardito Desio', University of Milan, Milano, Italy
Mascha **Dedert** - Dept. of Paleoclimatology & Geomorphology, FALW, Vrije Univ. Amsterdam, Amsterdam, The Netherlands; dedm@falw.vu.nl
Eric **de Kaenel** - DeKaenel Paleo Research (DPR), Matile 51, CH-2000 Neuchâtel, Switzerland & BP America, 200 West Lake Park Blvd., Houston, TX 77079, USA
Francesco **Dela Pierre** - Dipt. di Scienze della Terra, Univ. di Torino, via V. Caluso 35, 10125 Torino, Italy
Ben **De Mol** - GRC Geociències Marines, Universidad de Barcelona, 08028 Barcelona, Spain
Bernard **Dennielou** - Géosciences Marines, IFREMER, BP 70, 29280 Plouzané, France
Anne **de Vernal** - Geotop, Univ. du Québec à Montréal, PO Box 8888, Montréal Qué, Canada, H3C3P8
Margarita D. **Dimiza** - Univ. of Athens, Fac. of Geology & Geoenvironment, Dept. of Historical Geology-Paleontology, Panepistimiopolis 15784, Athens, Greece
Agata **Di Stefano** - Dipt. di Scienze Geologiche, Univ. of Catania, Corso Italia 57, I-95129 Catania, Italy; distefan@unict.it
Enrico **Di Stefano** - Univ. di Palermo, Dipt. di Geologia e Geodesia, Via Archirafi 22, 90134 Palermo, Italy
Nicole **Doepler** - Dept. of Geological Sciences, Florida State Univ., Tallahassee, FL 32306-4100, USA
O. **Drebeka** - Marine Biology Research Centre (MBRC), Tajura, Libya
Luis Vitor **Duarte** - IMAR-CIC, Dept. de Ciências da Terra, Fac. de Ciências e Tecnologia da Univ. de Coimbra, 3000-272 Coimbra, Portugal
Tom **Dunkley Jones** - Dept. of Geography, Univ. College London, Gower Street, London, WC1E 6BT, UK

Victoria M. **Egerton** - Dept. of Geological Sciences, Florida State Univ., Tallahassee, FL 32306-4100, USA
Malte **Elbrächter** - Deutsches Zentrum für Marine Diversitätsforschung, Forschungsinstitut Senckenberg, Wattenweerstation Sylt, Hafenstr. 43, DE-25992 List/Sylt, Germany
Elisabetta **Erba** - Dipt. di Scienze della Terra 'A.Desio', Univ. degli Studi di Milano, Italy; elisabetta.erba@unimi.it
Gilles **Escarguel** - UMR 5125 PEPS, CNRS, Université Lyon 1, Campus de la DOUA, Bâtiment Géode, 69622 Villeurbanne Cedex, France
Marta **Estrada** - Inst. de Ciències del Mar (CSIC), Passeig Marítim, 37- 49, E-08003 Barcelona, Spain; marta@icm.csic.es

