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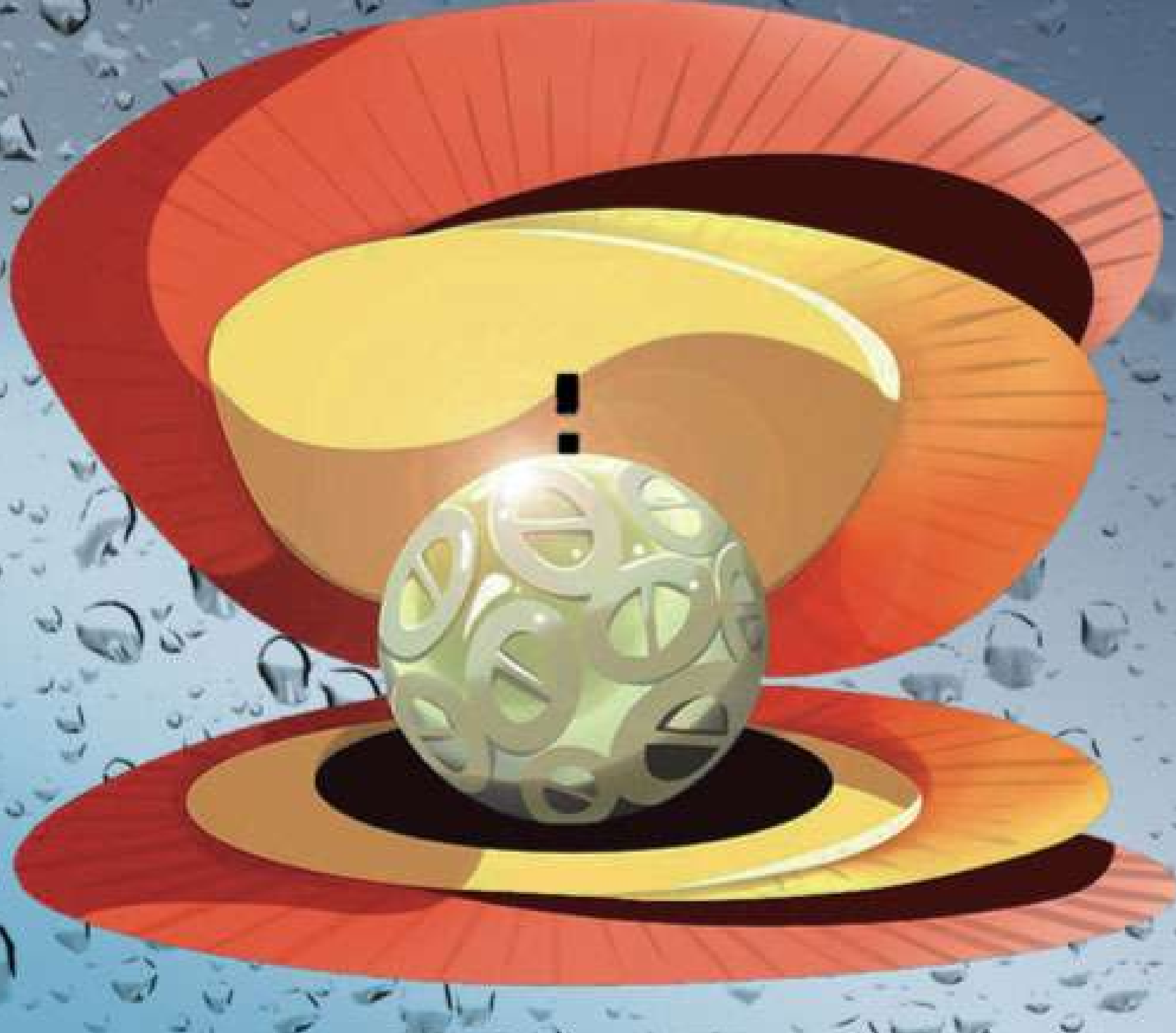

INA15

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International Nannoplankton Association

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INA15 Program

Saturday 7th March

6:30 am – 6:30 pm
Pre-Conference Fieldtrip A (Bohol Countryside Tour)

Sunday 8th March

7:00 am – 1:00 pm
Pre-Conference Fieldtrip B (Balicasag Island Snorkeling)

2:00 pm – 6:00 pm
Early Registration

6:30 pm – 8:30 pm
Ice Breaker Reception/Cocktails (Sponsored by Hon. Edgar M. Chatto, Governor of Bohol Province)

Monday 9th March

7:00 am – 9:00 am
Registration Open

9:00 am – 9:30 am
Opening Ceremony
Welcome Address: Hon. Edgar M. Chatto Governor of Bohol Province

9:30 am – 10:00 am
Morning Coffee Break
INA Group Photo Session 1

Session I: Micropaleontology and the IODP

Chair: Jose-Abel Flores

10:00 am
Kulhanek, D.K.
Micropaleontology and the International Ocean Discovery Program: a primer

10:20 am
Young, J.R., Bown, P.R. and Lazarus, D.
Interrogating the Neptune database for nannofossil occurrence data - species records and diversity estimates

Session II: Taxonomy and Evolution

Chairs: Jeremy Young and Richard Howe

10:40 am
Mattioli, E.
Environmentally driven evolutionary patterns in the size of the calcareous nannofossil Schizosphaerella through the Jurassic

11:00 am
Newsam, C., Bown, P. and Dunkley Jones, T.
Calcareous nannoplankton evolution across the Eocene-Oligocene transition

11:20 am
Šupraha, L., Gerecht, A., Probert, I. and Henderiks, J.
Strain-specific ecophysiological traits define the response to phosphorus limitation in Helicosphaera carteri

11:40 am
Hagino, K., Onuma, R., Takano, Y., Young, J., Tomioka, N. and Horiguchi, T.
Possibility of extracellular calcification of Braarudosphaera bigelowii deduced from cell-surface structure and elemental compositions of pentaliths by analytical electron microscopy

12:00 pm
Jafar, S.A.
The incredible Braarudosphaera bigelowii, a coccolithophore that displays exceptional mathematical traits

12:20 am – 1:40 pm
LUNCH
(Sponsored by Dr. Michael L. Tan, Chancellor of the University of the Philippines – Diliman Campus)

Session III: Advances in Nannofossil Biostratigraphy (Joint Industrial Academic Session)

Chairs: Jackie Lees and David Watkins

1:40 pm
Hadavi, F., Moheghy, M.A. and Ghadamagahi, M.
Nannostratigraphy of the Dalichai Formation in the Naviya section of Kopet Dagh Mountain Range in Iran

2:00 pm
Kadar, A.P., De Keyser, T., Neog, N. and Karam, K.A.
Middle to Upper Jurassic stratigraphy of Kuwait: calcareous nannofossils and maximum flooding surfaces

2:20 pm
Kita, Z.A. and Watkins, D.K.
Nannofossil biostratigraphy of the Late Cretaceous (Coniacian - Campanian) Niobrara Formation (Western Interior Seaway)

2:40 pm – 3:20 pm

Keynote Talk by Claudia Agnini
A new biostratigraphic and biochronologic framework for Paleogene calcareous nannofossils *(Agnini, C., Forniaciari, E., Raffi, I., Catanzariti, R., Pälike, H., Backman, J. and Rio, D.)*

3:20 pm – 3:50 pm
Afternoon Coffee Break

3:50 pm – 5:00 pm
POSTER SESSION 1

Tuesday 10th March

Session III: Advances in Nannofossil Biostratigraphy (Joint Industrial-Academic Session) – cont'd

Chairs: Denise Kulhanek and Emma Sheldon

9:00 am – 9:40 am
Keynote Talk by Isabella Raffi
Why an updated zonation of Neogene calcareous nannofossils? (Raffi, I., Backman, J., Fornaciari, E., Pälike, H. and Rio, D.)

9:40 am
Brace, B., Saavedra-Pellitero, M., Tada, R., Murray, R.W., Alvarez Zarikian, C.A. and Expedition 346 Science Party
IODP Expedition 346 "Asian Monsoon": calcareous nannofossil biostratigraphic and paleoenvironmental synthesis

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

Session III: Advances in Nannofossil Biostratigraphy (Joint Industrial-Academic Session) – cont'd

10:30 am – 11:10 am
Keynote Talk by Richard Denne
Calcareous nannofossil biostratigraphy in unconventional resource plays

11:10 am
ThiTham, N., Van Su, N. and Nio, D.
Early Miocene through Pleistocene calcareous nannofossils and the results of cyclostratigraphic analyses of gamma ray logs – StratPacs from the Nam Con Son Basin

11:30 pm – 1:00 pm
LUNCH

Session IV: Recent Nannoplankton/Coccolithophores: Biogeography and Ecology

Chairs: Karl-Heinz Baumann and Ric Jordan

1:00 pm
Cortés, M.Y., Rochin, H., SidónCeceña, K., UrcádizCázarez, F.J. and Bollmann, J.
Coccolithophorebiocoenosis, thanatocoenosis, and taphocoenosis in a marginal basin in the Gulf of California

1:20 pm
Hernández-Becerril, D.U., Ramírez-Robles, I., Salazar-Paredes, J., Lavín, M.F. and Godínez, V.M.
Abundance and distribution of coccolithophores and Parmales (Tetraparmainsecta) in the Gulf of California during the summer (July-August, 2011), and their relationship to oceanographic conditions

1:40 pm
Rochín, H., Cortés, M.Y., Bollmann, J., Urcádiz-Cázares, J., Silverberg, N. and Aguirre-Bahena, F.
Calcite export by sinking of coccoliths in the southern Gulf of California - Gephyrocapsa oceanica is the primary contributing species

2:00 pm
Álvarez, M.C., Temazatzi, A., Pérez-Cruz, L., Olivos-Ortiz, A., Quijano-Scheggia, S., Díaz-Flores, M.A. and Galicia-Pérez, M.A.
High-resolution assessment of coccolith assemblages during the last 150 years, Carmen Basin, Gulf of California

2:20 pm
Villarosa Garcia, M.
Biogeographic patterns of coccolithophore morphologic disparity

2:40 pm
Jordan, R.W., Kijima, A., Komuro, C., Tsutsui, H., Abe, K. and Konno, S.
Modern subtropical/tropical coastal coccolithophorid assemblages

3:00 pm
Thomsen, H.A.
Baltic Sea coccolithophores – an overview of findings from the last decades

3:20 pm
Guerreiro, C., de Stigter, H., Cachão, M., Cros, L., Sá, C., Oliveira, A. and Rodrigues, A.
Coccoliths from recent sediments of the central Portuguese margin: preservation of ecological signature in a dynamic sedimentary setting

3:40 pm – 4:00 pm
Afternoon Coffee Break

4:00 pm – 5:00 pm
POSTER SESSION 2

Wednesday 11th March

Session V: Paleoclimate Studies

Chairs: Claudia Agnini and Jean Self-Trail

9:00 am
Möller C., Mutterlose, J. and Heimhofer, U.
Calcareous nannofossil response to the Valanginian-Weissert event in a Boreal epicontinental sea

9:20 am
Kulhanek, D.K., Hollis, C.J., Hines, B.R., Littler, K., Strong, C.P., Zachos, J.C. and Villasante-Marcos, V.
A new Paleocene-Eocene thermal maximum record from Deep Sea Drilling Project Site 277 (Campbell Plateau): a window into calcareous nannofossil response in the southern high latitudes

9:40 am
Self-Trail, J.M., Robinson, M.M. and Wandless, G.A.
Calcareous nannofossil and foraminiferal evidence for a PETM pre-onset excursion, Atlantic Coastal Plain, USA

10:00 am
Bordiga, M., Henderiks, J., Tori, F., Monechi, S., Fenero, R. and Thomas, E.
Eocene-Oligocene shifts in calcareous nannofossil assemblages at ODP Site 1263 (Walvis Ridge, Atlantic Ocean)

10:20 am – 10:40 am
Morning Coffee Break

Session V: Paleoclimate Studies – cont'd

Chairs: JorijntjeHenderiks and Mike Styzen

10:40 am
Sulaiman, N. and Dunkley Jones, T.
The Eocene-Oligocene transition (EOT) boundary at Mossy Grove, Mississippi

11:00 am
Bartol, M. and Henderiks, J.
Nannofossil assemblage shifts in the aftermath of the Miocene Climatic Optimum – a North Atlantic latitudinal transect

11:20 am
Saavedra-Pellitero, M. and Baumann, K.-H.
Marine Isotope Stage 11 in the Southern Ocean

11:40 am
Barbarin, N. and Beaufort, L.
Insolation cycles as a major control on Coral Sea primary production

12:00 pm – 1:30 pm
LUNCH

1:30 pm –5:30 pm
WORKSHOPS

"Biogeography and Ecology of Extant Coccolithophores: Floristic similarities/differences among Oceans"
Organizers: Kyoko Hagino, Alicia Kahn, Karl-Heinz Baumann and Jeremy Young

Cenozoic Biostratigraphy: Updates, improvements and new zonations
Organizers: Isabella Raffi and Claudia Agninii

Mesozoic Biostratigraphy and Taxonomy
Organizers: Richard Denne, Emanuela Mattioli and Jackie Lees

6:30 pm – 9:30 pm
CONFERENCE DINNER
INA Group Photo Session 2

Thursday 12th March

Session VI: Paleoceanography and Paleoenvironment Studies

Chairs: Emanuela Mattioli and Elisa Malinverno

9:00 am
Faucher, G., Erba, E., Casellato, C.E. and Bottini, C.
Size variations in selected coccolith species through Mesozoic oceanic anoxic events: implications for paleoceanographic reconstructions

9:20 am
Ferreira, J., Mattioli, E., Cachão, M. and Pittet, B.
Changes in calcareous nannofossils across the Toarcian and Early Aalenian from the Lusitanian Basin (Portugal)

9:40 am
Giraud, F., Mattioli, E., Lécuyer, C., Martineau, F., López-Otálvaro, G.-E.,Suchéras-Marx, B., Alméras, Y. and de Kænel, E.
Deciphering control processes on mid-Jurassic coccolith turnover

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

10:30 am
Sheldon, E., Bjerager, M., Morigi, C. and Lauridsen, B.W.
Paleoecology of early Paleocene cold-water coral and bryozoan mounds in Denmark

10:50 am
Ćorić, S., Gebhard, H., Briguglio, A. and Linert, J.
Middle to late Eocene paleoenvironmental changes from the northern Tethyan margin (Adelholzen, Germany) traced by calcareous nannoplankton

11:10 am
Ausín, B., Flores, J.-A., Sierro, F.J., Hernández-Almeida, I., Grosjean, M., Francés, G. and Alonso, B.
Reconstructing sea surface salinity for the last 25 kyr in the western Mediterranean from a coccolithophore-based transfer function

11:30 am
Baumann, K.-H. and Weiser, J.
Coccolithophores in late glacial to Holocene sediments of the Norwegian Sea and their paleoceanographic implications

11:50 pm – 1:00 pm
LUNCH

Session VII: Coccolith Morphometrics, Imaging and other Techniques

Chairs: Mario Cachao and Luc Beaufort

1:00 pm – 1:40 pm
Keynote Talk by Luc Beaufort
Automated pattern recognition and biometry of calcareous nannofossils: 20 years of SYRACO development (Beaufort, L., Barbarin, N., Gally, Y. and Probert, I.)

1:40 pm
Cachão, M.
Replicates, why not?

2:00 pm – 2:40 pm
Keynote Talk by Jorijntje Henderiks
Coccolith morphometrics: why, how, and what's next?

2:40 pm
Tsutsui, H., Jordan, R.W., Abe, K. and Nishiwaki, N.
Morphometric analysis of early Eocene Corbisema skeletons (Silicoflagellata) from Mors, Denmark

3:00 pm
Young, J.R.
Semi-automated morphometrics on coccoliths using ImageJ

3:20 pm – 4:00 pm
Afternoon Coffee Break

4:00 pm – 5:00 pm
INA Business Meeting
Awarding of Best Student Oral and Poster Presentations

6:30 pm – 9:30 pm
DINNER
(Sponsored by Dr. Michael L. Tan, Chancellor of the University of the Philippines – Diliman Campus)

KEYNOTE SPEAKER

A new biostratigraphic and biochronologic framework for Paleogene calcareous nannofossils

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In 2014, we published a new calcareous nannofossil biozonation for the Paleogene period (Agnini *et al.,* 2014). This scheme was conceived as the natural continuation of the revision of Cenozoic calcareous nannofossil biostratigraphy and biochronology that started with the publication of a new Neogene biozonation (Backman *et al.,* 2012). The new scheme still partly relies on the biozonations of Martini (1971) and Okada & Bukry (1980), so it utilizes reliable biohorizons previously used by classical biozonal schemes, as well as new promising bioevents. To describe the semiquantitative abundance pattern of each biostratigraphically useful calcareous nannofossil taxon, we analyzed both DSDP/ODP sites and on-land sections located in the Atlantic and Pacific Oceans and Tethyan regions.

In our scheme, we use four different types of biohorizons (Base = B; Base common = Bc; T = Top; Top common = Tc), which serve to define five different types of biozones: Base Zone (BZ), Top Zone (TZ), Taxon Range Zone (TRZ), Concurrent Range Zone (CRZ), and Partial Range Zone (PRZ). The biozone code system consists of a code letter to identify the microfossil group (CN = calcareous nannofossils), a code letter for each series (P = Paleocene, E = Eocene, O = Oligocene), and a progressive number.

The biozonation contains a total of thirty-eight Paleogene biozones:

11 Paleocene Biozones (CNP1 to CNP11)

21 Eocene Biozones (CNE1 to CNE21)

11 Oligocene Biozones (CNO1 to CNO6)

This new Paleogene biozonation has an average duration of 1.1 Myr per biozone, which average 0.9 Myr in the Paleocene, 1.0 Myr in the Eocene, and 1.8 Myr in the Oligocene. Age estimations for calcareous nannofossil species events are also provided, and they are based on both magnetostratigraphic and astronomically tuned cyclostratigraphic data (Cande & Kent, 1995; Pälike *et al.,* 2006).

References

Agnini, C., Fornaciari, E., Raffi, I., Catanzariti, R., Pälike, H., Backman, J. & Rio, D. 2014. Biozonation and biochronology of Paleogene calcareous nannofossils from low and middle latitudes. *Newsletters on Stratigraphy*, **47**(2): 131-181.

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Cande, S.C. & Kent, D.V. 1995. Revised calibration of the geomagnetic polarity time scale for the Late Cretaceous and Cenozoic. *Journal of Geophysical Research*, **100**(B4): 6093-6096.

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KEYNOTE SPEAKER

Automated pattern recognition and biometry of calcareous nannofossils: 20 years of SYRACO development

Luc Beaufort
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Performing calcareous nannofossil identification and morphometry studies can be tedious work, especially in sediments with low occurrences. Twenty years ago at CEREGE, we began to develop an automatization process for these two tasks, which led to the development of the SYRACO tool. Originally, it was composed of an artificial neural network (ANN), developed by Dollfus and trained with a back-propagation algorithm (Dollfus & Beaufort, 1999). We implemented actions in the ANN and a suite of several ANN, working in pyramids (Beaufort & Dollfus, 2004). If the level of recognition were highly acceptable (>96%), the number of false positives was also high (up to 50% for some morphological groups). Human corrections on the result-files were necessary (*e.g.,* Beaufort *et al.,* 2001). Automated morphometry was used to diminish the number of false positives (Beaufort *et al.,* 2008). Morphometry was performed, not only on size measurements, but also on thickness and mass (Beaufort, 2005; Beaufort *et al.,* 2014). Morphometry was then incorporated into SYRACO with statistical pattern recognition tools (SPRT) such as Adaboost or SVM. The parallel use of ANN on images and SPRT on morphometry allowed a large generalization for recognition (>90%) with a low level of false positives (<5%) (Barbarin, 2014). The recent technological developments on microscopes, cameras, and computers also allowed an important increase in the level of coccolithophore automated recognition. SYRACO is now able to detect all calcareous nannofossils from the last 40 Myrs. We illustrate the use of SYRACO by showing intraspecific morphometric variability in the genera *Emiliania* and *Gephyrocapsa* in natural (Beaufort *et al.,* 2011) and artificial environments. However, the high plasticity of these placoliths in term of size and thickness should be considered before using these parameters for taxonomic purposes.

