

SCOR/IGBP Working Group 138
Modern Planktonic Foraminifera and Ocean Changes

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During the year, the focus of the WG has shifted from identifying research priorities and structuring the review product towards generating new data and compilation products, progressing on individual review papers and documents and generating collaborative research proposals. Dissemination activities included participation at the international FORAMS2014 meeting in January 2014 in Chile, where group members presented two keynote lectures, hosted a successful special session and organized screening of the WG138 promotional video. Building on the first review paper published on foraminifera biomineralisation, a discussion workshop has been organized in association with The Micropaleontological Society (TMS) spring meeting at Texel, The Netherlands, in June 2013. The workshop participants jointly identified a set of 12 key issues in the field of biomineralisation and shell chemistry of planktonic foraminifera that need to be addressed and discussed specific approaches to solving these issues. The results of the discussion are currently being transformed into a manuscript, the aim of which is to frame the issues into a science background and stimulate research in these directions. The final workshop of the WG will be held at the marine station at the Santa Catalina Island in California. Following our experience with the successful engagement of young researchers in the agenda of the WG during the kick-off meeting in Amsterdam in 2010, the final meeting will again address advanced PhD students and young postdocs by featuring a short course in culturing of living planktonic foraminifera. The final meeting will consider the status of the review papers, their integration into the envisaged eBook and consider how the WG will proceed beyond its SCOR funding period.

Specific achievements during the reporting period include

SCOR/IGBP WG138 @ FORAMS 2014

The FORAMS 2014 conference took place in January 2014 in Concepcion, Chile, being organized by Margarita Marchant, who is a member of the WG.

See: <http://www2.udec.cl/forams2014/congress.html>

Thanks to the engagement by the WG, SCOR has been considered and mentioned among the sponsors of the meeting, with SCOR logo featured prominently on all materials (see website above).

The FORAMS conference takes place every four years and is considered the most important international meeting of experts on fossil and modern foraminifera. Being held in Chile, FORAMS 2014 presented an excellent opportunity to engage with the South American community and disseminate the research agenda of the WG. To this end, the WG members present at the meeting organized a *screening of the documentary video*, which was attended by over 50 colleagues. In addition, the WG was represented by *two keynote lectures* by Howard Spero (Planktonic Foraminifera Test Development and Elemental Variations during Mineralization) and Michal Kucera (First assessment of the total extent of cryptic diversity in modern planktonic foraminifera). Finally,

a *SCOR special session* co-chaired by WG members Kate Darling and Michal Kucera was organized on the topic of the Ecology of planktonic foraminifera: from present to past, featuring next to the keynote lecture eight presentations. The stimulating discussions and high attendance of the session underscored the acceptance of the WG work on modern planktonic foraminifera within the community.



Foraminifera Geochemistry Workshops at Texel, The Netherlands, June 26, 2014

<http://www.tmsoc.org/foram-nanno2014.html>

Engaging 27 participants including 6 WG members, the one-day workshop began by reviewing the status of the review and discussing how to challenge people to contribute to missing chapters. Discussion with colleagues from across the community revealed that the WG will have to generate a standardized terminology list, because confusion on the meaning of many terms hinders scientific exchange.

Following the general discussion, the participants turned their attention to the geochemistry of foraminifera shell. Prior to the workshop, all registered participants were requested to provide written feedback on the following three issues; the responses form the backbone of the discussion:

1. What do you consider at present as the greatest challenge in our understanding of the process of biomineralization and trace-element geochemistry of foraminiferal calcite?
2. Which of the currently applied concepts of biomineralization and geochemistry do you consider most contentious, difficult to understand, in need of revision?
3. Can you think of an experiment that may help to understand such aspect of foraminiferal biomineralization/ geochemistry?