William **Falcon** - Dept. of Geological Sciences, Florida State Univ., Tallahassee, FL 32306-4100, USA
Fereshte **Farhad** - Dept. of Earth Sciences, Shahid Beheshti Univ., Tehran, Iran
Rainer **Feistel** - Baltic Sea Research Inst., Seestrasse 15, DE-18119 Warnemünde, Germany
Adrian Raymund C. **Fernandez** - National Inst. of Geological Sciences, Univ. of the Philippines, Diliman, Quezon City 1101, Philippines
Allan Gil S. **Fernando** - National Inst. of Geological Sciences, Univ. of the Philippines, Diliman, Quezon City 1101, Philippines; afernando@nigs.upd.edu.ph, braarudosphaera@yahoo.com
Christina **Fink** - Europrox, FB Geosciences, Univ. of Bremen, PO Box 220440, 28334 Bremen, Germany; cfink@uni-bremen.de
Chiara **Fioroni** - Dipt. di Scienze della Terra, Univ. di Modena e Reggio E., L.go S. Eufemia, 19, 41100 Modena, Italy
Florin **Florea** - Geomold, Campulung Moldovenesc, Romania
José-Abel **Flores** - Dept. de Geología, Univ. de Salamanca, Plaza de la Merced s/n, 37008 Salamanca, Spain; flores@usal.es
François **Fourel** - UMR 5125 PEPS, CNRS, France; Univ. Lyon 1, Campus de la DOUA, Bâtiment Géode, 69622 Villeurbanne Cedex, France
Ángela **Fraguas** - Dept. y UEI de Paleontología, Fac. de Ciencias Geológicas e Inst. de Geología Económica (CSIC-UCM), Calle José Antonio Novais, 2, 28040, Madrid, Spain; arfragua@geo.ucm.es
Dan **Franklin** - Lab. for Global Marine & Atmospheric Chemistry, School of Environmental Sciences, Univ. of East Anglia, Norwich, NR4 7TJ, UK
Conceição **Freitas -** Dept. of Geology, Fac. of Sciences, Univ. of Lisbon, Campo Grande, 1749-016 Lisbon, Portugal

Elke **Freytag** - FB5 Geowissenschaften, Univ. Bremen, Klagenfurterstr., 28359 Bremen, Germany
Jaume **Frigola** - GRC Geociències Marines, Univ. de Barcelona, 08028 Barcelona, Spain

Alessia **Gadaleta** - Dipt. di Scienze della Terra, Univ. di Parma, V. Usberti, 157A, 43100 Parma, Italy
Ines **Galoviç** - Croatian Geological Survey, Sachsova 2, 10 000 Zagreb, Croatia; ingalovic@hgi-cgs.hr
Markus **Geisen** - Alfred Wegener Inst., Am Handelshafen 12, 27570 Bremerhaven, Germany
Rainer **Gersonde** - Alfred Wegener Inst. für Polar- & Meeresforschung, Postfach 120161, D-27515 Bremerhaven, Germany
Fabienne **Giraud** - UMR CNRS 5125 PEPS, Univ. Claude Bernard Lyon 1, 69622 Villeurbanne cedex, France
Larisa **Golovina** - Geological Inst., Russian Academy of Sciences, Moscow, Russia
Felix M. **Gradstein** - Museum of Natural History, University of Oslo, PO Box 1172 Blindern, N-0318 Oslo, Norway
José M. **Gravalosa** - Dept. de Geología, Univ. de Salamanca, 37008 Salamanca, Spain
Joan O. **Grimalt** - Dept. de Química Ambiental, Inst. de Investigaciones Químicas y Ambientales (IIQAB-CSIC), 08034-Barcelona, Spain
Darren **Gröcke** - Dept. of Earth Sciences, Durham Univ., Science Labs, Durham, DH1 3LE, UK
Mauricio **Grossi** - Ist. Nazionale di Oceanografia e di Geofisica Sperimentale, Trieste, Italy
Vincent **Grossi** - UMR 5125 PEPS, CNRS, France; Univ. Lyon 1, Campus de la DOUA, Bâtiment Géode, 69622 Villeurbanne Cedex, France
Francis **Grousset** - CNRS, UMR 5805 EPOC, Univ. Bordeaux I, Ave. des Facultés, Talence, 33405 France; f.grousset@epoc.u-bordeaux1.fr