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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**(5539): 2440-2444.

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KEYNOTE SPEAKER

Calcareous nannofossil biostratigraphy in unconventional resource plays

Richard A. Denne
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Prior to the technological developments that enabled hydrocarbon production from shales, nannofossil biostratigraphy within industry was often focused on expanded sections. To be useful for reservoir correlations, these expanded sections required zonations at much higher resolutions than standard zonal schemes. Cenozoic sections benefit from the numerous extinctions and assemblage changes produced by rapid regional paleoceanographic shifts, so there are a number of high-resolution industry zonations, particularly in the Neogene.

Unconventional resource plays, however, usually result in hydrocarbon production from condensed, organic-rich shales and limestones deposited within epeiric seas during the Cretaceous and Jurassic (excluding the Paleozoic shales deposited prior to the evolution of nannoplankton). One recent example involves the Berriasian to Kimmeridgian Bossier/Haynesville Shales of northeastern Texas and northwestern Louisiana, where a zonation originally developed using DSDP and European outcrop sections was applied (Bergen et al., 2013).

The organic-rich marls of the Eagle Ford Formation were deposited in Texas during the Cenomanian to Turonian. Previous correlations of Eagle Ford outcrops relied on macrofossils, with only cursory use of microfossil data. Biostratigraphic correlation of subsurface sections, however, requires the use of microfossil data. Although several nannofossil datums occur near the Cenomanian-Turonian Boundary (i.e., OAE2), the remainder of the Cenomanian is poorly resolved, which is unfortunate because the majority of the organic-rich marls were deposited prior to OAE2. A correlation has now been made between the Eagle Ford outcrop belt and its subsurface equivalents in the south and east Texas, but further work on early-middle Cenomanian nannofossils and their integration with other biostratigraphic disciplines is needed to expand their utility.

References

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KEYNOTE SPEAKER

Coccolith morphometrics: why, how, and what's next?

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Morphometric data, which are inherent to nannoplankton taxonomy and nannofossil biostratigraphy, have become increasingly prominent in evolutionary, (paleo) ecological and (paleo) climate research since the late 1990's. The reasons why we "measure coccoliths" have become more diverse, and in some cases more urgent in light of global climate change and adaptation. Arguably, anyone looking through a microscope makes morphometric assessments of the assemblages they study, but still relatively few laboratories dedicate their research time to coccolith morphometrics. Technical advances during the 21st Century have greatly improved and facilitated data collection, resulting in numerous detailed time series and biogeographic databases. In this talk, I will review some of the key approaches and major insights gained to date and reflect on what scientific questions our community may be able to tackle in years to come. Hopefully, this will kick-start discussions in the workshop that is dedicated to this topic.

KEYNOTE SPEAKER

Why an updated zonation of Neogene calcareous nannofossils?

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Two new calcareous nannofossil biozonations were published in 2012 and 2014, one for the Neogene and one for the Paleogene (Backman *et al.,* 2012; Agnini *et al.,* 2014). These zonations incorporated updated biostratigraphic data and methodologies within the known biostratigraphic framework of Martini and Bukry (Martini, 1971; Bukry, 1973, 1978; Okada & Bukry, 1980). Because Martini's and Okada and Bukry's zonations have been used for almost 40 years, there was a need for an update. The revised biozonations represent low and middle latitude biostratigraphic data that we have generated over the past three decades. The aim was to pursue a detailed calcareous nannofossil biostratigraphy through the use of semi-quantitative methods in combination with short sample intervals. A "detailed" biostratigraphy, in our practice, does not mean the overuse of biohorizons for the highest biostratigraphic resolution attainable, at the expense of their reproducibility. It is rather aimed at finding a balance between accuracy and applicability, with the use of a limited set of selected biohorizons that result in a relatively coarsely resolved biozonation. This represents a guarantee of ease of communication and viability in practical geologic work. Each biozone boundary is defined with a single biohorizon. Subzones and auxiliary markers are avoided, in order to maintain stability within the new biozonation. For the Neogene biozonation, we used a new code system that was subsequently applied to the Paleogene. Code letters for each series and a number for each of the 31 biozones were used: calcareous nannofossil Miocene (CNM) biozones 1 to 20 and calcareous nannofossil Plio-Pleistocene (CNPL) biozones 1 to 11. Additional biohorizons were considered, mainly when they unequivocally characterized the assemblage composition within a biozone. We assigned updated age estimates to all biozone boundary markers and to several additional biohorizons that were derived from astronomically tuned cyclostratigraphies.

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Nannobiostratigraphy of Jaddala Formation (type section), Sinjar anticline, NW Iraq

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The study area lies in the foothill region of the unstable shelf of the Nubio-Arabian platform at the Sinjar Anticline, which is about 20 km west of the city of Mosul in northwestern Iraq near the Iraqi-Syrian border. There are many formations that crop out in this area, and they range from Cretaceous to Tertiary in age (Buday & Jassim, 1987). The samples for this study were collected from the type section of the Jaddala Formation, which was first described by Henson (1940, in Bellen *et al.,* 1959) near Jaddala village at the southern limb of the Sinjar Anticline in NW Iraq. The outcrop is about 342 m thick and consists of marly limestone, chalky limestone, and marlstone (Bellen *et al*., 1959). The Jaddala Formation has an unconformable contact (with glauconite present) with the underlying formation, the Sinjar Formation. The overlying unit is the Ibrahim Formation (Serikagni Formation of Bellen *et al.,* 1959). The upper part of the Jaddala Formation, which interfingers laterally with the shallower water Avanah Formation, was investigated for calcareous nannofossils. Two hundred calcareous nannofossil species were recorded, and based on the assemblages, four biozones were identified. These biozones are listed below, from oldest to youngest:

1. *Tribrachiatus orthostylus* Interval (Biozone CP10) (part)
2. *Discoaster lodoensis* Interval (Biozone CP11)
3. *Discoaster sublodoensis* Interval (Biozone CP12)
4. *Nannotetrina quadrata* Interval (Biozone CP13) (part)

Correlation of these four biozones with other calcareous nannofossil biostratigraphic data in the region indicates that the section is early to middle Eocene in age.

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High-resolution assessment of coccolith assemblages during the last 150 years, Carmen Basin, Gulf of California

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One hundred and thirteen samples from the Carmen Basin, Gulf of California, were studied in order to evaluate the abundance variations in coccolith assemblages during the last 150 years. The box core DIPAL IV-C53B (25°53.311'N, 110°52.267'W) was recovered from a 670-m water depth by the R/V El Puma, which is owned by the National University of Mexico. Core C53B (34 cm) was sampled every 3 mm, and an age model was determined based on ^{210}Pb, indicating a sedimentation rate of 1.7 mm/year.

In the Carmen Basin, the high-resolution study of the coccolith assemblage revealed a change in variability every 28 years. Variability was established by applying spectral analysis to the abundance data. Using the variations in total abundance and relative abundance that were observed for the different species, it was possible to develop a paleoceanographic characterization. Between 1913 and 1942, there was a very noticeable interval that had peaks in the abundances of all the taxa, especially Gephyrocapsa (>3 μm), Gephyrocapsa (<3 μm), and Emiliania huxleyi, and from these data we concluded that the most eutrophic water masses of the whole study occurred during this interval. The younger part of the core showed the lowest species abundances and decreased paleoproductivity, which was determined by the ratio between the inhabitants of the upper photic zone and lower photic zone.

Coccolithophore productivity and surface water dynamics in the Alboran Sea during the last 25 kyr

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Coccolithophore productivity and surface water dynamics were deduced for the last 25 kyr from two cores in the Alboran Sea (western Mediterranean), using high-resolution coccolithophore records, oxygen isotopes, and paleotemperature profiles. Combining these proxies with deep-water ventilation proxies, it was possible to determine water column conditions. The distinctive locations of the cores CEUTA10PC08 and HER-GC-T1 allowed us to describe the properties (in terms of nutrient content, salinity, and SST) of the inflowing Atlantic Water (AW), which proved to be a primary control on productivity in the nearby areas of the Strait of Gibraltar. In addition, local factors, such as fluvial discharge and wind- and eddy-induced upwelling, were proven to influence productivity in even more distant areas where the properties of the incoming AW are more diluted. During the stadials associated with Heinrich events 2 and 1, the water column was stratified due to the inflowing cold and less saline AW, thus preventing primary productivity. This stratification also affected the phases “Termination Ia” and “Termination Ib” of the deglaciation that was the result of gradual sea-level rise. Nevertheless, this did not hamper local wind-induced upwelling. An organic-rich layer, recorded during the Bølling-Allerød interstadial, was likely the partial result of a trend towards increasing coccolithophore productivity. During the Younger Dryas stadial, a colder and drier first phase was recognized, followed by a warmer and wetter second phase. Productivity during these two phases differed from one location to another, depending upon the amount of eastward dilution of the AW and other local factors, such as fluvial discharge. During the Holocene, coccolithophore productivity attained its maximum values, and at the same time experienced large fluctuations. From the onset of modern oceanographic conditions in the Alboran Sea at 7.7 ka cal. BP, the local hydrography, as influenced by the configuration of the Western Anticyclonic Gyre, played an important role in determining coccolithophore productivity and its variability in the study area.

Reconstructing sea surface salinity for the last 25 kyr in the western Mediterranean from a coccolithophore-based transfer function

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In order to quantify the relationship between modern coccolithophore species assemblages in the western Mediterranean Sea and environmental conditions, a new dataset of 89 surface sediment samples and related environmental variables (temperature, salinity, chlorophyll-*a*, oxygen, etc.) was created. Multivariate statistical analyses revealed that the sampling sites were primarily distributed along the sea surface salinity (SSS) gradient, and that this variable explains an independent proportion of variance in the coccolithophore data. A quantitative transfer function was then developed to estimate salinity from modern coccolithophore assemblages, using the Modern Analogue Technique (MAT) and weighted-averaging partial least square regression (WA-PLS). The bootstrapped regression coefficient (Boot_R^2) was 0.89_{MAT} and $0.81_{WA\text{-}PLS}$, with a root mean square error of prediction (RMSEP) of 0.26_{MAT} and $0.29_{WA\text{-}PLS}$ (‰). To date, no coccolithophore-based transfer function had been implemented for the Mediterranean Sea. This new information on coccolithophore species salinity preferences provides a useful tool for quantitatively reconstructing SSS changes over time. The resulting transfer function was applied to fossil coccolithophore assemblages from a sediment core in the Alboran Sea (CEUTA10PC08, 36°1′22″N, 4°52′3″W) in order to reconstruct SSS for the last 25 kyr. The reliability of the reconstruction was evaluated through comparison with other published SSS records from nearby cores. Decreased salinity during the stadials correlated with Heinrich Events 2 and 1, which were related to melt-water pulses from the North Atlantic. The SSS increased during the last glacial maximum, likely due to a restricted Atlantic-Mediterranean connection, although lower SSS values suggest wetter conditions from 21 to 18.5 ka. Increased rainfall was deduced for the Bølling-Allerød, while a transition from more to less SSS was seen for the Younger Dryas. During the Holocene, a SSS decreasing trend was linked to increasing sea level and/or to the African Humid Period (11-5.5 ka).

Insolation cycles as a major control on Coral Sea primary production

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The automated system SYRACO was used to analyze the percentage of *Florisphaera profunda* in the continuous sedimentary record of the core MD052930 in the Gulf of Papua (MD148/PECTEN, IMAGES XIII campaign). The results indicate that strong primary production fluctuations occurred in the Coral Sea during the past 700,000 years. The record of primary production shows a dominance of 38 kyr and 23-19.4 kyr cycles that are related to precession and obliquity cycles. This mechanism is directly related to insolation and is independent of global ice volume variations. Similar results have been observed elsewhere (*e.g.,* Beaufort *et al*., 1997) and appear to be diagnostic of synchronized tropical wind patterns. Moreover, a significant 30 kyr spectral signal, which is common in the tropical Indo-Pacific Ocean productivity records, is also present in the Antarctic atmospheric CO_2 record. These similar signals in the primary productivity could suggest an important role for equatorial biological productivity in modifying atmospheric CO_2, as proposed by Beaufort *et al*. (2001).

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Nannofossil assemblage shifts in the aftermath of the Miocene Climatic Optimum – a North Atlantic latitudinal transect

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According to marine and terrestrial sedimentary records, the Miocene Climatic Optimum ended between the start of the expansion of the Antarctic ice sheet at 14.5 Ma (*e.g.,* Zachos *et al.,* 2008) and large scale climatic changes recorded in terrestrial records at 13.5 Ma (*e.g.,* Böhme, 2003). We studied nannofossil assemblages in an interval between 16 and 11 Ma in three North Atlantic sites along a meridional transect from equatorial to high latitudes (4°, 42°, and 58°N). Sampling at 100-ky resolution provided insights into successive and evolutionary changes that affected nannoplankton communities during times of global climate change.

There was no detectible decrease in total species diversity that corresponded to the presumed steepening of environmental gradients between the poles and the equator (You *et al.,* 2009 and references therein). Instead, significant long-term shifts occurred in assemblage composition. The most prominent change, between 14.5 and 13.5 Ma, involved the dominant groups, and we recorded a rise in absolute coccolith abundance for *Reticulofenestra* spp. This rise coincided in the two northern sites with a decrease in *Coccolithus pelagicus* abundances and resulted in a crossover of dominance. The pattern of abundance fluctuations for these two dominant groups could indicate that these entities shared the same basic ecological preferences. However, distinct abundance fluctuation patterns, which characterize different sizes within the groups, reveal a significant difference in ecological behaviour within each group. For the *Reticulofenestra* genus, these patterns were unique for each of the three sites, while for *C. pelagicus,* a very similar pattern was recognized in both northern sites.

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Coccolithophores in late glacial to Holocene sediments of the Norwegian Sea and their paleoceanographic implications

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A coccolith-based investigation of sediment core GIK 23312, recovered from a 977-m water depth off western Norway (66°56'N, 7°44'E), was conducted in order to document the pattern and timing of changes in surface ocean conditions. The recorded variations in coccolith numbers and species assemblages indicate that the study region was subjected to drastic changes in surface water masses during the late Glacial to Holocene.

In general, the coccolith assemblage was of low diversity and was dominated by *Emiliania huxleyi* with other species, such as *Coccolithus pelagicus*, *Gephyrocapsa muellerae*, and *Calcidiscus leptoporus,* forming significant parts of the assemblage. Absolute total coccolith numbers were relatively low before about 10.8 kyr, indicating relatively harsh environmental conditions with an influence of melt water and a rather small inflow of Atlantic surface water. However, maxima of *G. muellerae, G. ericsonii,* and *C. leptoporus* suggest that an increased influence of Atlantic surface water was already present during the Bølling-Allerød at around 14 kyr. After a short return to more pronounced cool conditions, an early Holocene increase in coccolith productivity, due primarily to elevated numbers of *E. huxleyi,* illustrates another step in the inflow of relatively warm Atlantic water. However, coccolithophore productivity did not increase significantly before the middle Holocene at about 5.8 ka at the studied site. This is later than previously observed elsewhere and may be attributed to the fact that the main core of the Atlantic water intrusion was located further to the west and, thus, may not have drastically influenced the studied site at the upper continental margin. Following the observed coccolithophore production maximum between 4.2 and 2.5 kyr, indicated by changes in the numbers and relative abundances of the dominant coccolith species, cooling of the surface waters took place after 2.5 kyr. Furthermore, observed changes in the evolution of *E. huxleyi* morphotypes and calcification stages may explain changes in coccolith weight that were observed for the late Holocene in the study area.

Late Oligocene – early Miocene calcareous nannofossils from the basal Pisco Formation, Pisco Basin, Peru

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The East Pisco Basin, located along the central coast of Peru, is dominated by volcaniclastic and diatomaceous sedimentary rocks. It also contains an important Eocene to Pliocene vertebrate fauna (Bianucci *et al.,* 2010; Lambert *et al.,* 2010). Regional stratigraphic work has established five formations based on general lithologies and biozones. Sequence-based research is just beginning in the basin (DeVries, 1998). High-resolution chronostratigraphy in the basin is currently lacking, particularly for the base of the Pisco Formation (Miocene) and the top of the Chilcatay Formation (referenced as Miocene or Oligocene). Stratigraphic studies, based on lithology, diatoms, and mollusks, have suggested a different chronostratigraphic position for these formations (Dunbar *et al.,* 1990; León *et al.,* 2008). The presence of nannoflora in a unit between the Pisco and Chilcatay that lacks macrofossils has produced the highest resolution biostratigraphic age so far for this boundary. On the eastern side of Cerro Yesera de Amara, we sampled a 25-m-thick section, which consists of very fine sandstones, calcareous mudstones, and dolomite cemented mudstones. We also have a single Ar-Ar date (17.70±0.24 Ma) from biotite in a tuff about 20 m above the unit. Twenty-four samples of calcareous shale were examined following standard techniques, and twenty-two samples were productive. Nannofossil assemblages were moderately rich (38 species) with rare to abundant species occurrences in each productive sample. Nannofossils were concentrated in the middle and upper part of the section. Preservation was poor, showing strong dissolution and/or overgrowth in almost all samples. *Cyclicargolithus abisectus, Cyclicargolithus floridanus, Discoaster deflandrei, Discoaster adamanteus, Sphenolithus moriformis, Sphenolithus conicus, Reticulofenestra lockeri, Reticulofenestra bisecta, Helicosphaera granulata, Helicosphaera carteri, Helicosphaera euphratis,* and *Coccolithus pelagicus* were the dominant taxa recovered. Considering the co-occurrence of *C. abisectus, Sphenolithus dissimilis, S. conicus,* and *R. bisecta*, an age of latest Oligocene to earliest Miocene, Zone NP25 to NN1 (Martini, 1971) is proposed.

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Another drop in the ocean … how to determine absolute coccolith abundance?

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Absolute coccolith abundances (number per gram of sediment) can be calculated by (a) using the number of particles per field of view, with known concentration and total area of distribution (*e.g.,* Andruleit, 1996; Geisen *et al*., 1999; Koch & Young, 2007) or by (b) spiking the sediment sample with a known amount of microbeads and then using the ratio between a known and unknown concentration (*e.g.,* Bollman *et al*., 1999). Existing sample preparation techniques use (1) filtration (Andruleit, 1996), (2) random settling (Geisen *et al*., 1999), and (3) dilution (Koch & Young, 2007). We modified the dilution technique to the "drop technique" by preparing the nannofossil suspension directly and skipping the dilution step. Coccolith abundances were calculated independently on the basis of the observed area and ratio between coccoliths and added microbeads, as well as without microbeads. We determined the reproducibility and accuracy of the drop technique, and we compared it to other established techniques

In general, absolute abundance values that were calculated with the use of microbeads were much less variable among the different preparation techniques (average 10% s.d.) than those calculated using the number of particles per field of view (average 41% s.d.), so we consider the former to be closer to "real values". The range in values obtained with the different methods was less with the drop and settling techniques than for the filtration technique. The filtration technique appears to consistently underestimate "real values". The reproducibility within each preparation technique and calculation method, however, was comparable for each method (± 10% s.d.).

We conclude that the results obtained with different preparation techniques can only be directly compared when samples are spiked with microbeads. Abundance results obtained using the different methods should, however, allow the detection of the same trends. The drop technique yields results comparable to the random settling technique, and both seem more reliable than the filtration technique for samples not spiked with beads. In comparison to the other established techniques, the drop method is very fast and cheap.

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Eocene-Oligocene shifts in calcareous nannofossil assemblages at ODP Site 1263 (Walvis Ridge, Atlantic Ocean)

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During the Eocene-Oligocene transition (EOT), the world changed from a high- pCO_2 warm Eocene world to a cool, lower pCO_2 Oligocene world, and oceanic phytoplankton was affected in various ways (Persico & Villa, 2004; Dunkley Jones *et al.*, 2008; Henderiks & Pagani, 2008). To unravel the relations between changes in climate and calcareous nannofossil assemblages, we studied a high-resolution succession spanning the EOT (32.7-34.3Ma) at ODP Site 1263. Our analysis revealed a distinct decrease in both nannoplankton absolute abundance (N/g) and mean coccolith size across the Eocene-Oligocene (E-O) boundary (34 Ma). The absolute abundance of small- to medium-sized *Cyclicargolithus* did not vary much in the studied interval, but large-sized *Reticulofenestra* and *Dictyococcites* decreased abruptly across the E-O boundary. This is confirmed by principal component analysis, with PC1 (36% of variance) loaded negatively by small- to medium-sized species and positively by large species.