The workshop was introduced by summarising the review of de Nooijer et al. (2014). It proceeded by identifying and structuring the main issues, and discussing ways of communicating the results of the discussion to the broader community. The twelve key issues are currently being developed into a paper aimed to stimulate future research. The issues include:

1. Understanding the diversity of crystallography and mineralogy of the shell
2. Understanding the patterns, scale and origin of spatial heterogeneity and temporal inhomogeneity in shell elemental composition and isotopic signals

3. Understanding the ontogeny of biomineralisation
4. Understanding the relationship between heterogeneity and bulk composition
5. Deconvoluting primary factors affecting paleoproxies
6. Constraining the role and composition of the primary organic matter
7. Understanding what controls the amount of calcification per volume of cytoplasm
8. Characterizing phylogenetic signals in biomineralisation and geochemistry
9. Characterizing physiological controls on shell biomineralisation and geochemistry
10. Understanding the relationship between biomineral composition and the “mother solution” from which the mineral crystallise
11. Determining the rate of calcification
12. Understanding what is causing diversity in paleoproxy calibrations

A total of 14 of the workshop participants agreed to engage in the writing up of the summary paper, with L. de Nooijer as lead author.

Progress on review papers

The WG has decided to present the results of its work in an innovative open-access multi-media format. The envisaged final product – an evolving eBook – will be able to integrate work in any format (papers published in regular journals, reviews, taxonomic keys, data collection, video manuals), publish each item separately, incorporate updates (versions), link to other existing content and allow incorporation of rare back content (data and information rescue). Every item in the eBook will obtain a DOI and permanent hosting will be secured by Copernicus. The setting up of the eBook requires content. To this end, substantial progress has been achieved, as detailed below. As soon as about 1/3 of the planned content is available, the eBook structure will be generated.

Chapter/Topic	Progress/Products
Introduction	
Historical review of major breakthrough in the study of modern planktonic foraminifera	
Taxonomy	
Revised taxonomy including updated species key and a glossary of morphological features	Brummer, G.J., Kucera, M., et al.: Identification key and Glossary of terms version 2 completed and presented at TMS meeting in June 2014 for community consultation Gallery of images: http://foraminiferaimagedatabase.marum.de/gallery2/main.php
Genetic diversity, cryptic species	Morard, R. et al.: Curated database of planktonic foraminifera SSU rDNA sequences. (to be submitted in fall 2014) Weiner, A. et al.: Review of methods on single-cell DNA extraction in modern planktonic foraminifera (in progress)

Biology and calcification	
Physiology, nutrition, symbiosis	In progress: Spero, H.J. et al.
Life cycle and reproduction	Bijma, J., et al.: Reproduction of planktonic foraminifera (in progress)
Morphology and morphogenesis	
Biominaleralisation	de Nooijer, L.J., Spero, H.J., Erez, J., Bijma, J., Reichart, G.J., 2014. Biominaleralization in perforate foraminifera. Earth Science Reviews, 135, 48–58.
Shell geochemistry	Spero, H. and Bijma, J.: Geochemistry of planktonic foraminifera shells (in progress) de Nooijer L.J. et al: Key issues and challenges in using planktonic foraminifera shell geochemistry for paleoceanographic proxies (in progress; result of 2014 TMS workshop)
Shell weight and size	In progress: Metcalfe, B. et al.
Ecology	
Biogeography	Siccha, M. et al.: Revised dataset of planktonic foraminifera assemblage counts in surface sediments (in progress) Ivanova, E. et al.: Delimitation of biogeographical provinces (in progress)
Phenology	Jonkers, L., Kučera; M.: Seasonality of extant planktonic foraminifera determined from analysis of shell flux time-series (to be submitted in fall 2014)
Habitat: ontogenetic migration	
Modelling of biomass and calcite flux	
Methods	
Review of methods for collection	Cleroux, C., Brummer, G.J. et al: Methods of collection of living planktonic foraminifera (first draft available after 2013 workshop in Prague) Coll: Recommendation for data reporting (first draft available after 2013 workshop in Prague)
Manual for culturing	Keul, N. et al.: A manual on culturing of planktonic foraminifera (in progress)
Review of methods for analysis	
Glossary of terms	Ongoing

In addition to papers directly relevant to the envisaged review/eBook, following publications have benefited from the WG activities and acknowledge SCOR support:

Nathalie Gajardo & Margarita Marchant. 2012. Variaciones estacionales de los foraminíferos planctónicos durante 2005-2006 frente a Iquique (20° S) y Concepción (36° S), Chile. *Lat. Am. J. Aquat. Res.*, 40(2): 376-388.