Fatemeh **Hadavi** - Geology Dept., Ferdowsi Univ. of Mashhad, Mashhad, Iran
Kyoko **Hagino** - Dept. of Natural History Sciences, Hokkaido Univ., N10W8, Kita-ku, Sapporo, 060-0810 Japan & currently Inst. for Study of Earth's Interior, Okayama Univ., 827 Yamada, Misasa, Tottori, 682-0193 Japan
Eva **Halásová** - Dept. of Geology & Palaeontology, Fac. of Natural Sciences, Comenius Univ., Mlynská dolina G-1, 842 15 Bratislava, Slovak Republik; halasova@fns.uniba.sk
I.R. **Hall** - Dept. of Earth & Ocean Sciences, Cardiff Univ., Cardiff, UK
P.R. **Halloran** - Dept. of Earth Sciences, Univ. of Oxford, Oxford, UK
Till J.J. **Hanebuth** - Univ. Bremen, Fac. of Geosciences, PO Box 330440, 28334 Bremen, Germany
David M. **Harwood** - Dept. of Geosciences, Univ. of Nebraska-Lincoln, Lincoln, NE 68588-0340, USA; dharwood1@unl.edu
Jorijntje **Henderiks** - Dept. of Geology & Geochemistry, Stockholm Univ., Svante Arrheniusväg 8C, SE-106 91 Stockholm, Sweden; jorijntje.henderiks@geo.su.se
Sandra **Herrmann** - Geological Inst., ETH Zürich, Universitätstraße 6, CH-8092 Zürich, Switzerland; sandra.herrmann@erdw.ethz.ch
Johann **Hohenegger** - Dept. of Palaeontology, Univ. of Vienna, Althanstrasse 14, A-1090 Vienna, Austria; johann.hohenegger@univie.ac.at
Takeo **Horiguchi** - Dept. of Natural History Sciences, Hokkaido Univ., N10W8, Kita-ku, Sapporo, 060-0810 Japan

Olaia **Iglesias** - GRC Geociències Marines, Universidad de Barcelona, 08028 Barcelona, Spain
Alin **Igritan** - Babes-Bolyai Univ., Fac. of Biology & Geology, Dept. of Geology, 1 Kogalniceanu St., Cluj-Napoca, 400084, Romania
Alessandro **Incarbona** - Univ. di Palermo, Dipt. di Geologia e Geodesia, Via Archirafi 22, 90134 Palermo, Italy
Andrea **Irace** - CNR, Ist. di Geoscienze, Via V. Caluso 35, 10125 Torino, Italy
Marin **Ivanov** - Sofia Univ. 'St. Kliment Ohridsky', Fac. of Geology & Geography, 15 Tsar Osvoboditel Blvd., BG-1000 Sofia, Bulgaria

Shijun **Jiang** - Dept. of Geological Sciences, Florida State Univ., Tallahassee, FL 32306-4100, USA
Haiyan **Jin** - State Key Lab. of Marine Geology, Tongji Univ., Shanghai 200092, PR China
Richard W. **Jordan** - Dept. of Earth & Environmental Sciences, Fac. of Science, Yamagata Univ., 1-4-12 Kojirakawa-machi, Yamagata 990 8560, Japan
Elsa **Jullien** - CNRS, UMR 5805 EPOC, Univ. Bordeaux I, Ave. des Facultés, Talence, 33405 France; e.jullien@epoc.u-bordeaux1.fr
Doru Toader **Juravle** - Al. I. Cuza Univ., Iasi, B-dul Carol I, 20

Anoshiravan L. **Kani** - Geology Dept., Fac. of Earth Science, Shahid Beheshty Univ., Tehran, Iran
Atsuko **Kijima -** Dept. of Earth & Environmental Sciences, Fac. of Science, Yamagata Univ., 1-4-12 Kojirakawa-machi, Yamagata 990 8560, Japan
Eduardo Apostolos Machado **Koutsoukos** - Petrobras/CENPES, Brazil
Eva **Krasakopoulou** - Hellenic Centre for Marine Research, Inst. of Oceanography, 19013 Anavyssos, Greece
Denise **Kulhanek** - Dept. of Geological Sciences, Florida State Univ., Tallahassee, FL 32306-4100, USA