Thus, the most prominent ecological response patterns appear to be related to variations in species with different sizes of coccoliths. Mean cell sizes, expressed in mean volume to surface area ratio (V:SA of Henderiks & Pagani, 2008), decreased across the E-O boundary. Henderiks & Pagani (2008) and Pagani *et al*. (2011) documented similar decreases in reticulofenestrid size across the E-O boundary that corresponded to a marked decrease in alkenone-based pCO_2 estimates. They hypothesized that, during the late Eocene, large-celled coccolithophores were well adapted to high pCO_2 and CO_2 (aq) conditions, whereas during the early Oligocene, small species became more competitive at a lower pCO_2. Our study documents this size response in greater detail across the E-O boundary. It took ~43kyr for large-celled species to develop a competitive disadvantage in the early Oligocene "icehouse" oceans, which is linked both to pCO_2 and temperature decreases. The loss in large reticulofenestrids was not compensated for with an increase in abundance of other taxa, and total coccolith abundance decreased following the EOT.

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IODP Expedition 346 "Asian Monsoon": calcareous nannofossil biostratigraphic and paleoenvironmental synthesis

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Integrated Ocean Drilling Program (IODP) Expedition 346 (July 29-September 27, 2013) from Valdez, Alaska to Busan, South Korea, drilled seven sites in the Japan, Yamato, and Ulleung Basins in the mid-latitude northwest Pacific Ocean, and two additional sites in the East China Sea. The expedition recovered 6135.3 m of sediment core, which is a new record for core recovery for IODP expeditions. The nine sites covered a wide range of latitudes (~32° to ~44° N) and water depths (330 to 3429 m below sea level (mbsl)), and recorded deposition that was influenced by a variety of oceanic currents. All nine sites were investigated for calcareous nannofossils, and a total of 632 samples were taken on board ship from the core catcher and split cores. Although all documented assemblages lacked typical warm-water taxa, such as discoasters, it was still possible to generate consistent age models with the use of shipboard biostratigraphy and magnetostratigraphy.

Post-expedition research plans include a detailed, multi-approach reconstruction of Tsushima Warm Current variations in order to assess changes in the response of the marginal sea among the Japanese Islands, the Korean Peninsula, and the Eurasian continent to external climate-related forcing during the late Pleistocene. Therefore, Site U1427, located at 35°57.92'N, 134°26.06′E at approximately 330 mbsl in the Yamato Basin, was selected for our future studies. Its unique setting, high sedimentation rates (36 cm/ky), and good preservation of carbonate observed during Expedition 346 provide exceptional opportunities for high-resolution analyses of shifts in nannofossil assemblages through critical intervals of Pleistocene climate change, such as the mid-Pleistocene transition.

A high-resolution record of monsoonal dynamics in the eastern Arabian Sea

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This study presents a high-resolution primary productivity record for the last 30 ka in the eastern Arabian Sea (EAS), based on coccolithophore assemblages in the SK 17 core from the continental slope off Goa, India. Coccolithophores were proposed as indicators of primary productivity and nutricline position, and the results were used to reconstruct monsoonal dynamics, the main factor controlling productivity changes in the EAS. Both winter and summer monsoon seasons exert a strong control over the primary productivity in the Arabian Sea. Increased productivity was recorded during the late glacial period in the EAS, contrasting with records obtained in the western and northern Arabian Sea. This enhanced productivity was related to strengthened winter monsoon winds. Planktonic foraminiferal data suggest a weakened winter mixing during the last deglaciation, which would reduce productivity in the area. However, our coccolithophore data reveal a high primary productivity during the deglaciation, probably maintained by the nutrient supply from continental runoff due to the presence of an enhanced summer monsoon. With regard to the Holocene, surface waters have been highly stratified since 10.5 ka. Our data were compared with ice core isotopic records from high latitudes of both hemispheres, which allowed us to observe a good correlation between the stratification of the EAS and the climate variability over high latitude regions in the northern hemisphere. However, there has been some inconsistency between our coccolithophore data and planktonic foraminiferal records, particularly during the short time intervals that correspond to the Heinrich cold events described in the North Atlantic region.

Replicates, why not?

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Laboratory procedures in geology traditionally do not involve making replicates. This is because sometimes samples are unique, or there is limited material, or just because we are not used to the idea of replicating samples. Yes, at the beginning of our careers, we all methodologically checked and double-checked laboratory procedures. However, we rarely replicated samples or duplicated entire laboratory procedures unless slides ended up broken or ruined.

Why should we replicate samples for paleoceanographic/paleoecological analysis? After all, it can substantially increase time needed for sample preparation and microscope observation, at least by a factor of three. The easiest answer is because we can! Due to the tiny amount of raw material routinely needed, we can easily replicate our samples, even from cores. No other micropaleontological or palynological working group can easily do this. Replication may increase the robustness of our interpretations, as those with more biological and chemical backgrounds are well aware. Most of the sedimentary facies that I have been studying are from water too shallow to normally have calcareous nannofossils, so lateral replicates are routinely collected to increase the probability of finding any specimens at all. Recently, while working with colleagues with biological and chemical backgrounds, I noticed that their standard procedure is to replicate all lab experiments. So, replicating samples is an accepted procedure. I am now in the process of proposing/convincing young researchers to start replicating their samples in order to see what the balance is between the advantages and disadvantages of this procedure.

Coccolithophore assemblages in the northern Sulu Sea

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Coccolithophore assemblages and their distribution in the northern Sulu Sea, a marginal sea in the Philippines, were investigated in this study. The northern Sulu Sea receives warm, less saline water from the South China Sea (SCS) via the Mindoro Strait (Qu & Song, 2009). From the Sibuyan Sea, warmer and saltier intermediate waters enter the Sulu Sea through the Tablas and Panay Straits (Sprintall *et al.,* 2012). The mixing of these waters in this part of the study area contributes to the strong southward currents along the western borders of Mindoro and Panay Islands. During the 2007 Joint Cruise of the Philippine Strait Dynamics Experiment (PhilEx) onboard *R/V Melville*, water samples were collected from the Sibuyan and Sulu Seas at different depths (10 m, deep chlorophyll maximum [dcm], 200 m), and were filtered using 0.45 μm Millipore filters. Using polarizing light and scanning electron microscopy, initial investigations yielded 47 coccolithophore species, with the assemblage dominated by *Gephyrocapsa oceanica* and *Umbellosphaera irregularis*. These two taxa show negative correlation with each other along the transect that runs parallel to the eastern border of the northern Sulu Sea. A detailed analysis of the distribution of coccolithophores in the surface waters of the northern Sulu Sea was conducted, and microphotographs and morphological descriptions for all taxa were documented, which contribute to baseline data on coccolithophore assemblages in low-latitude tropical settings, including the Philippine inland seas.

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Revisiting Catanduanes Island: calcareous nannofossil biostratigraphy of its Cenozoic formations

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Paleontological studies have been important for stratigraphic correlation and determining the ages of lithologic units in Catanduanes Island, Philippines. The sedimentary rocks have been dated using foraminifera (Tan, 1986; Fernandez *et al.,* 1994; Militante-Matias, 1995; MGB, 2008), ammonites (Tumanda, 1985; Matsukawa *et al.,* 2012), and, most recently, calcareous nannofossils for the Cretaceous formations (Fernando *et al.,* 2014; Magtoto *et al.,* 2014). Despite the number of studies conducted on the island, the age of most Cenozoic formations remains unclear. The present study, therefore, uses calcareous nannofossils in an attempt to confirm and establish the age of the following lithologic units: Bote Limestone (late Oligocene-early Miocene), Santo Domingo Limestone (middle-late Miocene) and Viga Conglomerate (Pliocene-Pleistocene).

Preliminary results revealed the occurrence of rare to few, poor to moderately preserved calcareous nannofossils. The species observed in the samples, although long ranging, generally support the previously published ages of the formations. The Bote Limestone samples revealed a low diversity assemblage, consisting mostly of Cyclicargolithus floridanus and Reticulofenestra haqii, assigning the limestone to Zones NN2-NN7 (early-middle Miocene). Based on the occurrence of the large benthic foraminifera Lepidocyclina formosa, the limestone has also been dated as middle Oligocene to early Miocene. Similar to the Bote Limestone, the nannofossils observed in the Santo Domingo Limestone are long-ranging: Sphenolithus abies, Reticulofenestra haqii, and R. minuta. Based on these taxa, the limestone can be assigned to Zones NN7-NN15 (middle Miocene-early Pliocene). The age assignment of the Viga Conglomerate has always been a problem due to the absence of fossils. The age of the formation, therefore, was based on its “poorly-indurated” character. An attempt to date the formation was not successful, as the fine sandstone/mudstone lenses, as well as the matrix, were found to be barren of calcareous nannofossils.

This study’s attempt to date the Cenozoic formations in Catanduanes Island shows that nannofossil biostratigraphy is a promising tool for refining the stratigraphy of the island and is an important contribution to understanding the geologic evolution and history of Catanduanes.

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Middle to late Eocene paleoenvironmental changes from the northern Tethyan margin (Adelholzen, Germany) traced by calcareous nannoplankton

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The northern Tethyan margin is a key region for determining environmental changes associated with the collision of continental and oceanic tectonic plates during the Alpine orogeny. We investigated middle to upper Eocene sediments of neritic to bathyal origin that were deposited during an interval of unstable climatic conditions. The section at Adelholzen covers an almost complete Lutetian Stage (calcareous nannofossil Zones NP15a-16, planktic foraminiferal Zones E8-11, and shallow benthic Zones SBZ13-15) and large parts of the Priabonian Stage (Zones NP18-20 and E14/15), while the intermediate Bartonian Stage (Zone NP17) is completely missing. All investigated samples contain very well preserved and abundant autochthonous calcareous nannoplankton assemblages and only very low percentages of reworked nannoplankton. The succession of assemblages reflects the transition from the relatively stable shallow-water conditions with low nutrient availability (high relative abundances of *Cyclicargolithus floridanus*) during the deposition of the lower and middle Adelholzen Beds (early Lutetian) to the highly variable conditions of the upper Adelholzen Beds (late Lutetian).

This was followed by a period of relatively stable conditions that show a change from high paleotemperatures with probable increased nutrient availability and subsequent increased paleo-primary productivity in the uppermost Adelholzen Beds to open-ocean conditions and reduced paleo-primary productivity in the Stockletten Formation (latest Lutetian, Priabonian). Higher proportions of eutrophy and cold-water favoring *Coccolithus pelagicus* in the middle Adelholzen Beds and a stepwise increase in the Stockletten point to phases of increased surface-water nutrient availability, whereas low numbers of *C. pelagicus* in the upper Adelholzen Beds point to warming during this interval and even more oligotrophic conditions.

Middle Miocene calcareous nannoplankton from the southern Pannonian Basin (Bosnia and Herzegovina)

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Paleoenvironmental analyses based on calcareous nannoplankton and foraminiferal distribution were carried out on samples from a locality at the village of Bogutovo near Ugljevik. During the middle Miocene, the region was positioned on the southern margin of the Pannonian Basin and the Central Paratethys Sea. The studied section is a sedimentary succession that is dominated by marine marls with a single limestone package near the middle. Samples from borehole UI568 were also studied. All assemblages are dominated by small reticulofenestrids, with lesser numbers of *Coccolithus pelagicus*, *Helicosphaera carteri*, *H. walbersdorfensis*, *Holodiscolithus macroporus*, *Reticulofenestra gelida*, *R. pseudoumbilicus*, *Sphenolithus moriformis,* and *Umbilicosphaera jafari*. *Braarudosphaera bigelowii*, *Calcidiscus leptoporus, Coronocyclus nitescens*, *Coronosphaera mediterranea*, *Cyclicargolithus floridanus*, *Geminilithella rotula, Pontosphaera multipora*, *Rhabdosphaera sicca,* and *Syracosphaera pulchra* are rare but continuous in occurrence.

Above the nonmarine Oligocene sediments from the borehole are sediments that contain some unidentified nannoplankton taxa. Continuous occurrences of the calcareous nannoplankton zonal marker *Sphenolithus heteromorphus* and the absence of *Helicosphaera ampliaperta* in the middle and the upper part of the section allow placement in Zone NN5. The last occurrence of *S. heteromorphus* indicates that the Zone NN5/NN6 boundary can be placed in the top portion of the studied interval.

Using the standard Central Paratethys ecozones for benthic foraminifera, the analyzed time interval includes two zones: the early Badenian (Moravian) upper Lagenidae Zone and the middle Badenian (Wielician) *Spirorutilus carinatus* Zone.

Lowermost Miocene calcareous nannoplankton and foraminifers from the Austrian part of the Alpine-Carpathian Foredeep (paleoecology and biostratigraphy) of Upper Austria

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Lower Miocene sediments of core UE50 drilled near Ebelsberg (Upper Austria) were examined for calcareous nannoplankton and planktonic and benthic foraminifers. Quantitative analyses were performed to define the stratigraphic position of the Ebelsberg Formation and to investigate paleo-conditions during the lowermost Miocene in the Alpine-Carpathian Foredeep.

All samples contain high percentages of *Coccolithus pelagicus* and reticulofenestrids (*Reticulofenestra bisecta*, *R. daviesii*, *R. lockeri*, *R.* cf. *foveolata*, *R. gelida*, *R. haqii*, *R. minuta,* and *R. pseudoumbilicus*). Less common but regularly occurring species are *Cyclicargolithus floridanus, Helicosphaera carteri*, *H. euphratis*, *H. scissura*, *H. stalis,* and *Pontosphaera multipora*. Sphenoliths are present as rare specimens of *Sphenolithus capricornutus, S. dissimilis,* and *S. moriformis*. High numbers of *Braarudosphaera bigelowii* occur in the lower part of the section. *Pontosphaera ebelsbergi*, first described from the UE50 core material, was subsequently observed in other lower Miocene sections from the Austrian part of the Alpine-Carpathian Foredeep.

Stratigraphic analysis of the foraminiferal faunas, represented by common *Gaudryinopsis austriacus, Tenuitella minutissima,* and *Tenuitellinata pseudoedita,* suggests a late Egerian (early Aquitanian) age that is restricted to Zone NN1 on the basis of calcareous nannofossils. Paleoecological analyses of microfaunas and nannofloras indicate deposition in an outer neritic to bathyal realm with cold deep water and cool surface water. Increasing eutrophication, the result of upwelling and short-term, fresh water influx, is documented by blooms of *B. bigelowii*. High organic production in the water column resulted in an ongoing accumulation of organic material on the sea floor, which ultimately led to oxygen deficiency, and thus a drastic change in benthic foraminiferal faunas in the uppermost part of the core.

Coccolithophore biocoenosis, thanatocoenosis, and taphocoenosis in a marginal basin in the Gulf of California

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Since 2002, we have been monitoring the coccolithophore plankton assemblages, associated carbonate flux, and accumulation of coccoliths in surface sediments in a pristine marginal basin located close to a productive upwelling area in the Gulf of California. During the study period, cell density varied from less than 1×10^3 cells l^{-1} to 125×10^3 cells l^{-1} in the upper photic zone, and from 0.5×10^3 cells l^{-1} to 31×10^3 cells l^{-1} in the lower photic zone, respectively. In general, the highest cell density occurred during late winter-early spring. The total flux of coccoliths in the trap showed minimum fluxes (2×10^6 coccoliths m^{-2} d^{-1}) in spring-summer and maximum fluxes in autumn-winter (13×10^9 coccoliths m^{-2} d^{-1}). A total of 85 species from 44 genera were identified. Species richness varied from 57 species in plankton samples (dominated by *Emiliania huxleyi* in winter-spring and *Gephyrocapsa oceanica* in summer-autumn) to 55 species in sediment trap samples (dominated by *G. oceanica* and *E. huxleyi*) and 8 species in surface sediment samples (dominated by *G. oceanica*). Our data clearly show that species richness is significantly reduced in sediment assemblages because, on an average, only 10% of the plankton species are preserved in sediments.

Size variations in selected coccolith species through Mesozoic oceanic anoxic events: implications for paleoceanographic reconstructions

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Biometric analyses were performed on the coccolith species *Biscutum constans* and *Watznaueria barnesiae* across the Cenomanian–Turonian time interval. For each species, length and width of coccoliths were measured on digitally captured images. A total of 30 specimens of *B. constans* and 50 of *W. barnesiae* were analyzed in each sample, which resulted in a total of 4,870 measurements of *B. constans* and 7,500 measurements of *W. barnesiae*. In addition, the coccolith ellipticity and surface area were calculated. This study was carried out on samples coming from five sections situated at different paleolatitudes: Eastbourne, Clot de Chevalier, Novara di Sicilia, Pueblo, and Cuba.

The purpose of the study was to identify possible changes in coccolith size/shape in response to paleoenvironmental perturbations associated with Oceanic Anoxic Event 2 (OAE 2). A decrease in size or “dwarfism” of *B. constans* was observed in all sections during OAE 2, which is interpreted to be due to excess CO_2 that might have induced species-specific dwarfism. On the other hand, no changes in the size of *W. barnesiae* were detected, suggesting that this taxon was less sensitive to stressed environmental conditions.

The morphometric data collected for OAE 2 were compared with similar data available for *B. constans* and *W. barnesiae* across the early Aptian OAE 1a and the late Albian OAE 1d. Although absolute values differed, very similar trends were observed. In particular, *B. constans* decreased in size in the core at the OAE 1a perturbation, becoming a dwarf. For the Toarcian OAE, morphometric analyses were conducted on *Biscutum* and *Lotharingius*, both showing dwarfism in the anoxic interval.

We speculate that, even if different degrees (and maybe types) of paleoenvironmental perturbations were acting during the T-OAE, OAE1a, and OAE2, biocalcification of specific coccoliths reacted analogously with dwarfism when threshold conditions of excess CO_2 and warming were reached.

Paleoceanographic history of the Bohol Sea from calcareous nannofossils during the Quaternary

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The Bohol Sea, one of the least studied inland bodies of water in the Philippines, is located in the central Philippines between the Visayan Island Group and the island of Mindanao. It is connected to the Philippine Sea (Pacific Ocean) and Sulu Sea in the east and west, respectively, via various straits and channels. Strong westward currents in the Bohol Sea are believed to carry western Pacific surface waters into the Sulu Sea, while dense water overflows from the Sulu Sea into the depths of the Bohol Sea. At present, several rivers drain towards the southern part of the Bohol Sea, influencing both the nature of the sediments and productivity levels in the area.

Calcareous nannofossil analyses were conducted on three multicore and three gravity cores collected from the eastern, central, and western portions of the Bohol Sea. Variations in the calcareous nannofossil assemblage among the stations suggest that they are influenced by water influx from the Sulu Sea and the Philippine Sea (Pacific Ocean), as well as by intrinsic water circulation. Downcore variations in productivity proxies from computations of calcareous nannofossils and assemblages were attributed for the late Pleistocene to Holocene interval, which are usually recorded in high-latitude sedimentary records. Moreover, anti-correlations between the cool water vs. warm water species and open-ocean water vs. neritic species were observed. Some of the events that are coeval with nannofossil fluctuations are the Holocene Bond events (*i.e.,* 600-150 years before present (yBP), 1200–1000 yBP, 3500-2500 yBP, 4200-3800 yBP, and 6000-5000 yBP), as well as the Holocene-Pleistocene boundary, the Younger Dryas cold spell (12,900-11,500 yBP), the Bølling-Allerød interstadial (15,000–12,700 yBP), the Older Dryas cold spell (14,050-13,900 yBP), the Heinrich events during ~16,800 yBP and ~24,000 yBP, the Late Glacial Maximum (13,000-10,000 yBP), and the Last Glacial Maximum (25,000-13,000 yBP).