Nathalie Gajardo, Humberto E González, Margarita Marchant. 2013. Characterization of El Niño, La Niña, and normal conditions through planktonic foraminifera (2006 – 2007) in the southeastern Pacific. *Ciencias Marinas* (2013), 39(3): 253 – 264.

Nathalie Gajardo, Margarita Marchant & Dierk Hebbeln. 2013. Variación temporal de los afloramientos costeros frente a Chile central (36° S; 74° W), mediante los isótopos estables de oxígeno de foraminíferos planctónicos, durante El Niño 2006. *Gayana* 77(1): 10-20.

Progress on collaborative research projects

A shiptime proposal has been submitted in September 2013 (lead proponent Michal Kucera) for the German vessel SONNE for a cruise dedicated to solving remaining “mysteries” of the ecology of planktonic foraminifera, as described in report from last year. The proposal has been unsuccessful, but a resubmission has been encouraged. This is under preparation and will be submitted in September 2014 as a joint venture between MARUM (Bremen) and NIOZ (the Netherlands), with associated proposal via CEREGE (France) for subsequent recovery of moored particle traps.

A collaborative proposal aiming to synthesize data on distribution of planktonic foraminifera from plankton net samples is planned to be submitted within the French CESAB-FRC call (lead proponent Thibault de Garidel-Thoron, CEREGE). The proposal is strongly associated with the SCOR WG, arising from the 2013 Prague workshop and including among its international partners several WG members.

Outlook

The fourth and final year of the WG will feature the final workshop aiming to launch the first version of the eBook, review outstanding issues and chapters and facilitate knowledge transfer to the next generation by including a short course on culturing of planktonic foraminifera. The workshop is organized by Howard Spero; in addition to SCOR/IGBP resources, additional funds will be sought from the NSF and other national agencies.

Based on the status of the two collaborative proposals described above, the WG will consider during the final meeting ways to continue pursuing its agenda beyond the SCOR mandate.

Overview of progress on individual deliverables:

1. Synthesize the state of the science of modern planktonic foraminifera, from pioneering to ongoing research including as a peer-reviewed publication in an open-access journal (**deliverable 1**).

The first review paper/eBook chapter has been published, several others are nearing completion. The same applies to non-publication products, such as the revised taxonomy and identification key. Details of progress on individual chapters are given above.

2. Provide guidelines (cookbooks) in terms of species identification, experimental setup for culture studies, laboratory treatment prior to geochemical analysis (**deliverable 2**).

Manuscripts and/or draft versions of all documents are in existence. The first version of the revised taxonomy/identification key has been presented for community consultation at the TMS spring meeting in June 2014.

3. Establish an active Web-based network in cooperation with ongoing (inter)national research programs and projects to guarantee an open-access world-wide dissemination of results, data and research plans (**deliverable 3**).

The concept of such resource has been developed in the form of an evolving eBook.

4. Document the work of the group in a special issue of an open-access journal (**deliverable 5**) in connection with a specialized symposium with special emphasis on modern ocean change i.e. thermohaline circulation and ocean acidification, during one of the AGU or EGU conferences, ideally held at the joint EGU/AGU meeting (envisaged for 2013 or 2014) and/or at the FORAMS 2014 meeting in Chile (**deliverable 4**).

Deliverable 5 – see deliverable 1. The science of the WG has been promoted through the documentary video (https://www.youtube.com/watch?v=xfZ_9UWcAB8), attracting over 5k views, by organizing special session at FORAMS2014 (co-chairs M. Kucera and K. Darling), with keynote lectures by H. Spero and M. Kucera and by promoting the science of the WG with the micropalaeontological community at the yearly TMS spring meetings.