Sara **Lafuerza** - GRC Geociències Marines, Universidad de Barcelona, 08028 Barcelona, Spain
Marcos A. **Lamolda** - Dept. de Estratigrafía y Paleontología, Fac. de Ciencias, Univ. de Granada, Avda. de Fuentenueva s/n, 18002 Granada, Spain; mlamolda@ugr.es
Gerald **Langer** - Inst. of Environmental Science & Technology (ICTA), Univ. Autònoma de Barcelona (UAB), Bellaterra, Spain & Alfred Wegener Inst. for Polar & Marine Research, Bremerhaven, Germany
Galderic **Lastras** - GRC Geociències Marines, Universidad de Barcelona, 08028 Barcelona, Spain
Caroline **Lavoie** - GRC Geociències Marines, Universidad de Barcelona, 08028 Barcelona, Spain
Jackie A. **Lees** - Dept. of Earth Sciences, Univ. College London, Gower Street, London, WC1E 6BT, UK
M. **Leonardi** - IAMC-CNR, U.O. di Messina, Italy
Valia **Lianou** - Univ. of Athens, Fac. of Geology & Geoenvironment, Dept. of Historical Geology-Paleontology, Panepistimiopolis 15784, Athens, Greece
Christian **Linnert** - Ruhr-Univ. Bochum, Universitätsstr. 150, 44801, Germany; christian.linnert@rub.de
Camino **Liquete** - GRC Geociències Marines, Universidad de Barcelona, 08028 Barcelona, Spain
Chuanlian **Liu** - State Key Lab. of Marine Geology, Tongji Univ., Shanghai 200092, PR China

Carlos **Lopez** - Dept. of Geological Sciences, Florida State Univ., Tallahassee, FL 32306-4100, USA
Gatsby-Emperatriz **López-Otálvaro** - Dept. of Geology, Univ. of Salamanca, Plaza de la Merced, S/N, C.P. 37008, Salamanca, Spain; gatsbyemperatriz@usal.es
Francesca **Lozar** - Dipt. di Scienze della Terra, Univ. di Torino, Via V. Caluso 35, 10125 Torino, Italy; francesca.lozar@unito.it
Renata G. **Lucchi** - GRC Geociències Marines, Univ. de Barcelona, 08028 Barcelona, Spain
Claudia **Lupi** - Dipt. di Scienze della Terra, Univ. degli Studi di Pavia, Via Ferrata 1, 27100 Pavia, Italy; clupi@manhattan.unipv.it

Ken **MacLeod** - Dept. of Geological Sciences, Univ. of Missouri-Columbia, Columbia, MO 65211, USA
Azam **Mahanipour** - Geology Dept., Fac. of Earth Science, Shahid Beheshty Univ., Tehran, Iran
Gill **Malin** - Lab. for Global Marine & Atmospheric Chemistry, School of Environmental Sciences, Univ. of East Anglia, Norwich, NR4 7TJ, UK
Elisa **Malinverno** - Dept. of Geological Sciences & Geotechnologies, Univ. of Milano-Bicocca, 4, 20126 Milano, Italy
Nicoletta **Mancin** - Dipt. di Scienze della Terra, Univ. degli Studi di Pavia, Via Ferrata 1, 27100 Pavia, Italy
A. **Marini** - IAMC-CNR, U.O. di Messina, Italy
Sara **Marreco** - Dept. of Veg. Biology, Fac. of Sciences, Univ. Lisbon, Campo Grande 1749-016, Lisboa, Portugal
Edoardo **Martinetto** - Dipt. di Scienze della Terra, Univ. di Torino, Via V. Caluso 35, 10125 Torino, Italy
Akmal M. **Marzouk** - Geology Dept., Fac. of Science, Tanta Univ., Tanta 31527, Egypt; akmal_marzouk@hotmail.com
F. **Massa** - FAO MedSudMed Project, Roma, Italy
Emanuela **Mattioli** - UMR 5125 PEPS, CNRS, France; Univ. Lyon 1, Campus de la DOUA, Bâtiment Géode, 69622 Villeurbanne Cedex, France
S. **Mazzola** - IAMC-CNR, U.O. di Messina, Italy
Helge **Meggers** - Dept. of Geosciences, Univ. of Bremen, Germany
Sebastian **Meier** - Christian Albrechts Univ. zu Kiel, Lab. für Rasterelektronenmikroskopie, Ludewig-Meyn-Straße 16, 24118 Kiel, Germany; smeier@gpi.uni-kiel.de
Alejandra **Mejía-Molina** - Univ. de Salamanca, Dept. de Geología, Fac. de Ciencias, Salamanca, 37008 Spain; alejandra@usal.es
Mihaela C. **Melinte-Dobrinescu** - National Inst. of Marine Geology & Geo-ecology, 23-25 Dimitrie Onciul Street, RO-024053 Bucharest, Romania; melinte@geoecomar.ro
Fab **Minoletti** - Univ. Pierre et Marie Curie, Paris 6; Lab. Biominéralisations & Paléoenvironnements (JE2477), T56-55 5eme - Case 116, 4, Place Jussieu, 75252 Paris cedex 05, France
Alan C. **Mix** - College of Oceanic & Atmospheric Sciences, Oregon State Univ., Corvallis, Oregon, USA
Svetlana F. **Mizintseva** - Dept. of Earth & Planetary Sciences, Rutgers Univ., Piscataway, NJ 08854, USA
Simonetta **Monechi** - Dipt. di Scienze della Terra, Via La Pira 4, 50121 Firenze, Italy
Jörg **Mutterlose** - Ruhr-Univ. Bochum, Universitätsstr. 150, 44801, Germany; joerg.mutterlose@rub.de
Giovanni **Muttoni** - Dipt. di Scienze della Terra 'A.Desio', Univ. degli Studi di Milano, Italy