Changes in calcareous nannofossils across the Toarcian and Early Aalenian from the Lusitanian Basin (Portugal)

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This study provides a comprehensive and detailed account of calcareous nannoplankton assemblage changes across the Toarcian and early Aalenian in the strategically located Lusitanian Basin in Portugal. During the Toarcian, this basin was a seaway connecting the NW Tethys and Mediterranean water masses, so the nannoplankton community in the seaway would be expected to respond to influences from both water bodies. Accurate biostratigraphic control from two ammonite-calibrated and continuous sections (Rabaçal and Cabo Mondego) were merged with an intermediate section (Brenha). This resulted in a complete 286-m-thick composite section of Toarcian and lower Aalenian sediments. Qualitative and quantitative analyses of calcareous nannofossil assemblages were performed, along with factor analysis and stable carbon and oxygen isotopes analyses from brachiopods shells. Three factors were extracted from the factor analysis, and they provide good illustrations of temperature, NW European water mass incursions, and primary productivity. Three major ecological events also were recognized from this work. During the early Toarcian, a hot and humid transgressive period where calcareous nannoplankton thrived, the nannofossil assemblages document water mixing between NW European and Mediterranean water masses. Across the middle and part of the late Toarcian, as climatic conditions stabilized, water masses became more stratified, and primary productivity decreased, as testified by $\delta^{13}C$ data and total nannofossil abundances. From part of the late Toarcian ammonite speciosum Zone upwards, the environment again became meso-eutrophic as the connection between northern and southern water masses decreased, and high fertility taxa such as *Schizosphaerella* thrived within the shallow photic zone. Moreover, perturbations in water paleotemperatures seem to be linked to *Lotharingius* and *Watznaueria* radiation in the middle Toarcian and early Aalenian.

Deciphering control processes on mid-Jurassic coccolith turnover

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The Middle Jurassic is characterized by major changes within the calcareous nannoplankton with a transition from *Lotharingius*-dominated assemblages to *Watznaueria*-dominated assemblages (Erba, 1990; Cobianchi *et al.,* 1992; Mattioli & Erba, 1999; Tiraboschi & Erba, 2010), which was concomitant with a large increase in pelagic carbonate production (Suchéras-Marx *et al.,* 2012, 2014). The mechanisms that triggered this replacement within the nannoplankton community remain poorly understood. We investigated possible triggers such as plate tectonics, temperature, primary productivity, and evolution that could lead to nannoplankton turnover. We acquired new stable carbon and oxygen isotope data from brachiopod shell calcite. We integrated these data with already published data to estimate changes in both marine primary production and temperature. For the first time, a compilation of the abundance changes of *Lotharingius* and *Watznaueria* through time was made. Major environmental changes occurred at the Aalenian-Bajocian transition. The negative $\delta^{13}C$ excursion in the latest Aalenian occurred during a cooling stage, whereas the early Bajocian positive $\delta^{13}C$ excursion took place during a warming stage. The replacement of *Lotharingius* by *Watznaueria* occurred through several steps. First, *Watznaueria* with a cross in the central area proliferated during the latest Aalenian, a very unstable period, with turnovers in many marine groups. From the early Bajocian to the end of the Bathonian, two other *Watznaueria* groups successively dominated the coccolith assemblages: first forms with a bridge and later those without structure in the central area. In addition, the early Bajocian radiation event that is documented by *Watznaueria* is also recorded in other marine groups. Increased mid-ocean ridge activity since the early Bajocian, combined with oceanographic and climatic changes, may have been responsible for increased fertilization of the ocean that ultimately triggered marine organism radiations. We propose that the nannoplankton community changes were forced more by abiotic mechanisms rather than stochastic evolutionary processes.

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The significance of coccolithophore assemblages as indicators of marine influx in Miocene deposits of the Eastern Paratethys

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Nannofloral assemblages were investigated to identify biostratigraphic events and paleoenvironmental changes during the Miocene from key sections in the Eastern Paratethys (southern Russia). The latest Oligocene to basal Miocene interval (upper part of Zone NP25 and base of Zone NN1) is characterized by scarce nannofloral assemblages and consists principally of cosmopolitan taxa (North Caucasus and North Ossetia).

The Tarkhanian assemblages (Zones NN4-NN5) reflect a distinct marine influx and consist primarily of *Sphenolithus* and *Helicosphaera* species that indicate shallow-water environmental conditions (North Caucasus, Taman Peninsula, Dagestan, and Azerbaijan). The Konkian assemblages (Zones NN6-NN7) are not diverse and reflect the fluctuating character of the ecologic conditions. The coccolith limestone deposits (latest Konkian to basal Sarmatian interval) contain a *Reticulofenestra pseudoumbilicus* bloom (Taman Peninsula, North Caucasus, and Mangishlak).

The lower Sarmatian deposits are characterized by the development of a monospecific assemblage of *Syracosphaera* sp. that contains extremely small coccoliths. In the lower Maeotian (Taman Peninsula), nannoplankton were encountered only at those levels with the most marine conditions. The upper Maeotian and the lower part of the lower Pontian are composed of thick clayey beds that are interbedded with laminated diatomite strata that have been named "transitional strata" (Radionova & Golovina, 2011).

Thus, the Miocene nannofloral assemblages are indicative of environments in the Eastern Paratethys that fluctuated between open-sea and shallow-water conditions, especially during transitional intervals with inconstant environments (Radionova *et al.,* 2012).

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Biostratigraphic analysis of the upper member of the Klondyke Formation using calcareous nannofossils

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This study provides a preliminary age estimate for an outcrop located along the Pugo River in the Philippines, using calcareous nannofossil assemblages. De Leon *et al.* (1991; 1998) performed detailed biostratigraphic analyses on material from parts of the Central Luzon Basin and Marcos Highway in La Union and Benguet. These previous studies constrained the age of the Klondyke Formation to the middle Miocene. Nannofossil examination reveals a moderately to well-preserved assemblage that is dominated by discoasters and sphenoliths, dissolution-resistant forms that are the most common species throughout the sequence. *Coccolithus, Reticulofenestra, Pontosphaera,* and *Scyphosphaera* also occur in rare numbers. The presence of *Discoaster berggrenii* in the Pugo River outcrop restricts it to calcareous nannofossil Zone NN11A (8.6 to 7.3 Ma), or the late Tortonian of the middle late Miocene. Biostratigraphic and lithologic correlations suggest that the Pugo River outcrop is part of the upper member of the Klondyke Formation, which consists of turbiditic sandstones and shales. A shelfal marine environment is proposed based on lithologic and paleontologic evidence.

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Coccoliths from recent sediments of the central Portuguese margin: preservation of ecological signature in a dynamic sedimentary setting

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Recent coccolith assemblages were studied from surface sediments collected along five transects that cut across the central Portuguese continental margin. By investigating variation in coccolith concentrations and relative abundances along north-south and onshore-offshore gradients and between submarine canyons and open-shelf and slope areas, and by correlation with sediment characteristics (sediment accumulation rate, sediment bulk composition, particle-size, and C_{org}/N_{tot}), we assessed to what extent (paleo) ecological information can be distinguished from taphonomic effects.

Despite the vigorous current dynamics and active sediment transport on the shelf and in the canyons, we found that the original distribution patterns reported for living coccolithophores from Portuguese margin surface waters (Guerreiro *et al.,* 2013; 2014) are reflected by patterns in relative abundances of coccoliths in the underlying sediment (Guerreiro *et al.,* in press). As found in the surface water assemblages, *Gephyrocapsa oceanica*, *Coronosphaera mediterranea*, *Helicosphaera carteri,* and *Coccolithus pelagicus* are more prevalent on the continental shelf and upper canyon reaches, whereas *Gephyrocapsa muellerae*, *Calcidiscus leptoporus,* and the group comprising *Umbilicosphaera sibogae*, *Umbellosphaera irregularis,* and *Rhabdosphaera* spp. have higher relative abundances on the open slope. The higher abundances in the coastal assemblages in the upper Nazaré Canyon appear to be associated with persistent high productivity that is driven by an amplification of coastal upwelling and internal tidal pumping at the canyon head and the adjacent southern shelf.

We propose a taphonomy-driven scenario to explain how the primary ecological signal can be preserved in an environment known for its dynamic sedimentary processes. In this scenario, coccolith preservation is favored by rapid incorporation in the sediment near their area of origin, while coccoliths reworked by currents and transported away from their area of origin are subject to non-selective destructive processes, including dissolution and mechanical abrasion. While demonstrating the importance of taphonomic processes on the preservation of coccoliths in the sedimentary record, this study also underlines the enormous potential of coccoliths in paleo-applications, even in dynamic coastal settings.

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Cretaceous nannostratigraphy of the Kopet Dagh Mountain Range (northeast Iran)

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The Kopet-Dagh Mountain Range, which stretches nearly 650 km in a WNW-ESE direction east of the Caspian Sea from the former Soviet Union through Iran and into Afghanistan, is composed of a succession of gently folded rock. The base of this succession is only exposed in the eastern part of this mountain range in Iranian territory. The most complete Cretaceous sedimentary succession in eastern Iran is found in the Kopet Dagh Mountain Range and is comprised of marine shales, marls, and limestones and a subordinate amount of sandstone. This sequence appears to represent all major stages of the Cretaceous (Stocklin, 1968). These deposits are exposed throughout most of the Kopet Dagh Range with few exceptions. For the first time, calcareous nannofossils were used to determine the age of these sedimentary beds. The distribution and relative abundances of Cretaceous calcareous nannofossil taxa were recorded from the lower and upper boundaries of all formations (*e.g.,* Mozduran, Shurijeh, Sarcheshmeh, Sanganeh, Aitamir, Abderaz, Abtalkh, Nizar, and Kalat) in both the eastern and western part of the Kopet Dagh.

For this study, samples were collected about 5 m above and below the lithological boundaries of the formations in 4-6 sections (Lower-Upper Cretaceous). These samples were prepared with a smear slide technique and photographed with a light microscope. Based on nannoplankton biostratigraphic results, a correlation chart for the Cretaceous sediments of Kopet Dagh range was made. Results show that the ages of the studied formations were almost the same from east to west, except for the Aitamir-Abderaz, Abderaz-Abtalkh, Abtalkh-Nizar, and Nizar-Kalat formational boundaries in the west. The Abtalkh and Nizar Formations are absent in the west, as evidenced by the absence of Zones CC21-CC25.

A discontinuous sedimentary pattern between the Abderaz and Kalat Formations is suggested. The variability of species abundances in the studied section is likely related to paleoenvironmental conditions. Quantitative studies of species suggest that the Cretaceous formations were deposited in a shallow-marine basin that increased in depth from east to west. The results match studies from adjacent areas.

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Nannostratigraphy of the Dalichai Formation in the Naviya section of Kopet Dagh Mountain Range in Iran

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For the first time, the calcareous nannofossils of the Dalichai Formation have been studied. The Dalichai Formation, which contains oil and gas reserves, is a well-bedded greenish-gray, tarry (bituminous), pyritic, marly shale with thin layers of limestone (Afshar-Harb, 1979). The Dalichai Formation is overlain by the Lar Formation and is underlain by the Kashaf Rud Formation. A total of 110 samples were examined, and nannofossil species were well preserved. In this study, 37 species belonging to 23 genera and 11 families were recorded. Using ammonites, previous workers assigned an Oxfordian-Kimmeridgian age to this formation. Using the first and last occurrences of calcareous nannofossils, the age of the Dalichai Formation is lower Bajocian-Tithonian/Berriasian in the Naviya section, which corresponds to Zones Nj9-Nj18/CC1 of Bown (1998).

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Possibility of extracellular calcification of Braarudosphaera bigelowii deduced from cell-surface structure and elemental compositions of pentaliths by analytical electron microscopy

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Braarudosphaera bigelowii is a nannolith-bearing coccolithophore, which is characterized by pentagonal calcareous scales called pentaliths. Pentaliths of *B. bigelowii* consist of five trapezoidal segments with a laminar structure. The calcifying stage of *B. bigelowii* has never been successfully grown in culture, despite repeated attempts, and so the mechanism of calcification of pentaliths is still unknown.

We have studied the fine morphology of the membranous structure of *B. bigelowii* with scanning electron microscopy (SEM) and transmission electron microscopy (TEM), and the elemental composition of pentaliths of *B. bigelowii,* using energy dispersive spectroscopy (EDS). *Braarudosphaera bigelowii* has a characteristic membranous structure, which closely underlies the proximal surface of the pentaliths and extends between the sides of the individual pentaliths. The EDS analyses revealed that pentaliths of *B. bigelowii* have a relatively high-Mg content compared to that of heterococcoliths. Our observations suggest that the calcification mechanism of pentaliths of *B. bigelowii* differs from that of the low-Mg content of heterococcoliths, which are produced intracellularly, and that the membranous structure appears to act as a template for shaping the pentaliths of *B. bigelowii*.

Abundance and distribution of coccolithophores and Parmales (Tetraparma insecta) in the Gulf of California during the summer (July-August, 2011), and their relationship to oceanographic conditions

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Recent studies have shown particular oceanographic conditions in the Gulf of California, such as the presence of eddies. The influence of these eddies on the phytoplankton is not well known. The structure of the phytoplankton community, especially the coccolithophores and Parmales (Chrysophyceae), was studied along a transect parallel to the main axis, where evidence of two eddies was noted during one oceanographic cruise in the Gulf of California (July-August, 2011). Environmental variables, such as temperature, salinity, and dissolved oxygen, as well as fluorescence were measured *in situ.* Samples for nutrient and phytoplankton (filtered material) analyses were also taken. Thirty-one species of coccolithophores and one species of Parmales (*Tetraparma insecta*) were identified and counted, using both light and scanning electron microscopy. *Emiliania huxleyi* and *Gephyrocapsa oceanica* were the most frequent and abundant species. The highest cell densities found for coccolithophores and *T. insecta* were 6.7 X 10^4 cells L^{-1} and 1.3 X 10^4 cells L^{-1}, respectively. The vertical distribution of coccolithophores was heterogeneous, usually with a subsurface peak (between 18 and 35 m) in most stations, whereas Parmales showed a preference for slightly deeper waters (always below 20 m). Abundances of *T. insecta* were comparable with those of Parmales species in more temperate waters. The distribution of both groups showed a striking similarity with the distribution of temperature and chlorophyll *a*, thus indicating a strong influence by the oceanographic eddies for that period in the Gulf.

The incredible Braarudosphaera bigelowii, a coccolithophore that displays exceptional mathematical traits

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Complete tests of *Braarudosphaera bigelowii* (Late Cretaceous-Recent), representing a regular pentagonal dodecahedron with either flat (Euclidean) or slightly convex (elliptic) pentagonal plates, are rarely found as fossils. However, recent plankton specimens commonly exhibit slightly concave (hyperbolic) pentagonal plates in terms of mathematical terminology. Compared to hypothetical coccosphere models of other members of Braarudosphaeraceae (*i.e., Pemma* and *Micrantholithus*), *B. bigelowii* opts for a more stable architecture. Each pentagonal plate is invariably traversed by five dextrally oriented (chiral) radial sutures, so that the radial sutures of the adjoining plate meets it at an offset position, thereby imparting architectural strength (Jafar, 1998). The intercept of the radial suture on the pentagonal line creates small and larger line segments, usually in the ratio of 1:2, but occasionally the golden ratio: Ø = 1+ / 2 = 1.618… is achieved even on the same test. Thus, radial sutures carve out tiles of five golden trapeziums, altogether 60 in the entire test. A golden trapezium by definition is an isosceles trapezium having two legs of identical length and a larger base, and the base angles are: 108° – 108° - 72° – 72°. An intercept of a smaller base made on any of the larger and equal line segment again results in the golden ratio. Such tiles of golden trapezium could be radially arranged to generate extraordinary tiling, expanding to infinity and retaining a regular pentagonal outline at each generation with pseudo-five-fold chiral-rotational symmetry of a twinned periodic crystal (Levine & Steinhardt, 1984). *Braarudosphaera bigelowii* also represents a perfect platonic body of the ancient mathematicians with its unique combination of periodic calcite lattice enveloping a quasiperiodic frame of a regular pentagonal dodecahedron. The hollow tests of *B. bigelowii,* like those of other nannoplankton, remain cryptic and invisible to the unaided human eye. However, larger and solid regular pentagonal dodecahedra (ca. 1mm), which are visible to human eye, were recently produced artificially in certain metallic alloys that display a quasiperiodic diffraction pattern (Schechtman *et al.,* 1984; Ohashi & Spaepen, 1987).

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Modern subtropical/tropical coastal coccolithophorid assemblages

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In order to determine diagnostic coccolithophorid assemblages for shallow waters, lagoonal and/or coastal water samples were collected and examined around various subtropical (Shikoku, Okinawa, Ogasawara Islands, and Guam) and tropical (Puerto Rico and Palau) islands. The species diversity at each location was then compared in order to identify regional differences and cosmopolitan species. Generally, the water samples were filtered and observed with a scanning electron microscope, but some live material was also examined with a light microscope. All localities contained *Emiliania huxleyi* var. *huxleyi* (= morphotype A) and *Gephyrocapsa oceanica*, while *Umbellosphaera* spp., *Umbilicosphaera hulburtiana,* and *Helicosphaera carteri* were often present. *Cruciplacolithus neohelis* (which lives on the sand surface in shallow waters), *Reticulofenestra maceria,* and *Gephyrocapsa ericsonii* (often linked with upwelling) have now been found at a number of localities. Holococcolithophorids occurred in just two sets of samples (off Guam and Palau), suggesting that seasonal differences (*e.g.,* dry vs. wet seasons) may control their distribution. This highlights the need for taking samples at different times of the year. Surprisingly, middle and lower photic zone species (*Algirosphaera robusta*, *Calciopappus rigidus*, *Calciosolenia* spp., *Reticulofenestra sessilis*, and *Syracosphaera anthos*) have occasionally appeared in our shallow coastal waters, a phenomenon now being reported elsewhere by other workers.

In general, the species diversity of coastal communities is low, compared with offshore records (*e.g.,* for Puerto Rico, 17 taxa in the lagoons vs. >100 taxa offshore), but this may be just a matter of undersampling and low abundances. In addition, we have a dilemma: are all or some of these species part of the tychoplankton (merely transported into the lagoons from offshore) or are they *bona fide* members of local populations (*i.e.,* growing in-situ)? To answer this will require extensive fieldwork and detailed culture experiments. Clearly, we still have a lot to learn about coccolithophorid ecology and distribution.

Middle to Upper Jurassic stratigraphy of Kuwait: calcareous nannofossils and maximum flooding surfaces

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Calcareous nannofossils were studied in detail from 11 cores that represent a complete Middle to Upper Jurassic stratigraphic succession of onshore Kuwait, and involve samples from the Dhruma Formation, Sargelu Formation, Najmah Shale, Najmah Limestone, and Jubaila Formation. The age interpretation, using the Jurassic Tethyan nannofossil zones of Mattioli & Erba (1999) and Casellato (Channell *et al.,* 2010) is that the well section ranges in age from early Bajocian to Kimmeridgian in age. The Dhruma Formation is early-late Bajocian in age, Subzone NJT 10a. The Sargelu-Dhruma transition unit is late Bajocian in age, Subzone NJT 10b. The Sargelu Formation is mainly barren, but its stratigraphic position indicates a Bathonian to Callovian age within Zone NJT 11. The Najmah Shale is Callovian to middle Oxfordian in age, Zone NJT 12 to basal Sub-zone NJT 13b, and the Najmah Limestone is late Oxfordian, Subzone NJT 13b. The Jubaila Formation is Kimmeridgian in age, Zone NJT 14.

A more precise location for the regional maximum flooding surfaces (MFS) of Sharland *et al*. (2001) was identified. MFS J20 is located in the lower Dhruma Formation. MFS J30 is placed in the Sargelu Formation, right above the top of the Sargelu-Dhruma transition. MFS J40 is picked just above the top of the lower Najmah Shale, and MFS J50 is in a condensed zone just below the top of the upper Najmah Shale. MFS J60 coincides with the post-Najmah unconformity, separating the Najmah Limestone from the Jubaila Formation. The hiatus that separates the Jubaila Formation from the overlying Gotnia Formation coincides with MFS J70 and may also include MFS J80 and J90, where the third and fourth Salt, as well as the third and fourth Anhydrite, are absent.

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Vertical and horizontal distribution of modern coccolithophore species across the HV Melville Biological and Hydroacoustic Cruise transect, southern Indian Ocean

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The species distribution of coccolithophores generally follows latitude, with diversity decreasing with increasing latitude. This distribution also broadly depends on depth in temperate and tropical regions where the deeper part (~150-200 m) of the photic zone is inhabited by a characteristic community of coccolithophores that includes *Florisphaera profunda, Gladiolithus flabellatus, Oolithotus antillarum,* and *Algirosphaera robusta* (Okada &Honjo, 1973), plus recently described *Solisphaera* spp. (Aubry & Kahn, 2006; Bollmann *et al.,* 2006) and *Navilithus altivelum* (Young & Andruleit, 2006). Fifty-five water samples were taken at 13 sites along a SW-NE transect from Cape Town, South Africa (35°S 20°E) to Port Hedland, Australia (17°S 117°E) by the HV *Melville* Hydroacoustic and Biological Sampling Cruise. Samples were taken between May and June 2003, ranging in depth from 0 to 201 m.

Diverse coccolithophore communities with generally narrow depth distributions were observed. By studying extant coccolithophore communities with dominant species, it is possible to quantify species size from large numbers of coccospheres, thus expanding the database for modern intraspecific variability. Recent morphological studies on extant coccolithophores have investigated size range as a possible indicator of speciation or seasonal change (*e.g.,* Renaud & Klaas, 2001; Renaud *et al.,* 2002), and also to show the distribution and known size range of observed species (*e.g.,* Reid, 1980; Cros & Fortuño, 2002; Young *et al.,* 2003). All new species were defined by size, as well as by the structure of their coccospheres and coccoliths (*e.g.,* Quinn *et al.,* 2005; Bollmann *et al.,* 2006). Measurements were taken from coccospheres along the HV *Melville* transect, and they significantly increase the known size variability of extant coccoliths and coccospheres (Kahn & Aubry, 2006). Here, I provide a record of the species observed along the HV *Melville* transect in order to document further their known geographic ranges.

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Quantifying rates of plankton evolution immediately following the Cretaceous-Paleogene mass extinction event (IODP Site U1405, NE Atlantic)

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The Cretaceous-Paleogene (K/Pg) mass extinction event, the most significant geological event to have affected calcareous nannoplankton, caused extinction of over 90% of species and was followed by the rapid diversification of new groups that form the core of modern coccolithophore diversity. In this study, we aim to quantify the rates of evolution in calcareous nannoplankton immediately following the mass extinction event (Danian). Our initial data come from a recently recovered K/Pg section (IODP Site U1403) drilled on the J-Anomaly Ridge in the northeast Atlantic Ocean during IODP Expedition 342. The succession includes an intact spherule layer and well-preserved nannofossils. We focus on a variety of morphometric traits, including coccolith length and width, and cellular traits, including cell geometry (cell size and number of coccoliths per cell). We will provide information on the evolution rates in the newly evolved lineages (*i.e., Prinsius, Coccolithus,* and *Cruciplacolithus*) and also survivor lineages (*i.e., Cyclagelosphaera* and *Markalius*) as a comparison. These data provide us with a better insight into the post mass extinction recovery of the marine ecosystem.

Nannofossil biostratigraphy of the Late Cretaceous (Coniacian - Campanian) Niobrara Formation (Western Interior Seaway)

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Two localities (western Kansas and Miner County, SD) from the upper Coniacian to lower Campanian Niobrara Formation were investigated to assess the utility of traditional calcareous nannofossil zonation schemes in the Western Interior Seaway (WIS). The Niobrara Formation is comprised of alternating chalks and marls deposited in the WIS during the late Turonian to early Campanian (~89-82 Ma). Cretaceous sediments are often assigned relative ages according to generally cosmopolitan zonation schemes that are based on calcareous nannofossil extinction and origination events. Several diagnostic taxa commonly used in these schemes, such as holococcoliths, are absent, extremely rare, or diachronous with respect to open-ocean biostratigraphic events, thereby limiting the utility of traditional zonation schemes for the WIS.

An enhanced, high-resolution biostratigraphic analysis of the Niobrara Formation from the Smoky Hill type section in western Kansas is presented. The Smoky Hill type section is an expanded section of the Niobrara Formation with very good to excellent calcareous nannofossil preservation, making it ideal for high-resolution biostratigraphic analyses. The biostratigraphic framework of the Smoky Hill section is correlated to the Miner County, SD core to enable regional comparisons. Previously undocumented taxa that are present in both Kansas and South Dakota are shown to have biostratigraphic utility in the WIS. The resultant biostratigraphic framework will serve as a template for the assignment of geochronologic ages to bioevents in the WIS.

Micropaleontology and the International Ocean Discovery Program: a primer

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The new International Ocean Discovery Program (IODP) continues a long history of scientific ocean drilling, beginning with the Deep Sea Drilling Project (DSDP) in 1968. Two-month long expeditions on the drilling vessel JOIDES Resolution target scientific objectives within four themes of IODP: climate and ocean change, deep biosphere, planetary dynamics, and geohazards. A typical expedition includes a diverse group of ~30 scientists from the various IODP member counties led by two co-chief scientists. During the expedition, the science party characterizes the collected cores through visual description (sedimentology, petrology, and structural geology), age determination (micropaleontology and paleomagnetism), physical properties, geochemistry, and microbiology. Most expeditions also include downhole logging to relate recovered core to in-situ borehole properties. Micropaleontology is an integral part of most expeditions, with two to eight scientists sailing as part of that laboratory. Micropaleontologists are the first scientists to receive a physical portion of the retrieved core, as they collect part of the core catcher sample as soon as the core arrives on deck. The core catcher is processed for analysis of various microfossils, including calcareous nannofossils, foraminifers, radiolarians, diatoms, and sometimes palynomorphs. The micropaleontologists provide age constraints for the recovered core, and also provide valuable information about depositional environment, paleoceanographic conditions, etc. This primer will provide an introduction to sailing as a micropaleontologist on an IODP expedition, including the application process, and what to expect before, during, and after an expedition.

A new Paleocene-Eocene thermal maximum record from Deep Sea Drilling Project Site 277 (Campbell Plateau): a window into calcareous nannofossil response in the southern high latitudes

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We recently discovered an intact Paleocene-Eocene boundary and record of the initial onset of the Paleocene-Eocene Thermal Maximum (PETM) in a 34-cm-thick interval of Deep Sea Drilling Project (DSDP) Site 277 (Hollis *et al.,* submitted). This site was drilled on the western margin of the Campbell Plateau in the southwest Pacific Ocean (paleolatitude ~65ºS), and together with Ocean Drilling Program Site 1172 (Tasman Plateau), it represents the southernmost record of the PETM in the Pacific Ocean. We conducted high-resolution geochemical and paleontological studies to characterize this interval, which show that the PETM is truncated, with some or all of the main phase missing due to either a hiatus or drilling disturbance. Diagenesis at this site affects the stable isotope records; however, laser ablation Mg/Ca measurements on foraminifers show that sea-surface and intermediate water temperatures rose by ~6ºC at the onset of the PETM and then remained relatively stable before declining abruptly across the hiatus.

Late Paleocene to early Eocene calcareous nannofossil assemblages are moderately preserved at Site 277. The PETM is characterized by increased abundances of *Coccolithus* spp., *Sphenolithus* spp., and *Zygrhablithus bijugatus*, whereas the abundance of *Chiasmolithus* spp. decreases. The absence of excursion taxa, such as members of the *Rhomboaster* lineage or *Discoaster araneus* and *D. anartios,* may be due to paleobiogeographic restriction or to truncation of the record. Although the discoasters typical of the excursion are not found at this locality, deformed discoasters, many resembling *Discoaster nobilis*, characterize the interval. In addition, *Bomolithus supremus* is restricted to the carbon isotope excursion. The genus *Ellipsolithus* also reaches maximum abundance over the PETM interval, which is striking as this taxon has a significantly delayed first appearance in the southwest Pacific region (Edwards, 1971). This, together with increased abundances of other warm-water taxa (*e.g., Sphenolithus* spp. and *Z. bijugatus*), suggests that a significant incursion of temperate to subtropical waters to the southern high latitudes occurred at this time.

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Coccolith calcite Sr/Ca ratios: investigating a potential proxy for Late Cretaceous nannofossil paleoecology

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Calcite Sr/Ca ratios for modern coccolithophores are mainly dependent on calcification and cellular growth rates, which are further dependent on the rate of primary productivity. In fossil material, Sr/Ca ratios likely represent preserved original values, although values can be biased by calcite overgrowth and adhering clay particles. We have measured calcite Sr/Ca ratios on hundreds of Late Cretaceous coccolith specimens in order to test the consistency of species-specific values and to investigate whether Sr/Ca can be developed as a proxy for Mesozoic paleoproductivity.

The calcareous nannofossils used for this study come from six Campanian to Maastrichtian samples from the Shuqualak borehole (Mississippi, USA), a section containing sediments lithologically well disposed to fine-fraction filtering, which is one of the techniques required for secondary ion mass spectroscopy (SIMS) on single coccoliths. A total of 497 measurements were made of three element ratios: Sr/Ca (productivity?), Mg/Ca (diagenesis?), and Al/Ca (clay contamination?) on 430 specimens, representing 33 taxa.

The Cretaceous taxa show a wider spread of Sr/Ca ratios than either late Eocene-early Oligocene fossil taxa or modern cultured species (*Coccolithus, Reticulofenestra* of Prentice *et al*., 2014), which tend to cluster between approximately 2 to 4 mmol mol^{-1} Sr/Ca. However, there is consistency in the species-specific Cretaceous values. Some of the measured Cretaceous taxa show similar values to younger taxa, such as *Cribrosphaerella* (1.32 – 4.32 mmol mol^{-1} Sr/Ca; mean 2.29) and *Prediscosphaera* (0.65 – 4.70 mmol mol^{-1} Sr/Ca; mean 3.27), whereas *Watznaueria* has lower values (0.38 – 3.84 mmol mol^{-1} Sr/Ca; mean 1.03). *Braarudosphaera* has values usually lower than 2 mmol mol^{-1} Sr/Ca, similar to the nannolith, *Micula*. Holococcolith (*Lucianorhabdus*) values are generally greater than 4 mmol mol^{-1} Sr/Ca. We are currently refiltering and refining our data to remove those values that were likely affected by diagenesis (indicated by drifting of the 20 cycles of values and by high Mg/Ca ratios; see Prentice *et al*., 2014) and will present our most recent findings at INA15.

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Age refinement of Cretaceous units on Catanduanes Island (eastern Philippines) based on calcareous nannofossils

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Validation and refinement of the age of the Yop and Codon Formations were performed using calcareous nannofossil biostratigraphy. Previous studies, based on stratigraphic and structural relationships, as well as paleontological analysis, suggest a late Early to Late Cretaceous age for the Yop Formation and late Late Cretaceous (Maastrichtian) for the Codon Formation. The age of the Codon Formation, however, was determined primarily from exposures of the formation in the southwestern part of the island (*i.e.*, Codon Point) and does not include the exposures in the southeastern part of the island (*i.e.*, Nagumbuaya Point) where the olistostromic nature of the formation is best exposed.

Analysis of shale, mudstone, and limestone samples that were collected from exposures of the Yop and Codon Formations during a recent fieldwork revealed poorly to moderately preserved, rare to few calcareous nannofossils. Based on the occurrences of *Quadrum intermedium* and *Eiffellithus eximius* in the shale samples from the Yop Formation, nannofossil Zones UC8a – UC9b were recognized, suggesting a Turonian age. Two distinct nannofossil zones were recognized for the Codon Formation. Based on the occurrence of *Eprolithus moratus, Eprolithus rarus,* and *Micula staurophora* at Nagumbuaya Point (SE Catanduanes), the UC10-UC12 Zones (Coniacian to Santonian) were recognized. At Codon and Bonagbonag Points (SW Catanduanes), the UC20b Zone (late Maastrichtian) was recognized based on the occurrence of *Micula* spp. (*M. cubiformis, M. murus, M. praemurus, M. staurophora,* and *M. swastica*).

This study represents the first report of calcareous nannofossils from the SE part of Catanduanes that also recognized that the Codon Formation includes limestones older than the Maastrichtian. This necessitates the revision of the age of the formation (revised as Coniacian to Maastrichtian). The results also suggest that there were at least two episodes of mass wasting/slumping events that involved limestone units with different ages, which is important for understanding the geologic evolution of Catanduanes Island.

Calcareous nannofossil assemblages at the Cretaceous-Paleogene transition at Lali section, SW Iran

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Calcareous nannofossil assemblages were investigated at the Lali section in the Zagros Basin in Iran. The studied interval is one of the best outcrops where the Cretaceous-Paleogene (K/Pg) boundary can be investigated. The K/Pg lies at the upper part of the Gurpi Formation (Darvishzadeh *et al.,* 2007). The studied interval extends from Zones CC25b/UC20aTP to NP3/NTp5A. Latest Maastrichtian assemblages are abundant and diverse, and no decrease was observed towards the boundary. Dominant species of the Maastrichtian were *Watznaueria barnesiae, Micula decussata, Micula murus, Cribrosphaerella ehrenbergii, Cyclagelosphaera reinhardtii, Prediscosphaera cretacea, Lithraphidites* spp., and *Retecapsa* spp. At the K/Pg boundary, a decrease in the abundance of Cretaceous species and an increase in the abundance of *Thoracosphaera operculata* were recorded, along with the appearance of Paleocene species. The relative abundance of *T. operculata* is approximately 48% at the K/Pg boundary, which is reduced to 7% towards the top of the studied interval. A high abundance of *T. operculata* at the K/Pg boundary interval has been reported from other parts of the world (Tantawy, 2003; Bernaola & Monechi, 2007). Above the K/Pg boundary in the Danian sediments, Cretaceous species were observed along with the new Paleocene species. It must be mentioned that the relative abundance of the Cretaceous species decreased from the K/Pg boundary upward: *A. cymbiformis* (from 2% to 0%), *Eiffellithus* spp. (from 2% to 0%), *W. barnesiae* (from 11% to 1%), *Retecapsa* spp. (from 6% to 1%), *M. decussata* (from 7% to 0%), *C. ehrenbergii* (from 5% to 1%), and *P. cretacea* (from 4% to 1%).

The Cretaceous species that are recorded continuously and with good preservation in the Danian sediments can be considered as true survivors, while the ones that are not observed continuously in the Danian sediments can be considered as reworked.

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Coccolithophore contribution to sea-surface PIC along a latitudinal transect in the W Pacific sector of the Southern Ocean under non-bloom conditions

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Coccolithophores are important particulate inorganic carbon (PIC) producers. Their blooms can be detected from satellites as areas of high backscattering (Holligan *et al.,* 1983; Balch *et al.,* 1991). The "Great Calcite Belt" (Balch *et al,* 2011) is a region of high reflectance during the austral summer between 30° and 60° S that is related to high concentrations of *Emiliania huxleyi*. We calculated the contribution of *E. huxleyi* to sea-surface PIC along a latitudinal transect in the Southern Ocean that crosses different fronts of the Antarctic Circumpolar Current (ACC). Coccosphere/coccolith concentrations were below $130x10^3/6x10^6$ L^{-1} (Malinverno *et al.,* submitted), representing non-bloom to outer bloom conditions. Species-specific coccolith PIC was obtained from morphometric analyses of free coccoliths on SEM images from water samples (volume calculation following Young & Ziveri, 2000). Satellite-derived PIC was estimated from eight-day composites from MODIS and SeaWiFS sensors.
Our results show that:

a) *E. huxleyi* morphotypes A and C show little latitudinal variation in size and degree of calcification along the transect. The coccolith PIC contribution in surface waters is mainly controlled by the dominant morphotype.

b) *In situ* and satellite-derived PIC show good agreement in the region between 45-62° S, an area characterized by intermediate coccolithophore concentration and limited contribution from other biogenic particles.

c) The strong peak in satellite-derived PIC southward of 62.5°S is not related to a coccolithophore bloom. The shift in the source of backscattering corresponds to the location of the southern ACC front, which separates carbonate-dominated waters to the north from opal-dominated waters to the south. Although opal particles have a much lower refractive index than calcite (Balch & Utgof, 2009), abundant fragments of diatom frustules, setae, and silicoflagellates can produce a similar high-reflectance signal.

Satellite products are an invaluable tool to estimate global PIC, but these should be combined with field sampling and ecological knowledge whenever possible.

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Calcareous nannofossil and planktonic foraminiferal biostratigraphy of sedimentary units in Pangasinan, Philippines

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The sedimentary units exposed in Bani and Bolinao (Pangasinan Province) have been assigned to various formations and ages in previous studies by De Ocampo (1983), Janssen (2007), and Wani *et al*. (2008). They have been dated Pliocene (Shuto, 1986; Janssen, 2007) and Pleistocene (Fierstine & Welton, 1983; Wani *et al*., 2008) through the use of planktonic foraminifera, holoplanktonic molluscs, and calcareous nannofossils. Recently, the Mines and Geosciences Bureau included these deep-water sedimentary units within the uppermost Miocene Sta. Cruz Formation, which is overlain by the coralline/reefal Pliocene-Pleistocene Bolinao Limestone. The Sta. Cruz Formation plays an important role in Cenozoic nautiloid taphonomy because it has yielded the first and oldest fossil record of *Nautilus pompilius* (Wani *et al*., 2008). Based on the same study of Wani *et al*. (2008), however, the formation was dated as early Pleistocene. Thus, in order to resolve the age assignment of the Sta. Cruz Formation, and to refine the stratigraphy of Bani and Bolinao, samples were collected from several sections for reinvestigation using calcareous nannofossil and planktonic foraminifera biostratigraphy.

Analysis of the samples suggests an early Pliocene age for the sections exposed in Tiep, Zaragoza, and Anda. The planktonic foraminifera Zone N19 was recognized using the last occurrence (LO) of *Globorotalia merotumida* and the first occurrence (FO) of *Sphaerodinella dehiscens*. The calcareous nannofossil NN15 Zone was recognized using the LOs of *Sphenolithus abies*, *Reticulofenestra pseudoumbilicus,* and *R. haqii*, and the FOs of small *Gephyrocapsa* and *Pseudoemiliania lacunosa*. The age of the Sta. Cruz Formation that was obtained in the present study, therefore, supports the study of Janssen (2007). This necessitates the revision of the age of the Sta. Cruz Formation, which will have implications for the ages of the *Nautilus* fossil and the overlying Bolinao Limestone.

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Environmentally driven evolutionary patterns in the size of the calcareous nannofossil *Schizosphaerella* through the Jurassic

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The size structure of marine phytoplankton communities greatly affects food web structure and organic/inorganic carbon export into the ocean interior. This last mechanism plays a fundamental role in the transfer of carbon from the surface oceanic reservoir to carbonate sediments and thus to the lithospheric reservoir. Yet, evolutionary patterns through time for the size structure of calcareous nannoplankton have been poorly investigated, especially in the Jurassic.

We present the size-structure evolution of *Schizosphaerella* (a probable calcareous dinoflagellate) in the interval late Sinemurian to Bajocian (~192 to 170 Ma, Early-Middle Jurassic). *Schizosphaerella* was the main pelagic carbonate producer during this time interval, and it dominated the calcareous nannoplankton community both in quantity and in size. Long-term size evolution patterns of *Schizosphaerella* were explored in samples coming from the Jurassic Lusitanian basin (Portugal).

In spite of generally opposite trends between *Schizosphaerella* absolute abundances and calcium carbonate contents of rock, *Schizosphaerella* sizes fluctuate between average values of 8-15μm, but are higher in carbonate-rich samples. This pattern is verified both on short- (~200 kyr) and long-term intervals. For long-term intervals, *Schizosphaerella* sizes also display an inverse correlation with marine temperatures that are inferred from the $\delta^{18}O_{carbonate}$ of brachiopods. Size changes seem also to be related to $\delta^{13}C$ positive and negative shifts, although the relationships between these two parameters are not straightforward.