Áurea **Narciso** - Dept. of Geology, Fac. of Sciences, Univ. of Lisbon, Campo Grande, 1749-016 Lisbon, Portugal
Hiroshi **Nishi** - Division of Earth & Planetary Sciences, Graduate School of Science, Hokkaido University, N10W8, Kita-ku, Sapporo 060-0810, Japan

Hisatake **Okada** - Division of Earth & Planetary Sciences, Graduate School of Science, Hokkaido University, N10W8, Kita-ku, Sapporo 060-0810, Japan
Mathew **Olney** - Dept. of Geological Sciences, Florida State Univ., Tallahassee, FL 32306-4100, USA

Silvia **Palandri** - Dipt. di Scienze della Terra, Univ. di Pisa, Via S. Maria 53, 56126 Pisa, Italy
Stefano **Palmerini** - UMR 5125 PEPS, CNRS, France; Univ. Lyon 1, Campus de la DOUA, Bâtiment Géode, 69622 Villeurbanne Cedex, France
Guido **Parisi** - Dipt. di Scienze della Terra, Univ. di Perugia, Italy
B. **Patti** - IAMC-CNR, U.O. di Messina, Italy
Laura **Pea** - Dipt. di Scienze della Terra, Univ. di Parma, V. Usberti 157A, 43100 Parma, Italy
Maria Teresa **Pedrosa** - GRC Geociències Marines, Universidad de Barcelona, 08028 Barcelona, Spain
Alyssa M. **Peleo-Alampay** - National Inst. of Geological Sciences, Univ. of the Philippines, Diliman, Quezon City, Philippines
Nicola **Pelosi** - Consiglio Nazionale delle Ricerche, Ist. per l'Ambiente Marino Costiero, Calata Porta di Massa, Interno Porto di Napoli, 80133 Naples, Italy
Nicola **Perilli** - Dipt. di Scienze della Terra, Univ. degli Studi di Pisa, Via Santa Maria 53, 56100 Pisa, Italy; perilli@dst.unipi.it
Davide **Persico** - Dipt. di Scienze della Terra, Univ. di Parma, V. Usberti 157A, 43100 Parma, Italy
Bernard **Pittet** - UMR 5125 PEPS, CNRS, France; Univ. Lyon 1, Campus de la DOUA, Bâtiment Géode, 69622 Villeurbanne Cedex, France
Andrea **Piva** - ISMAR, Consiglio Nazionale delle Ricerche, Via Gobetti 101, I-40129 Bologna, Italy
Julien **Plancq** - UMR 5125 PEPS, CNRS, France; Univ. Lyon 1, Campus de la DOUA, Bâtiment Géode, 69622 Villeurbanne Cedex, France
Mirela Violetta **Popa** - Babes-Bolyai Univ., Fac. of Biology & Geology, Dept. of Geology, 1 Kogalniceanu St., Cluj-Napoca, 400084, Romania
Alex **Poulton** - National Oceanography Centre, Southampton, SO14 3ZH, UK
Channarayapattana **Prabhu** - Centre for Marine & Environmental Research, 289, Porto, 4050-123 Portugal & Dept. of Marine Geology, INETI, 2720 Alfragide, Amadora, Portugal
C.T. **Pressley** - Dept. of Geological Sciences, Florida State Univ., Tallahassee, FL 32306-4100, USA
Ian **Probert** - Station Biologique de Roscoff, 29682 Roscoff, France