Through the Jurassic, climatically induced changes in oceanic mixing may have altered nutrient availability in the euphotic zone and driven evolutionary shifts in the size of calcareous nannoplankton. Evolutionary patterns in the size distribution of calcareous nannoplankton can thus be a useful proxy to improve the interpretation of the effects of climatic change on marine ecosystems.

New data on the structure of early fasciculiths from a combined LM and SEM study

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With the appearance of several new genera of calcareous nannofossils in the early to late Paleocene, this is a time interval where we see new nannofossil morphological structures. Due to their rapid diversification, fasciculiths have considerable biostratigraphic relevance for this time interval. Recently, GSSP studies on the base of Selandian renewed interest in the fasciculiths with detailed studies on taxonomy, biostratigraphy, and evolution. The second radiation of *Fasciculithus* has been used to approximate the Danian-Selandian boundary in the low-middle latitudes (Bernaola *et al.,* 2009). Several studies have been performed on the earlier forms with identification of new species and taxonomic reviews (Bernaola *et al.,* 2009; Aubry *et al.,* 2011, 2012; Monechi *et al.,* 2013a, b). The genus *Fasciculithus* was emended by Aubry *et al*. (2011), and three new genera, *Gomphiolithus, Diantholitha,* and *Lithoptychius,* were identified based on to their structural features (column, collaret, calyptra, and central body). However, doubts concerning identification of the new taxonomy have been expressed by Agnini *et al*. (2014), reporting a scarcity of data for a systematic emendation of this group.

We present new results obtained by the analysis of nannofossil assemblages of several successions spanning the Danian-Selandian transition in different paleogeographic settings. ODP Site 1209 (Shatsky Rise, Pacific Ocean), Site 1262 (Walvis Ridge, Atlantic Ocean), and the Bottaccione, Contessa (Italy), and Qreiya (Egypt) land sections have been investigated. The specimens belonging to *Gomphiolithus, Diantholitha, Lithoptychius,* and *Fasciculithus* have been analyzed both with the light and scanning electron microscope (SEM) in order to enhance the structural characters of the genera as defined by Aubry *et al*. (2011). The new data provide better descriptions of the previous genera and allow the introduction of a new genus and the recognition of seven new species.

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Calcareous nannofossil response to the Valanginian Weissert event in a Boreal epicontinental sea

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During most of the Cretaceous, northern Germany was covered by a relatively shallow epicontinental sea. In the earliest Cretaceous (Berriasian; 145 – 139.4 myr), however, a phase of widespread regression caused nonmarine conditions to prevail in this area. The onset of the early Valanginian transgression re-established marine conditions in the Lower Saxony Basin (northwest Germany). Coccolithophores appeared in the basin in the late Berriasian and became abundant and diverse only in the late Valanginian (139.4 – 133.9 myr).

Worldwide, the Valanginian records a prominent positive carbon isotope excursion (CIE), the Weissert event. The causes for this disturbance of the global carbon cycle are still under debate. Potential causes suggested for the Weissert event are increased terrigenous input into the oceans and/or high oceanic crust production rates. Both factors can explain the increase of nutrients and biolimiting metals that were necessary to stimulate primary production. Just preceding the positive CIE, a marked decrease in the abundance of nannoconids, large and heavily calcified *incertae sedis* nannoliths, has been reported from several low latitudinal settings. Decreasing sizes of certain nannoconid species also have been observed to coincide with this decline.

For a better understanding of the abundance and diversity patterns during the Valanginian, calcareous nannofossils were studied from a recently drilled core. Quantitative analyses provided an interpretation of temperature, nutrient content, and light penetration. The calcareous nannofossils show a gradual diversification and an increase in abundance throughout the Valanginian. Palynofacies data from the same core suggest an overall transgressive trend during the Valanginian. The project further aims at examining calcareous nannofossil assemblage patterns specifically across the CIE. A potential nutrification event, associated with the CIE, should be reflected in the composition of calcareous nannofossil assemblages. Our first data suggest that the nannoconids disappear at the base of the CIE and return after its climax.

Operational biostratigraphy of KBB gas field, offshore deep-water Sabah, Malaysia: the use of nannoplankton in optimizing operational decisions in the oil and gas industry

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Kebabangan Petroleum Operation Company Sdn Bhd (KPOC) is a joint operating company, comprised of PETRONAS Carigali Sdn Bhd, ConocoPhillips Sabah Gas Limited, and Shell Energy Asia Limited, that acts as operator for the Kebabangan Cluster production sharing contract, to develop a large Kebabangan ("KBB") gas field located in the South China Sea offshore of Sabah, Malaysia. The KBB gas field is a folded structure, which is the result of compressional faulting that subsequently underwent uplift and erosion. Based on detailed biostratigraphic analyses of upper Miocene sediments in four legacy wells, the stratigraphic relationship between reservoir and seals is now well understood. The top of the hydrocarbon-bearing reservoir sands is marked by an intra-Tortonian (upper Miocene) regional erosional unconformity. The stratigraphic hiatus of this unconformity, which occurs at the crest of the structure, has been identified by biostratigraphic analyses. Above the hiatus is nannoplankton Zone NN11A (*Discoaster berggrenii*) and below are nannoplankton Zones NN9A (*Catinaster coalitus*) and NN9B (*Discoaster hamatus*), while Zone NN10 (*Discoaster bollii*) is missing. In terms of geologic time, the duration of the hiatus at the crest is estimated to be approximately 1.8 Ma. On the flanks, Zone NN9B (*D. hamatus*) underlies the unconformity, and the stratigraphic hiatus is estimated to be approximately 0.9 Ma.

During 2013-2014, KPOC completed a Phase 1 drilling campaign comprised of six gas wells. The objective of Phase 1 was to set a 9 5/8" casing within the first 5 meters of the Zone NN9A/B reservoir. On the flanks of the structure, seismic imaging was very good, so there was little uncertainty about the depth of the reservoir. However, for wells located nearer to the crest, seismic imaging was severely degraded due to an overlying gas chimney, and it was determined that biostratigraphic analyses might be necessary in order to set casing within the Zone NN9A/B reservoirs.

The Phase 1 drilling campaign consisted of two batches with three wells in each batch. While drilling the second well of batch 1, the gas-bearing interval was penetrated 120 m deeper than expected. This 120-m interval was composed of shale, and it was unknown at the time of drilling whether it was in Zone NN11A or NN9A/B, which would directly impact the location for the casing for the four remaining wells. Representative drill cutting samples for this interval were sent to Shell's biostratigraphy laboratory for a "quick-look" age interpretation. Results of nannoplankton analyses indicated that the 120 m of shale were in Zone NN11A and that the unconformity was much deeper than previously interpreted. Because of the rapid response time, KPOC was able to successfully set casings for the four remaining wells of Phase 1 and modify well locations for Phase 2.

Quantitative analysis of Late Campanian calcareous nannofossils in the Gurpi section (SW Iran)

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The Late Cretaceous was a period of long-term climatic cooling that occurred after the extreme warmth of the mid-Cretaceous greenhouse world (Jenkyns *et al.*, 1994; Huber *et al.*, 2002). A global cooling trend commenced during the late Campanian and continued into the Maastrichtian (Huber *et al.*, 1995; Clarke & Jenkyns, 1999). The highest provincialism in the calcareous nannofossil assemblages was recognized during this time interval (Burnett, 1998). This study focused on the paleoclimate and paleoceanography of the late Campanian by analyzing the calcareous nannofossil assemblages at the Gurpi section in the Zagros Basin. The studied interval ranges from UC15eTP to the first part of UC17. The calcareous nannofossils are well preserved, highly abundant, and diverse. The assemblages are dominated by *Watznaueria barnesiae* (22%), *Prediscosphaera* sp. (11%), *Retecapsa* sp. (10%), *Cribrosphaerella ehrenbergii* (10%), *Micula swastica* (9%), *Micula decussata* (8%), *Arkhangelskiella cymbiformis* (8%), *Microrhabdulus decoratus* (8%), and *Placozygus fibuliformis* (7%). The abundance of cold-water taxa (*Ahmuellerella octoradiata, Gartnerago segmentatum,* and *Kamptnerius magnificus*) is less than 0.5%. Other taxa that are considered as cool-water species, such as *Tranolithus orionatus, Biscutum constans, Zeugrhabdotus* spp., *A. cymbiformis, M. decussata, Prediscosphaera cretacea,* and *Eiffellithus turriseiffelii,* are present are abundant. Warm-water taxa, such as *W. barnesiae, Ceratolithoides* spp., *Uniplanarius trifidus,* and *Aspidolithus* spp., are also present. The number of warm-water species is higher than cool-water forms. Although cool- and warm-water species were observed together, an opposite trend was observed between them. The relative abundance of warm-water species decreased toward the top of the Campanian, while the relative abundance of cool-water species increased, which is indicative of climate cooling at this time interval.

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Calcareous nannoplankton evolution across the Eocene-Oligocene transition

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Calcareous nannoplankton were the dominant phytoplankton group in the early Paleogene, yet during the dynamic long-term climatic change of the 'greenhouse to icehouse' transition, they underwent significant turnover and diversity loss from which they have arguably never fully recovered. The 'greenhouse to icehouse' transition culminated at the Eocene-Oligocene transition (EOT), a rapid cooling event when continental ice sheets formed on Antarctica, marking the initiation of the Cenozoic icehouse world. The EOT saw significant disruptions to physical, chemical, and biological parameters in the marine realm. Marine biota were significantly affected, with plankton groups suffering elevated rates of extinction and turnover, and the extinction of the planktonic foraminifera group Hantkeninidae marks the Eocene-Oligocene boundary. The calcareous nannoplankton underwent significant shifts within their population assemblage structure at this time.

Here we will report on the EOT calcareous nannoplankton response through use of the recently drilled succession at IODP Site 1411, which has high sedimentation rates and exceptionally well-preserved calcareous nannofossils. Semi-quantitative data and relative abundance counts highlight diversity changes, species bioevents, and major shifts in abundance patterns. These data reveal that a striking reorganization within the dominant reticulofenestrid group was a particular feature of the interval. Determining the precise timing of these events allows us to examine the relationship between plankton evolution and the strongly shifting paleoceanographic conditions in the North Atlantic.

To place these observations into a wider context, we have compiled calcareous nannofossil data from a range of global sites that vary in latitude, ocean basin, and oceanographic setting, and have assessed the overall global population response to this extreme climatic change transition.

Evidence of coccolithophore dissolution in the southern Philippine Sea

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Surface and subsurface (deep chlorophyll maximum-DCM) water samples were collected in the southern Philippine Sea, in the West Philippine Basin-Southern sub-basin (WPB-SSB) during the MR 13-01 Cruise of R/V *Mirai* on March 12-17, 2013. The survey included two transects: (1) perpendicular to the coast of Davao Oriental, Philippines along 7°N, and (2) north of Halmahera Sea along 130°E, where they intersect at the cold-ring Mindanao Eddy. The distribution of living coccolithophores in this region was previously identified (Nogot *et al.*, 2013). Scanning electron microscopic analysis of the coccolithophores both from the surface and subsurface waters showed varying degrees of dissolution. Surface-dwellers, such as *Umbellosphaera irregularis,* and the deep-photic species *Oolithotus antillarum* exhibited definite signs of dissolution. Calcite removal, however, was most prominent in the dominant taxon, *Gephyrocapsa oceanica*, which was also observed to have generally smaller coccoliths. This study suggests that *G. oceanica* is sensitive to dissolution, although the factors responsible for the dissolution have not been isolated. This study did recognize that depth does not appear to be the main driver for dissolution because substantial dissolution was also present in coccoliths collected from surface waters.

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Xenospheres (coccolithophores) from plankton samples of the southern Indian Ocean

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The scanning electron microscope was used to document new xenospheres (coccospheres that contain two or more coccolithophore species) from Indian sector sites in the Southern Ocean. These associations include: (1) different *Emiliania huxleyi* morphotypes, (2) *Emiliania huxleyi* and *Syracosphaera* sp., (3) *Calcidiscus leptoporus* and *Syracosphaera nodosa* Type A XCs, (4) *Calcidiscus leptoporus* and *Emiliania huxleyi,* and (5) fused *Calcidiscus leptoporus* coccospheres. A possible tintinnid-agglutinating aragonitic *Polycrater* sp. was also documented. Combination coccospheres generally represent a natural two-phase life cycle of a coccolithophore species. In contrast, the xenospheres denote abnormal coccospheres that primarily are the result of accidental inclusion of strange coccoliths but potentially can be the result of rarely occurring biologic processes. Hybridization and fecal pellet occurrences are considered to be unrelated to xenosphere formation. The most likely method for xenosphere formation is discussed.

Petasaria heterolepis (Prymnesiaceae) from the southern Indian Ocean

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Sea-surface (0-110 m) water samples, which were collected from the southern Indian Ocean between 39°S and 65°S (along ~48°E and 57.3°E) during the austral summer of 2010, yielded *Petasaria heterolepis*. Of the two known *P. heterolepis* forms, the scales with a brim were observed with a size range (short and long axes length) of 1.68×1.80 µm and 2.17×2.27 µm. There were minute pores on the scales, except on the brim, which was poreless. An elemental analysis of the scales revealed that silica (Si) was the major constituent, together with a small amount of calcium (Ca). *Petasaria heterolepis* was neither recognizable in the fossil record nor in the bottom sediments. This species has an affinity with the extant haptophyte *Prymnesium neolepis,* which has been recorded from off the Japan coast and in the southern Indian Ocean. The present study highlights the occurrence of *P. heterolepis* in open-ocean regions of the Southern Ocean, stressing its ability to grow under diverse oceanographic conditions. The phylogenetic-molecular aspects need to be investigated, which could reveal a better understanding of the rare and combined Si and Ca accumulation among siliceous haptophyte algae.

A 700 km and 145 million year ride: Mesozoic calcareous nannofossils in Holocene to recent sediments at the Bahía Blanca Estuary, Argentina

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Calcareous nannoplankton analysis of Holocene to recent sediments in the Bahía Blanca Estuary revealed a high abundance of reworked Mesozoic taxa. The samples came from an outcrop along the Napostá Stream and were dated as Holocene, 5610 +/- 40 years BP (c. 5960 cal yr BP, shells-197 cm) at the base, 5170 +/- 40 years BP (5680 cal. BP, organic matter-124 cm), and 4090 +/- 40 yr BP (4330 cal yr BP, organic matter-76 cm) in the middle section (Calvo-Marcilese *et al.,* 2013). The autochthonous calcareous nannoplankton taxa were *Emiliania huxleyi, Gephyrocapsa oceanica, Coccolithus pelagicus,* and *Calcidiscus leptoporus,* among other less abundant Holocene species. Within the Mesozoic reworked taxa, it was possible to identify some marker species of the Late Jurassic-Early Cretaceous and of the Late Cretaceous from the outcropping Mesozoic marine sediments of the Neuquen Basin, west-central Argentina, ~700 km west of the Bahía Blanca Estuary. These allochthonous elements are thought to have been transported by the western winds, which eroded the outcropping rocks and discharged the uplifted particles near the Buenos Aires coast. The establishment of arid conditions in west-central Argentina is believed to be associated with the establishment of the western winds in the late Pleistocene (Tonni *et al.,* 1999). The recognition of this reworked fraction in Quaternary sediments in the area might be used as a complementary proxy for estimating arid and wet conditions and for local stratigraphic correlation. A brief analysis of modern and Pleistocene –Holocene sediments from several places in the estuary (Almirante Brown, Maldonado stream, Isla Verde, and offshore Core 1) also showed a reworked Mesozoic fraction.

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Pliensbachian-Toarcian calcareous nannofossil events in the Los Molles Formation, Neuquen Basin, Argentina

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Calcareous nannofossil investigations of Arroyo Lapa, Arroyo Lapa Norte, Chacay Melehue, and Arroyo Picún Leufú outcrops, southern Huincul high, Neuquen Basin, led to the recognition of a series of nannofossil events that could be correlated to the ammonite zones of west-central Argentina. These local nannofossil events were also compared to those of the Boreal and Tethys realms. In the late Pliensbachian *Fanninoceras fannini* ammonite Zone, the first occurrence (FO) of *Biscutum finchii* was documented. In the *Fanninoceras disciforme* ammonite Zone, the FO of *Lotharingius hauffii* and *Lotharingius barozii* occurred. In the early Toarcian *Tenuicostatum* ammonite Zone, the FO of *Calyculus* spp. and *Lotharingius sigillatus*, and last occurrence (LO) of *Crucirhabdus primulus* and *Parhabdolithus liasicus* were documented.

These nannofossil events fall within the NJ5 calcareous nannofossil Zone of Bown *et al*. (1988). In the *Dactyloceras hoelderi* ammonite Zone, the FO of *Carinolithus superbus* and the LO of *Orthogonoides hamiltoniae* were documented. These nannofossil events can be correlated to Zone NJ6. The identification of these nannofossil events is the first step in establishing a local biostratigraphic scheme for the Early Jurassic of the Neuquen Basin based on calcareous nannofossils. Both the recovered assemblages and the nannofossil events found in the studied area show more affinities with the Tethyan Realm (Morocco and Italy/ France: de Kaenel & Bergen, 1993; de Kaenel *et al.,* 1996; Mattioli & Erba, 1999) than the Boreal Realm (Bown *et al.,* 1988).

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Mussels as biological filters of coastal calcareous nanno-plankton: a case study from the western coast of Portugal

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Modern coccolithophore studies usually involve cruises and filtration of large amounts of water. With the objective of reducing costs and simplifying the sampling method, we tested *Mytilus galloprovincialis*, a common, local rocky shore filter mollusk, as a potential coccolithophore biogenic sampler.

A small device was developed, named musseldrome, to harvest the mussel's abundant pellet filaments. Mussel pellets were collected every week for seven weeks between May and July, 2014. Coccoliths, which were abundant, were dominated by *Gephyrocapsa oceanica* and *Emiliania huxleyi*, followed by *Coccolithus pelagicus* and *Coronosphaera mediterranea*. Coccospheres were also present, and they were dominated by *G. oceanica*, which was frequently present in agglomerates, showing that the filter process undertaken by mussels has little effect on coccospheres themselves or their clusters.

Preliminary results show that mussels can be used as samplers for calcareous nannoplankton species and for community structure studies, since the estimated concentration for each species found is in agreement with results from water column of coccolithophores off west Portugal.

Calcite export by sinking of coccoliths in the southern Gulf of California - Gephyrocapsa oceanica is the primary contributing species

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Coccoliths are a major component of marine sediments and have an important role within the biogeochemical carbon cycle. The goal of the research project was to calculate calcite export by sinking of coccoliths and determine the main species contributor to the coccolith carbonate flux. Sinking material was collected with a Technicap sediment trap (model PPS-3/3 with an opening of 0.125 m^2, 6 to 30 days opening interval) at a 310 or 360 m depth in the Alfonso Basin, southern Gulf of California. A total of 116 sediment trap coccolithophore samples were collected during January 2002-October 2003, September 2006-February 2008, and September 2011-September 2012.

The total flux of coccoliths varied considerably and showed a clear seasonal pattern with minimum fluxes ($2x10^6$ coccoliths m^{-2} d^{-1}) in spring-summer and maximum fluxes in autumn-winter ($13x10^9$ coccoliths m^{-2} d^{-1}), which is in the hurricane season and has significant wind gusts (>4 m s^{-1}). Calcite exported by sinking of coccoliths showed minimum fluxes (1 mg m^{-2} d^{-1}) in summer and maximum fluxes (130 mg m^{-2} d^{-1}) in autumn, which represents an average of 18% of the total $CaCO_3$ that was exported at the sediment trap. *Gephyrocapsa oceanica* (equatorial and larger morphotypes) was present in all the samples and presented maximum fluxes (102 mg m^{-2} d^{-1}) of $CaCO_3$ in autumn and minimum fluxes (0.01 mg m^{-2} d^{-1}) in spring-summer. The highest fluxes of $CaCO_3$ by coccoliths in the three sampling periods were associated with hurricane conditions and high sea-surface temperatures. The main contributor to the coccolithophore carbonate fluxes was *G. oceanica,* which accounted for 47% of the total $CaCO_3$ that was exported by coccoliths. This species is probably the largest contributor of $CaCO_3$ in the entire Gulf of California.

A new species of Late Triassic nannofossil, Botulus triassicus, and observations on Triassic assemblages from the NW Shelf of Australia

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A new genus of calcareous nannofossil, *Botulus*, is described from the Upper Triassic of the North West Shelf of Australia. The type species, *Botulus triassicus*, is distinctive, occurs commonly/abundantly, and is biostratigraphically useful due to its short range that is probably restricted to the Rhaetian stage. It has a well-defined extinction level that has already proven useful in subdividing the Triassic succession encountered in a BHP Billiton well from the Exmouth sub-basin.

Botulus triassicus has an unusual/unique morphology that is comprised of a curved, sausage-shaped body with a distinct outer wall surrounding a calcite in-filled core. The biological affinities of this new form are uncertain. It might be related to the calcispheres (probable calcareous dinoflagellates) *Orthopithonella* and *Obiquipithonella*, which are conspicuous within Upper Triassic nannofossil assemblages. Alternatively, we can speculate that it might possibly represent the earliest holococcolith, or a holococcolith-like structure produced by an early coccolithophorid.

The Late Triassic Subzone NT2b (= *Eoconusphaera zlambachensis* Subzone) *sensu* Bralower *et al*. (1991) can be readily subdivided on the North West Shelf based upon:

A distinct switchover in dominance between *Prinsiosphaera triassica* and *Eoconusphaera zlambachensis,* the latter dominating the upper part of NT2b.

The extinction of *Botulus triassicus* n.sp., which occurs within the lower part of the NT2b.

We document Late Triassic Rhaetian records of *Schizosphaerella punctulata* from sidewall core samples. The evolutionary appearance of *Schizosphaerella punctulata* has previously been used to approximate the Jurassic/Triassic boundary (*e.g.*, Bown *et*. *al*., 1988; Bown & Cooper 1998). However, Hamilton (1982) observed *S. punctulata* in Rhaetian samples from the UK, and subsequent academic studies may not have had access to complete Jurassic/Triassic transition sections.

In addition, we illustrate the distinctive, but often overlooked, species *Thoracosphaera wombatensis*, which is frequent in the studied Australian well material. We also illustrate an overlooked variant of *Prinsiosphaera triassica*, *P. triassica crenulata*, which appears to have a distinct acme within the NW Shelf.

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Marine Isotope Stage 11 in the Southern Ocean

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This work provides new insights into the late Pleistocene interglacial Marine Isotope Stage 11 (MIS 11) in the Pacific sector of the Southern Ocean. MIS 11, between ca. 424 and 374 kyr, is a unique, exceptionally long interglacial period that often is regarded as an analogue for what the Holocene would be without any anthropogenic interference. Thick white sedimentary layers with high carbonate content were observed at high southern latitudes during this time interval. We generated a multi-parameter record of coccolithophore data on MIS 11 sediments from core PS75/059-2, which was retrieved west of the East Pacific Rise crest at 54°12.90'S and 125°25.53'W (3613 m water depth) during R/V *Polarstern* ANT XXVI/2 expedition in the polar South Pacific. In order to characterize the coccolithophore paleoproductivity during MIS 11, two independent proxies were chosen: the number of coccoliths per gram of sediment and the coccolith Sr/Ca ratio measured in the $<20\mu m$ coccolith size fraction. Coccolithophore assemblage counts that were performed under a scanning electron microscope indicated that in the fine coccolith fraction almost all the carbonate came from *Gephyrocapsa caribbeanica.* Coccolith Sr/Ca results vary from 1.58 to 2.47 mmol/mol during the interval selected for this study, which extends from MIS 12 to the onset of MIS 10 (*i.e.,* ~469.3 to ~364.7 kyr). The number of coccoliths per gram of sediment and the Sr/Ca ratio show a steep increase in productivity during MIS 11, with values always above 2.12 mmol/mol. This pattern remains the same even after applying a correction for the temperature effect. All the information retrieved, together with the ongoing research, allows us to determine whether the coccolithophores modified the equilibrium of the inorganic carbon system during MIS 11 in the Pacific sector of the Southern Ocean.

Calcareous nannofossil and foraminiferal evidence for a PETM pre-onset excursion, Atlantic Coastal Plain, USA

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The Paleocene-Eocene thermal maximum (PETM) in coastal plain sediments of Maryland is marked by a carbon isotope excursion (CIE) of approximately -5 per mil in normal marine sediments, and as much as a -23 per mil shift in marine sediments with a large terrestrial input (Self-Trail *et al.,* 2014). Carbon and oxygen isotope analyses of the South Dover Bridge (SDB) and Mattawoman Creek Billingsley Road (MCBR) cores in Maryland revealed the presence of a PETM pre-onset excursion (POE) in both cores in the Aquia Formation (Robinson *et al.,* 2014). The POE in the SDB core began ~2m below the CIE, is 0.9 m thick, and was characterized by a -2 per mil shift in carbon isotopes. The POE in MCBR began ~1.13m below the CIE, is 0.88m thick, and was characterized by a ~4 per mil shift. Preliminary analyses of calcareous nannofossils from SDB document assemblage changes across the POE. Overall species richness declined during the POE, and the percent abundances of *Discoaster* spp., *Semihololithus biscayae*, and *Hornibrookina* spp. decreased significantly. At the same time, there was a corresponding increase in the percent abundance of *Calsiosolenia aperta* and *Prinsius bisulcus*. Several species (*i.e., Chiasmolithus bidens* and *Fasciculithus involutus*) began a slow decline in abundance during the POE, which continued to the base of the CIE, and two species, *C. aperta* and *Prinsius bisulcus*, began a decline immediately following the POE that ultimately resulted in their extinction at the P/E boundary. Foraminiferal response to the POE included a decrease in both abundance and species richness of planktic foraminifers and an increase in specimens showing visible signs of dissolution, which is similar to the dissolution zone response at the CIE onset but less severe. Foraminifers in both the CIE onset and POE were fully recrystallized due to diagenetic alteration. However, the POE also was characterized by partially dissolved foraminifers that lacked any evidence of surface texture and commonly had collapsed chambers. In addition to changes in foraminiferal and nannofossil assemblages, the sediments of the Aquia Formation became more clayey across the POE, decreasing from a baseline weight percent of ~60% sand prior to the event, to 40% during the event, before rebounding to 80% after the event.

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Preliminary biostratigraphic and morphometric comparisons between a new species of *Tribrachiatus* and *T. orthostylus*

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Detailed biostratigraphic analyses of lower Eocene sediments from the South Dover Bridge (SDB) core, Maryland (USA), and preliminary analyses of outcropping sediments along the Waipara River in New Zealand, have revealed the presence of a new species of *Tribrachiatus* that has a distinctly different morphology and biostratigraphic range from *T. orthostylus*. *Tribrachiatus orthostylus* consists of triangular-shaped specimens that exhibit low birefringence under polarized light, and have three relatively flat arms of equal length, often showing bifurcations at the ends. The first occurrence (FO) of *T. orthostylus* is in upper Zone NP10, and is commonly used to delineate the base of Zone NP11 in truncated sections. In comparison, *Tribrachiatus* sp. consists of crescent-shaped specimens that exhibit a higher order of birefringence under polarized light, have two arms of similar length that are strongly curved, and a third, shorter arm that extends upward and is perpendicular to the curved arms. In the SDB core, the first occurrence of *T. orthostylus* is at the base of Zone NP11 (187.1 m); NP10 is truncated because of erosion at this site. The first occurrence of *Tribrachiatus* sp. is at 184.8 m, after the FO of *Discoaster kuepperi* and just before the FO of *D. lodoensis* at 184.0 m. The last occurrence of both species occurs at the top of Zone NP12, after the FO's of *Ericsonia formosa*, *Helicosphaera seminulum*, and *Reticulofenestra* spp. Comparison of the percent abundances of both *T. orthostylus* and *Tribrachiatus* sp. to the bulk $\delta^{13}C$ curve of the SDB core suggests that both of these species were sensitive to changing paleoclimate conditions during early Eocene hyperthermal events.

Paleoecology of early Paleocene cold-water coral and bryozoan mounds in Denmark

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During the middle Danian (early Paleocene), cold-water coral reefs and bryozoan mounds developed along submarine highs in the 'boreal' epicontinental sea that covered the Danish Basin. The intercalating reefs and mounds, which formed complexes up to 40 m high and several km long, are exposed in the Faxe Quarry, southeast Denmark. Reconstruction of the depositional environment of the co-existing reefs and mounds is based upon sedimentary facies analysis, invertebrate and nannofossil paleoecology, and mound architecture (Bjerager & Surlyk, 2007).

High velocity, nutrient-rich bottom currents are thought to have been ideal for the extensive colonization of scleractinian corals, *e.g.,* the frame-building *Dendrophyllia* and *Faksephyllia* with patchy *Oculina*. Nannofossil assemblages include *Chiasmolithus danicus*, *Coccolithus pelagicus*, *Biscutum harrisonii*, *Prinsius tenuiculus*, and *Prinsius dimorphosus*, which place the complex in Zone NNTp2G-3 ('mid' middle Danian). 'Survivor' and reworked species from the Cretaceous are present. Assemblages are dominated by high-latitude forms, *e.g., Chiasmolithus* spp. and *Prinsius* spp. (Wei & Pospichal, 1991), which verifies that cold-water environments prevailed. *Coccolithus pelagicus* (associated with warmer water in the Tertiary) increases in abundance from the base to the top of the reef/mound complex.

Foraminiferal assemblages include *Parasubbotina pseudobulloides* and *Globigerina triloculinoides*, which place the complex in Zone P1b-3a (middle Danian to early Selandian).

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Early Eocene nannofossil responses to climate change, Canterbury Basin, New Zealand

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In order to have a better prediction of the response of calcareous nannoplankton to future climate change, we must study periods in the geological past that were warm with high CO_2. Similar conditions occurred during the early Eocene climatic optimum (EECO, ~52-50 Ma), a warming event where global temperatures reached their Cenozoic peak and atmospheric CO_2 exceeded 1000 ppm. Our study examined calcareous nannofossil assemblages from two Canterbury Basin, New Zealand sections that span the lower to middle Eocene and include the EECO. The mid-Waipara River (northern Canterbury Basin) and Hampden Beach (southern Canterbury Basin) sections represent important records of Paleogene climatic change (Hollis *et al.,* 2012). In this study, we investigated changes in calcareous nannofossil assemblages across the EECO and compared these changes to paleoceanographic parameters, such as sea-surface temperature (SST), to gain a better understanding of nannofossil responses to changes in environment.

Better preservation of nannofossils at mid-Waipara generally correlates with warmer TEX_{86}- and $\delta^{18}O$-derived SST (Hollis *et al.,* 2012), with the best preservation recorded in the EECO, followed by a marked decrease in preservation in the upper lower to middle Eocene section. This decrease in preservation may result from early diagenesis due to cooler and more corrosive bottom waters, as evidenced by a reduction in the $\delta^{18}O$ planktic-benthic gradient during the early-middle Eocene.

The genus-level Shannon H diversity index shows a close correlation with the TEX_{86} temperature record, and there is an increase at the onset of the EECO that is followed by a gradual decline into the middle Eocene. Despite some questions regarding the usefulness of the *Discoaster*/*Chiasmolithus* ratio, this index appears to work well in the New Zealand region and shows good agreement with the temperature trends at mid-Waipara, with higher values recorded during the EECO, followed by a significant decline thereafter. These initial results support the utility of nannofossil assemblages as recorders of paleoceanographic conditions that are associated with changing climate during the mid-Paleogene in the New Zealand region.

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Nannofossil occurrences across the Paleocene-Eocene boundary in Bulgaria, SE Europe: state of the art

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Stoykova & Ivanov (2005) published the first biostratigraphic data that identified a continuous succession across the Paleocene-Eocene (P/E) boundary in Bulgaria (SE Europe) and the related it to the Paleocene-Eocene thermal maximum (PETM). Since this pioneering work, a significant amount of new data has been accumulated, including the discovery of new onshore and offshore locations of the PETM.

We conducted a detailed study of calcareous nannofossil occurrences from three land sections (Kladorub, Riben, and Bozhuritsa), which are located in North Bulgaria. These sections have been re-investigated quantitatively in order to document abundance fluctuations of selected nannofossil taxa during the PETM and to provide insight into the biotic response of nannoplankton communities to the extreme global warming at that time. An industrial quantitative technique (Blaj *et al.,* 2013), involving counting of 60 FOV or 10 mm at x 1000 magnification, was applied. High-resolution cm-scale sampling, at approximately every 20 cm, was performed throughout the entire PETM interval. The sedimentology of the studied successions suggests that deposition likely took place in two different settings: deep water bathyal (Kladorub section) and middle to outer shelf (Riben and Bozhuritsa sections). It is noteworthy that in both shelf locations, two carbon dissolution intervals are recorded: one in the top of Zone NP9a and one at the Zone NP9b-NP10 boundary (*i.e.,* P/E boundary). The P/E boundary in this area is marked by the first occurrence of the representatives of *Rhomboaster (Rhomboaster spp., R. bramlettei*, and *R. cuspis*).

Bulgarian PETM data show an overall similarity with other records from the low-mid latitude sites: Italy (Agnini *et al.,* 2007) and the eastern shore of Maryland (Self-Trail *et al.,* 2012), but there are some specific differences in nannoplankton response to the PETM event in Bulgaria.

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The calcareous nannofossil record in the Cretaceous-Paleogene boundary interval of the Mudurnu-Goynuk Basin, NW Turkey: implications for intercalibration and reliability of nannofossil biohorizons

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We present the first high-resolution nannofossil record across the Cretaceous-Paleogene (K/Pg) boundary interval for three sections (Okcular, Hacimahmut, and Goynuk North) that were recently discovered and characterized by Acikalin *et al*. (2015) in the Mudurnu-Goynuk Basin, NW Turkey. All the sections display the same expanded hemipelagic succession: alternation of mudstones/siltstones intercalated by thin sandstone beds in the topmost Maastrichtian and rhythmic alternation of mudstone and limestone beds in the basal Danian.

The cyclo-magnetostratigraphic framework was constructed by means of a 5-15 cm sampling resolution, starting at the uppermost Maastrichtian Zone C29r, spanning the K/T boundary, and extending up into the early Danian Zone C29n. This includes a total of 15 m in the Okcular section (0.5 m in the Maastrichtian and 14.5 m in the early Danian, Zones UC 20d^{TP} to CNP2), which provides an accurate age calibration for the main nannofossil bioevents. The calcareous nannofossil biozonation for the upper Maastrichtian interval is based on the low-latitude UC $^{"TP"}$scheme of Burnett (1998), whereas the newly produced scheme of Agnini *et al*. (2014) was used for the lower Danian sediments. The primary nannofossil biohorizons include: (1) first occurrence (FO) of *Cyclagelosphaera alta,* (2) FO of *Cruciplacolithus primus,* (3) FO of *Futyania petalosa,* (4) FO of *Coccolithus pelagicus,* (5) FO of *Cruciplacolithus intermedius,* and (6) FO of the *Praeprinsius dimorphosus* group. The succession of nannofossil datums is generally comparable with other records from the low-mid latitude sites, but does not match in the fine details. In conclusion, we consider that the FOs of *C. alta, Cr. primus, C. pelagicus,* and *Cr. intermedius* are reliable biohorizons for global correlation in the lowermost Danian. The mid-latitude Mudurnu-Goynuk lower Paleocene succession, which was studied at an unprecedented resolution, represents a key area to tackle fundamental issues for global paleoclimatic and biotic reconstructions for the early Paleogene.

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The Eocene-Oligocene transition (EOT) boundary at Mossy Grove, Mississippi

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Events surrounding the Eocene-Oligocene boundary are considered to be the most recent transition from greenhouse to icehouse conditions. The significance of global cooling, associated with the onset of Antarctic glaciation across the E/O transition, was first documented by Kennett *et al*. (1975) and is now recognized as one of the largest climate transitions in the Cenozoic (Zachos *et al*., 2008). Here, we present new calcareous nannofossil assemblage data from the Mossy Grove core, Mississippi, which contains the Eocene-Oligocene transition (EOT). The study shows that calcareous nannofossils in the Mossy Grove core are very well preserved and abundant. Assigning an exact position to the E/O boundary is difficult, due to the rare occurrence of the planktic foraminiferal marker *Hantkenina*. The consistent presence of *Coccolithus formosus* up to a major lithological change at the top of the Yazoo Clay indicates that all of this section is within nannofossil Zone NP21 or older. The tops of both *Discoaster saipanensis* and *Discoaster barbadiensis* at 164' indicates that the EOT occurs between 164' and 55'. Nannofossil abundance patterns are also consistent with the EOT in this interval, which has a sudden drop in the abundance of several species. Pilot TEX86 and planktic foraminiferal isotope data demonstrate the links that exist between surface ocean temperature changes and calcareous nannofossil assemblages.

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Strain-specific ecophysiological traits define the response to phosphorus limitation in *Helicosphaera carteri*

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The scale of the impact of coccolithophores on the environment, and *vice versa*, is largely defined by the physiological traits of coccolithophore cells. Climate models predict an increase in ocean temperature in the near future, accompanied by decreased nutrient availability in the photic zone (Sarmiento *et al.*, 2004). Changes in nutrient availability will affect the biogeography, community composition, and physiology of coccolithophores, ultimately affecting the biogeochemical carbon cycle. In order to predict the response of coccolithophores to changes in nutrient availability, it is essential to understand their nutrient-related adaptive traits.

We investigated the physiology of two strains of *Helicosphaera carteri* under various phosphorus (P) concentrations using batch cultures. Strains were isolated from contrasting environments. The Atlantic strain was isolated from the nutrient-rich southern Benguela upwelling area, and the Mediterranean strain was isolated from the oligotrophic western Mediterranean (Villefranche-sur-Mer Bay). Strains were grown in modified K/2 medium (Gerecht *et al.*, 2014) that was enriched with 10 μM of phosphorus in order to detect intrinsic strain-specific traits. Additionally, strains were exposed to the same level of phosphorus limitation (1 μM P) to test their response patterns.

The two strains exhibited significantly different physiology under both P-replete and P-limited growth. The larger Mediterranean strain had lower phosphorus requirements, lower growth rates, and lower production rates of particular inorganic carbon (PIC) compared to the Atlantic strain. When grown in the low-P medium, the Mediterranean strain reached 89% times higher cell concentrations and kept growing exponentially for 10 days longer than the Atlantic strain. The observed physiological and morphological traits reflect an adaptation to the local phosphorus availability in the respective isolation regions. Under a future low-nutrient scenario, *H. carteri* will likely reduce its phosphorus requirements, resulting in slower growth rate, larger cell size, and decreased production rate of particulate inorganic carbon.

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Combination coccospheres from the eastern Adriatic coast (Mediterranean Sea)

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Coccolithophores commonly exhibit a heteromorphic life cycle, alternating between morphologically distinct heterococcolith (diploid) and holococcolith (haploid) phases (Young *et al.,* 2005). Transition between the two phases is occasionally observed in field samples in the form of combination coccospheres containing both heterococcoliths and holococcoliths. Such coccospheres have great taxonomic importance as they link previously unrelated morphospecies to a common life cycle (Cros *et al.,* 2000). Here, we present combination coccospheres that were observed in a survey of coccolithophore distribution and diversity along the Krka River estuary (eastern Adriatic Sea). Samples were collected at six stations along a coastal-to-estuarine transect during winter and summer 2013. Water samples from four to six different depths were obtained, using a series of 5L Niskin water samplers. Seawater was filtered in a pre-determined volume onto a polycarbonate filter (0.8 μm pore size), rinsed with bottled fresh water, and oven dried at 50°C. Samples were sputter-coated with gold and studied under a Zeiss Supra35-VP scanning electron microscope.