Isabella **Raffi** - Dipt. di Geotecnologie per l'Ambiente e il Territorio, Univ. 'G. d'Annunzio' di Chieti-Pescara, Via dei Vestini 31, 66013 Chieti, Italy
Naser **Raisossadat** - Geology Dept., Fac. of Science, Birjand, Iran
Sarah **Ramdeen** - Dept. of Geological Sciences, Florida State Univ., Tallahassee, FL 32306-4100, USA
Viviana **Reale** - Dipt. di Scienze della Terra, Univ. degli Studi di Firenze, Via G. La Pira 4, 50100, Firenze, Italy
Michele **Rebesco** - Ist. Nazionale di Oceanografia e di Geofisica Sperimentale, Trieste, Italy
Letizia **Reggiani** - Dipt. di Scienze della Terra, Univ. degli Studi di Perugia, Italy & UMR 5125 PEPS, CNRS, France; Univ. Lyon

1, Campus de la DOUA, Bâtiment Géode, 69622 Villeurbanne Cedex, France
Frédéric **Ricciardi** - Total S.A., Dept. Biostratigraphy
R.E.M. **Rickaby** - Dept. of Earth Sciences, Univ. of Oxford, Oxford, UK
Stuart **Robinson** - Dept. of Earth Sciences, Univ. College London, Gower Street, London, WC1E 6BT, UK
Teresa **Rodrigues** - Dept. of Marine Geology, INETI, 2720 Alfragide, Amadora, Portugal
Olga M. **Rodríguez V.** - PDVSA E&P, Gerencia de Laboratorios y Nucleotecas, Puerto La Cruz, Venezuela; rodriguezou@pdvsa.com
Björn **Rost** - Alfred-Wegener-Inst. for Polar & Marine Research, Bremerhaven, Germany