Of the 11 combinations that were detected, four were previously described: *Coronosphaera mediterranea** - *Calyptolithina wettsteinii, Coronosphaera mediterranea** - *Zygosphaera hellenica*, *Syracosphaera bannockii** – *Corisphaera* sp. type A, and *Syracosphaera pulchra** – *Calyptrosphaera oblonga*. Combination coccospheres of *Acanthoica quattrospina** – *Sphaerocalyptra* sp. 1, *Syracosphaera didyma – Homozygosphaera arethusae**, and *Syracosphaera marginaporata** – *Anthosphaera* sp. type B were verified. A new life cycle association was observed between *Syracosphaera hirsuta* and *Corisphaera strigilis**, as well as *Alisphaera unicornis** and a nannolith-producing *Polycrater galapagensis*. A possible association between *Rhabdosphaera xiphos** and an undescribed holococcolithophore needs to be verified in future investigations. Following the taxonomic principle of priority, species names marked with (*) should be used for both the heterococcolith and the holococcolith phase.

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Response of coccolithophores to paleoproductivity changes in the western tropical Indian Ocean (off Tanzania, East Africa) for the past 25 kyrs

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Relative to other parts of the western tropical Indian Ocean, the study area off the coast of Tanzania (05º29.28□ S, 40º56.01□ E) has a characteristically unique environment. Studies of the modern day oceanographic conditions on this side of the Indian Ocean suggest that the area has stratified waters year round, a steady thermocline, and relatively low surface-water productivity. In general, the surface waters of the western Indian Ocean are governed by seasonally reversing monsoon winds that lead to upwelling and downwelling in the ocean, which in turn affect the nutrient availability and surface-water productivity. Coccolithophores are the most common primary producers of the world's oceans and are found to respond directly to variations in temperature, salinity, and nutrient availability.

The upper part of sediment core GeoB12613, encompassing the last 25 kyrs, was analyzed for coccolithophore downcore abundance and assemblage composition in order to reconstruct the past productivity of the western tropical Indian Ocean. The core was collected off Tanzania, East Africa at a 2292 m water depth during the 2008 R/V *Meteor* Expedition. Results show that coccolithophores off the coast of Tanzania are influenced in various ways by the productivity variations in the study area through time. Total coccolithophore abundances increased during the last glacial maximum and declined during the Holocene. The assemblages in the study area are primarily dominated by the low productivity indicator species *Florisphaera profunda,* which comprises up to 70% of the total assemblage. This is followed by the high-productivity indicator species *Emiliania huxleyi*, which has relative abundances between 10 to 22%, and by *Gephyrocapsa oceanica* and *G. ericsonii*, which have up to 12% relative abundances. Species that favor oligotrophic waters, such as *Umbellosphaera irregularis*, *U. tenuis*, and *Discosphaera tubifera,* were also present. Other significant contributors to the assemblages are *Calsiosolenia brasiliensis*, *C. murrayi*, *Ceratolithus cristatus*, *Oolitothus antillarum*, *O. fragilis*, *U. foliosa*, and *U. hulburtiana,* which comprise up to 5% of the assemblage. The syracosphaerids and helicosphaerids also contributed to the total assemblage.

Early Miocene through Pleistocene calcareous nannofossils and the results of cyclostratigraphic analyses of gamma ray logs – StratPacs from the Nam Con Son Basin

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Nannofossils are always a good indicator of the relative geological age in sedimentary basins that have a marine origin. More recently, however, by combining data from nannofossil zones (NN Zones of Martini or CN Zones of Bukry), foraminiferal zones (N Zones of Blow), and the cyclostratigraphic analysis of gamma ray logs on CycloLog software (StratPacs), it is possible to obtain more precision for stratigraphic boundaries. An important aspect of the cyclostratigraphic analysis of gamma logs is the log transform routine called INPEFA Log Transform. The INPEFA Log Transform is able to predict stratigraphic discontinuities downhole using well logs.

The study of nannofossil zones and StratPacs in the post rift stage in the Nam Con Son Basin (early Miocene to Pleistocene) has proved that this combination method for biostratigraphic research works well for obtaining a high-resolution biostratigraphy. The nannofossil zones found in the Nam Con Son Basin are from Zones NN2 to NN19, which are equivalent to M1000 to PS2000 in INPEFA StratPacs. (After Enres International).

Baltic Sea coccolithophores – an overview of findings from the last decades

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It is an established fact that coccolithophores are of little importance in the Baltic proper. The likely biogeochemical and environmental reasons for this have been critically analyzed and reviewed by Tyrell *et al*. (2008), and their main conclusion is that calcium carbonate saturation in the Baltic Sea is the primary controlling factor for coccolithophores and in particular an undersaturation during wintertime remains the critical impediment for coccolithophore development in the Baltic proper. While there is no reason to question these observations, it is still relevant to record the actual occurrences of coccolithophores from the Baltic proper. Repeated examinations of Baltic Sea material from Bothnian Bay and the Gulf of Finland by means of transmission electron microscopy has revealed a consistent presence of a small community of lightly calcified coccolithophores (*i.e., Balaniger virgulosa* HOL and HET, *Turrisphaera* sp., and *Papposphaera* sp.). If material examined from the Danish transitional waters that connect the North Sea and the Baltic proper is also considered, it is possible not only to define a demarcation line for *Emiliania huxleyi,* which runs into the Arkona Basin east of the island of Bornholm, but also to document the presence in the western Baltic, the Sounds, and the Kattegat of a small contingent of coccolithophores that appear to be persistently present within the area.

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Morphometric analysis of early Eocene Corbisema skeletons (Silicoflagellata) from Mors, Denmark

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Silicoflagellates are present in the modern ocean, but they first appeared in the Cretaceous. Their siliceous skeletons consist of radial spines, a basal ring, struts, an apical ring or bar, and pikes. Tsutsui & Takahashi (2009) used a species-specific biometric program to take skeletal measurements of the species *Distephanus medianoctisol* in order to document its morphological variation. Their results showed that the radial spine length changed, depending on environmental conditions.

In this study, we present the biometric results for the genus *Corbisema* using a new biometric program that runs on Windows®. The program creates two datasets: coordinate data and direct measurement results. If necessary, the coordinate data can be remeasured with another program. The *Corbisema* specimens are from an early Eocene diatomite sample collected from Mors, Denmark.

Three morphological characteristics were revealed by this study: 1) like modern *Distephanus*, the radial spine length of all *Corbisema* taxa is variable, 2) *Corbisema triacantha* specimens either had no pikes (small basal ring type) or two different pikes (large basal ring type), one of which is short, and the other is long with a tiny Y- or T-shaped tip, and 3) there are two pike positions, one located near the strut and the other at the basal ring/strut junction. Pikes are associated with double skeleton formation and cell division (McCartney *et al.*, 2014), so variations in pike position and length may represent successful or unsuccessful evolutionary strategies.

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A semi-automated identification and semi-manual tally system for calcareous nannoplankton using light microscope images

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Coccolith identification is a labor-intensive process, but the recent application of image recognition technology has reduced the time needed for this task. Beaufort & Dollfus (2004) introduced a real-time coccolith recognition system called the Système de Reconnaissance Automatique de Coccolithes (SYRACO). However, these recognition programs often miss broken or tilted coccoliths, which otherwise would have been correctly identified during a manual tally. Therefore, a system that combines both computer-aided and semi-manual tallies may be more beneficial.

This study has two aims: 1) to develop a semi-automatic identification program for a speedy tally, and 2) to calculate the coccolith fluxes of two sediment trap sites with this new program. This computer application runs on Windows® with identification algorithms that use pattern matching. The pattern relies on an external database file, which includes the species name and morphological information. The main program size is approximately 50 kb. The count and identification errors can be corrected manually.

The coccoliths and coccospheres were counted at two sediment trap sites, Station AB located in the Bering Sea (53.5°N, 177°W; water depth 3,788 m, trap depth 3,198 m), and Station SA in the subarctic Pacific Ocean (49°N, 174°W; water depth 5,406 m, trap depth 4,812 m). The sediment traps were moored from 1990 to 2009. The main results include: 1) the coccosphere fluxes of *Emiliania huxleyi* at Station SA responded to the positive mode of the Pacific Decadal Oscillation (PDO), while those of *Coccolithus pelagicus* responded to the negative mode of the PDO, 2) the coccosphere fluxes increased at Stations AB and SA during 1990 to 2009, and 3) the coccosphere fluxes increased suddenly from June 2008 to early 2009, following an iron-fertilization event by volcanic ash.

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Calcareous nannofossil biostratigraphy and temporal variation of the flora near the Neogene-Quaternary boundary, Pacific side of central Japan

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We present calcareous nannofossil biostratigraphy for and the temporal variation of the flora found up through the Gauss into the lowermost Matuyama Chronozone in forearc basin fills that are exposed on the Miura Peninsula (35°18′ N, 139°36′ E) on the Pacific side of central Japan. The upper Ikego Formation consists mainly of sandy mudstone, and the overlying Urago Formation consists mainly of sandstone and muddy sandstone, both of which would have been deposited at water depths of 400 to 2000 m (Eto *et al.,* 1987; Utsunomiya & Majima, 2012). In the continuous section through the upper Ikego and Urago Formations, we recognized the following stratigraphic markers in ascending order: last occurrence datum (LO) of *Reticulofenestra pseudoumbilicus*, LO of *Sphenolithus* spp., LO of *Discoaster tamalis*, top of the Gauss Chronozone, key tuff bed assigned to 2.5 Ma, and LO of *Discoaster pentaradiatus*. Four species of *Reticulofenestra* (*R. minuta*, *R. minutula*, *R. haqii,* and *R. producta*) dominated the studied horizons (totaling more than 60% of the assemblages). *Coccolithus pelagicus* showed a slight increase of up to 16% in the interval above the LO of *D. tamalis* (2.78–2.76 Ma), but generally remained at 2–10% throughout the studied horizons, in contrast to higher-latitude Pacific regions and the Sea of Japan where *C. pelagicus* abruptly increased, while reticulofenestrids decreased at 2.75 Ma (Sato *et al*., 2002). Our results suggest that the warm Kuroshio Current had a significant impact not only on the Miyazaki region (32°07′ N, 131°30′ E) (Chiyonobu *et al*., 2012), but as far north as the current study area.

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Miocene Andean uplift and its impact on planktonic communities in eastern equatorial Pacific basins

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An interaction between morphotectonic/climatic processes in the northern Andes (uplift, erosional exhumation, and orographic barrier development) and ocean circulation dynamics in the eastern equatorial Pacific (EEP) was interpreted for the Miocene development of orogenic systems and forearc basins of western Colombia. Following a detailed biostratigraphic and biochronological study, a detailed analysis of oceanic microfossil assemblages (calcareous nannofossils, planktonic foraminifers, and diatoms) was compared with continental proxies (thermochronology and pollen), revealing patterns that are indicative of coupling among morphotectonic, climatic, and oceanic dynamic systems. Marked shifts in sedimentation rates for EEP basins, such as the Guatemala, Colombian, and Panamá Basins, in conjunction with uplift/exhumation-driven cooling events of cordilleran massifs of the western Cordillera, are associated with discrete pulses of Andean topographic build-up between 18 and 10 Ma. As a consequence of these morphotectonic events, significant changes in rainfall intensity/distribution (enhanced orographic effects) and erosional efficiency of the drainage network resulted in increased input of terrigenous materials into EEP basins. In addition, we identified an increase in the oceanic productivity after ~12 Ma that is linked to the reorganization of oceanic circulation and/or variation in the continental input of biolimiting nutrients. This new information that was obtained from the forearc basins of Colombia provides a complex signal of continental, oceanic, and climatic factors that influenced the EEP evolution during the Miocene.

Biogeographic patterns of coccolithophore morphologic disparity

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The pelagic realm is spatially heterogeneous, and this variety of environments plays a role in structuring planktonic communities. Observations of extant coccolithophores demonstrate that different regions harbor different assemblages of species and that the total number of species varies by region and latitude. But what about the morphologic diversity of the taxa in a region? Are there spatial patterns of disparity? I investigated whether different biogeographic provinces, latitudes, and biomes differ in their average regional morphological diversity. I based my pelagic province scheme on Spalding *et al*. (2012), wherein a province is a large area defined by spatially and temporally stable (or seasonally recurrent) oceanographic conditions that host a distinct assemblage of species. I tabulated presence/absence of a species in a given province based on observations from the published literature and the Nannotax3 database. I analyzed 68 discrete, binary, morphological characters of body coccoliths from over 100 extant species, using SEM images available through the Nannotax3 database and other literature sources. I calculated disparity as the mean dissimilarity between species, using the Gower distance, and generated a coccolith morphospace portrayed via principal coordinates. Taken at the coarsest level of locality resolution, *i.e.,* observations known from a region, *e.g*., West Indian Ocean,, my analyses showed very similar values of average provincial disparity. However this average varies notably when I used the finest level of locality resolution, *i.e.,* observations know from a province or smaller area, increasing in some provinces and decreasing in others. There is also more overlap between biomes in morphospace at the coarsest level of resolution because biomes are represented by fewer provinces at the finest level of resolution. Unlike diversity metrics based on species richness, disparity values of a region and its position and breadth in morphospace depend on which species are sampled. This results in a more complex but complementary picture of taxonomic diversity.

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Paleoenvironmental changes in the North Atlantic (ODP Site 984) during Marine Isotope Stage 5 as deduced from coccolith reconstruction

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Ocean Drilling Program (ODP) Site 984, located on the North Atlantic Bjørn sediment drift close to the modern locations of the Arctic and Polar hydrographic fronts, provides high-resolution records for the late Pleistocene. The last interglacial, Marine Isotope Stage (MIS) 5, was the last extended warm period before the Holocene and gives insight into natural climate variability during interglacials. In order to reconstruct regional changes in productivity and hydrography of the North Atlantic during MIS 5, coccolith assemblages in ODP Site 984 sediments were investigated. For this purpose, changes in coccolith abundances, coccolith accumulation rates, assemblage composition, and diversity, as well as morphotypes and calcification stages of *Emiliania huxleyi,* were analyzed.

Using coccolith data, progressive southward advances of the Arctic and Polar fronts into the subpolar North Atlantic Ocean were documented. The observed coccolith assemblages were generally dominated by *Gephyrocapsa muellerae* and are characterized by an average of only six species. Limited coccolith numbers and lowered species diversity point to the influence of progressive cold-water mass expansions into subpolar latitudes, in particular during the last glacial and stadial stages (MIS stages/stadials 6, 5d, 5b, and 4). Three intervals (MIS interstadials 5e, 5c, and 5a) of warm surface-water expansion were identified by increased coccolith numbers and elevated diversities. Differences in the composition of the coccolith assemblages also indicate that the main northward expansions of the warm surface currents occurred during MIS 5e and 5a, with highest coccolith production observed in stage 5a, which is contrary to observations at other locations in the North Atlantic (Stolz & Baumann, 2010).

An unexpected finding is the occurrence of *Emiliania huxleyi* >4 µm in sediments influenced by expanded warm surface water. This morphotype is often used as an indicator of cold surface waters, as suggested by Colmenero-Hidalgo *et al*. (2002). In this study, however, both *E. huxleyi* >4 µm and *E. huxleyi* <4 µm show up in higher numbers during warm intervals. This questions the usage of this morphotype as a cold-water indicator, at least for the MIS 5 and previous intervals. It seems more likely that *E. huxleyi* has undergone various evolutionary adaptations during MIS 5, which may also lead to an evolutionary step in the exchange of dominance between *E. huxleyi* and *G. muellerae*.

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Late Holocene climate variability off southwestern Africa as inferred from coccolithophore assemblages and sediment elemental composition

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Given the latest scenarios by the IPCC (2013), there are major concerns regarding water availability in south-eastern Africa and the drastic consequences for the resident population and economies that are to be expected. Consequently, a better understanding of climate dynamics in this region is crucial. Nannofossil analyses, as well as X-ray fluorescence measurements, were performed on a marine sediment core (GeoB 8323-2) that was retrieved from a 93-m water depth off the Olifants River, South Africa, in order to reconstruct paleoceanographic changes in the southern Benguela upwelling system, as well as variations in continental hydrology. These draw a consistent picture for late Holocene environmental change during the last three millennia.

The generally low diversity of the coccolithophore communities indicates phases of surface-water warming from 2.75 – 2.25 ka BP, around 1 ka BP, and during the last 250 years, whereas increasing abundances of *Coccolithus pelagicus* reveal colder SSTs in between those warm spells. Warming in the southern Benguela is accompanied by drier conditions on the continent, and cooling generally coincides with greater moisture availability in the summer rainfall zone of South Africa.

Coccolithophore productivity appears to be directly linked to sea surface temperature (SST), and thus, to upwelling intensity, while an overall increase in total coccolith numbers after 1.5 ka BP is superimposed on this general relation.

Remarkably, the current study found pronounced warming and aridity during the Medieval Climate Anomaly, which contrasts with many earlier studies and implies a greater zonal asymmetry for this period than previously thought. Synchronous changes in the extent of Antarctic sea ice give credence to the conceptual model of latitudinal migration of the westerly wind belt and its interaction with the southeasterly trade winds as an important driver for Ekman-induced upwelling and continental moisture availability.

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Semi-automated morphometrics on coccoliths using ImageJ

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The use of morphometrics has the potential to improve significantly our knowledge of shape and size variation in coccolithophore taxa and so our ability to define taxa and describe their evolutionary history and response to ecological change. A great advantage of working with coccoliths is that the numbers of specimens are virtually infinite, but a compensating disadvantage is that morphologies are typically rather simple and that there are few independently variable parameters that can be measured. In practice, this means that typical studies involve measuring a few parameters on a very large number of specimens and that a prime constraint is time available for specimen imaging and measuring. This further means that developing an efficient workflow is critical for the delivery of an effective study. For the measurement phase of studies, efficiency can be greatly improved by development of semi-automated routines that minimize the time taken to make standardized measurements. ImageJ and its derivative FiJi are powerful public domain image analysis programs with flexible abilities to write macro routines and plug-in modules. I have applied these in a range of studies on living and fossil coccoliths using light and electron microscopy that includes recent work on *Emiliania huxleyi* (Young *et al.,* 2014). This talk provides an introduction to the use of ImageJ with coccoliths and guidance in the design of measurement routines. It will also include discussion of some interesting recent research and priorities for future research.

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Interrogating the Neptune database for nannofossil occurrence data - species records and diversity estimates

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Deep sea drilling within the DSDP, ODP, and IODP programs has provided an enormous volume of publically accessible data on the occurrence of planktonic microfossils in deep-sea sediments. In an attempt to synthesize this data, the Neptune database was compiled by David Lazarus, Katharina von Salis, and co-workers at ETH-Zurich in the 1990s (Lazarus 1994; Spencer-Cervato 1999; current version is at www.nsb-mfn-berlin.de). They compiled data from the published reports on radiolaria, diatoms, planktonic foraminifera, and nannofossils. Key aspects of the compilation included integrated age models for each site and synonymies created by taxonomic experts. Both aspects significantly improve the quality and consistency of the data, although it is, inevitably, still far from perfect. The database has subsequently been used in a number of studies, including Hannisdal *et al*. (2012) and Lloyd *et al*. (2012). David Lazarus has now received funding to add additional more recent data from key ODP legs, and the synonymies have been improved through the use of integrated name lists produced for the ODP. For calcareous nannofossils, the name lists were produced by Paul Bown, Jackie Lees, and Jeremy Young in collaboration with Woody Wise.

We have investigated the use of the database as a source of data on the stratigraphic distribution of individual species for the Nannotax database. To do this, the database was queried to produce a table of number of records per taxon per 2 Ma bin. This raw data is strongly skewed by the variable number of records per time bin (ranging from 1800 records for the 0-2 Ma bin to <20 from some Cretaceous bins). However, if raw counts of records are divided by total number of records per bin, to obtain a frequency of records, then a much more meaningful dataset can be obtained. As will be shown, this provides an objective record of taxon occurrence, which closely matches subjective models of taxon abundance. The data are now being incorporated into Nannotax species pages. In addition, the frequencies per time bin can be summed to give a measure of the average number of taxa recorded per time bin. This is a relatively simple measure of biodiversity change, but the shape of the curve closely resembles the biodiversity estimates produced by summation of known ranges (*e.g.,* Bown *et al.,* 2004).

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A new species of Late Triassic nannofossil, Botulustriassicus, and observations on Triassic assemblages from the NW Shelf of Australia

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Preliminary biostratigraphic and morphometric comparisons between a new species of Tribrachiatus and T. orthostylus

Šupraha, L., Ljubešić, Z. and Henderiks, J.
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