Mariem **Saavedra-Pellitero** - Dept. de Geología, Univ. de Salamanca, Plaza de la Merced s/n 37008, Salamanca, Spain; mariemsaavedra@usal.es
Armando Antônio **Scarparo Cunha** - PETROBRAS/CENPES, Rio de Janeiro, Brazil
Niels **Schovsbo** - Geological Survey of Denmark & Greenland (GEUS), Øster Voldgade 10, DK 1350, Copenhagen K, Denmark
Hans M. **Schrader** - Dept. of Geological Sciences, Florida State Univ., Tallahassee, FL 32306-4100, USA
Ekaterina **Shcherbinina** - Geological Inst. of the Russian Academy of Sciences, Russia
Emma **Sheldon** - Geological Survey of Denmark & Greenland (GEUS), Øster Voldgade 10, DK 1350, Copenhagen K, Denmark
Seirin **Shimabukuro** - PETROBRAS/CENPES, Brazil
Anatoliy **Shumnyk** - Dept. of Geological Sciences, Florida State Univ., Tallahassee, FL 32306-4100, USA; anatoliy.shumnyk@bugware.com
Francisco Javier **Sierro** - Dept. de Geología, Univ. de Salamanca, Plaza de la Merced s/n, 37008 Salamanca, Spain; sierro@usal.es
Norman **Silverberg** - Centro Interdisciplinario de Ciencias Marinas, Inst. Politécnico Nacional, México
Débora **Simón-Baile** - Dept. de Geología, Univ. de Salamanca, Plaza de la Merced s/n, 37008 Salamanca, Spain
Patricia A. **Sims** - Botany Dept., The Natural History Museum, Cromwell Road, London, SW7 5BD, UK
Claudia **Sprengel** - Bundesanstalt für Geowissenschaften & Rohstoffe, Stilleweg 2, D-30655 Hannover, Germany
Mario **Sprovieri** - Consiglio Nazionale delle Ricerche, Ist. per l'Ambiente Marino Costiero, Calata Porta di Massa, Interno Porto di Napoli, 80133 Naples, Italy
Rodolfo **Sprovieri** - Univ. di Palermo, Dipt. di Geologia e Geodesia, Via Archirafi 22, 90134 Palermo, Italy
Lars **Stemmerik** - Dept. of Geography & Geology, Copenhagen Univ., Øster Voldgade 10, DK 1350, Copenhagen K, Denmark
Heather **Stoll** - Dept. de Geología, Univ. de Oviedo, Arias de Velasco, s/n 30005, 33005 Oviedo, Asturias, Spain & Geoscience Dept., Williams College, Williamstown, MA 01267, USA
Katharina **Stolz** - EUROPROX - Univ. Bremen, Fac. of Geosciences, PO Box 330440, 28334 Bremen, Germany; kstolz@uni-bremen.de
Kristalina **Stoykova** - Geological Inst., Bulgarian Academy of Sciences, 24 G. Bonchev Str., BG-1113 Sofia, Bulgaria
Gioconda **Sturiale** - Dipt. di Scienze Geologiche, Univ. of Catania , Corso Italia 57, I-95129 Catania, Italy; gsturia@unict.it
Guillaume **Suan** - UMR 5125 PEPS, CNRS, Univ. Lyon 1, Campus de la DOUA, Bâtiment Géode, 69622 Villeurbanne Cedex, France
Baptiste **Suchéras-Marx** - UMR 5125 PEPS, CNRS, Univ. Lyon 1, Campus de la DOUA, Bâtiment Géode, 69622 Villeurbanne Cedex, France
Finn **Surlyk** - Dept. of Geography & Geology, Copenhagen Univ., Øster Voldgade 10, DK 1350, Copenhagen K, Denmark
Lilian **Švábenická** - Czech Geological Survey, Klárov 131/3, PO Box 85, 118 21 Praha 1, Czech Republic; lilian.svabenicka@geology.cz
Olivia **Swedberg** - Dept. of Geological Sciences, Florida State Univ., Tallahassee, FL 32306-4100, USA

Yoshihito **Takano** - Inst. for East China Sea Research, Nagasaki Univ., Nagasaki, Japan
Reishi **Takashima** - School of Marine & Resources, Tokai Univ., 3-20-1, Orido, Shimizu-ku, Shizuoka, 424-8610, Japan
M. **Talha** - Marine Biology Research Centre (MBRC), Tajura, Libya
Deborah N. **Tangunan** - National Inst. of Geological Sciences, Univ. of the Philippines, Diliman, Quezon City, Philippines
Alison **Taylor** - Marine Biological Association, The Laboratory, Citadel Hill, Plymouth, PL1 2PB, UK
Nicolas **Thibault** - Dept. of Geography & Geology, Copenhagen Univ., Øster Voldgade 10, DK 1350, Copenhagen K, Denmark
Hans R. **Thierstein** - Geological Inst., ETH Zürich & Univ. Zürich, Universitätstraße 6, CH-8092 Zürich, Switzerland; hans.thierstein@erdw.ethz.ch
Daniele **Tiraboschi** - Dept. of Earth Sciences, Univ. of Milan, Milan, Italy; daniele.tiraboschi@unimi.it
Lucio Riogi **Tokutake** - PETROBRAS/UN-ES/EXP/SE, Espírito Santo Sedimentology & Stratigraphy Sector, Brazil
Felipe Antonio de Lima **Toledo** - Lab. de Paleoceanografia do Atlântico Sul (LaPas), Inst. Oceanográfico (IO), Univ. de São Paulo (USP), Brazil
Vladimir **Torres Torres** - Inst. Colombiano del Petróleo, ICP, ECOPETROL S.A., Km.7 vía Piedecuesta, Santander, Colombia; vladimir.torres@ecopetrol.com.co
G. **Tranchida** - IAMC-CNR, U.O. di Mazara del Vallo, Italy
Iacopo **Trattenero** - Dipt. di Scienze della Terra, Univ. degli Studi di Pavia, Via Ferrata 1, 27100 Pavia, Italy
Stefania **Trenkwalder** - CNR, Ist. di Geoscienze, Via V. Caluso 35, 10125 Torino, Italy
Maria V. **Triantaphyllou** - Univ. of Athens, Fac. of Geology & Geoenvironment, Dept. of Historical Geology-Paleontology, Panepistimiopolis 15784, Athens, Greece

Francisco. J. **Urcádiz-Cázares** - Dept. Geología Marina, Univ. Autónoma de Baja California Sur, A.P. 19-B, CP 23080, La Paz, BCS, México
Roger **Urgeles** - GRC Geociències Marines, Universidad de Barcelona, 08028 Barcelona, Spain

Anja **van der Plas** - National Marine Information & Research Centre, PO Box 912, Swakopmund, Namibia
Giuliana **Villa** - Dipt. di Scienze della Terra, Univ. di Parma, V. Usberti 157A, 43100 Parma, Italy
Donata **Violanti** - Dipt. di Scienze della Terra, Univ. di Torino, via V. Caluso 35, 10125 Torino, Italy
Antje **Voelker** - Dept. of Marine Geology, INETI, 2720 Alfragide, Amadora, Portugal

Dennis Daniel **Waga** - National Enterprise 'NAUKANAFTOGAZ', Kiev region, Vyshneve - 08132, Kievska Street, 8, Russia; wagadennis@rambler.ru
Maria Dolores **Wanderley** - UFRJ, CCMN, Inst. de Geociências,

Dept. de Geologia
David K. **Watkins** - Dept. of Geosciences, University of Nebraska, 214 Bessey Hall, Lincoln, NE 68588, USA
Andrew F. **Weller** - Geological Inst., ETH Zürich, Universitätstraße 6, CH-8092 Zürich, Switzerland; andrew.weller@erdw.ethz.ch
Glenn **Wheeler** - Marine Biological Association, The Laboratory, Citadel Hill, Plymouth, PL1 2PB, UK
Amos **Winter** - Dept. of Marine Sciences, Univ. of Puerto Rico, PO Box 9013, PR 00681-9013 Mayagüez, Puerto Rico
Monica **Winsborrow** - University of Tromsø, Dept. of Geology, Tromsø, Norway
Sherwood S. **Wise**, Jr. - Dept. of Geological Sciences & the Antarctic Marine Geology Research Facility, Florida State Univ., Tallahassee, FL 32306-4100, USA; wise@gly.fsu.edu
Audra **Wood** - Dept. of Geological Sciences, Florida State Univ., Tallahassee, FL 32306-4100, USA

George **Yordanof** - UMR 5125 PEPS, CNRS, France; Univ. Lyon 1, Campus de la DOUA, Bâtiment Géode, 69622 Villeurbanne Cedex, France
Jeremy R. **Young** - Palaeontology Dept., The Natural History Museum, Cromwell Road, London SW7 5BD, UK

S. **Zgozi** - Marine Biology Research Centre (MBRC), Tajura, Libya
Shiying **Zhang** - State Key Lab. of Marine Geology, Tongji Univ., Shanghai 200092, PR China
Patrizia **Ziveri** - ICTA, Universitat Autónoma de Barcelona (UAB), Edifici Cn - Campus UAB, 08193 Bellaterra, Spain & Dept. of Paleoclimatology & Geomorphology, Fac. of Earth & Life Sciences, Vrije Univ. Amsterdam, De Boelelaan 1085 1081HV, Amsterdam, The Netherlands