

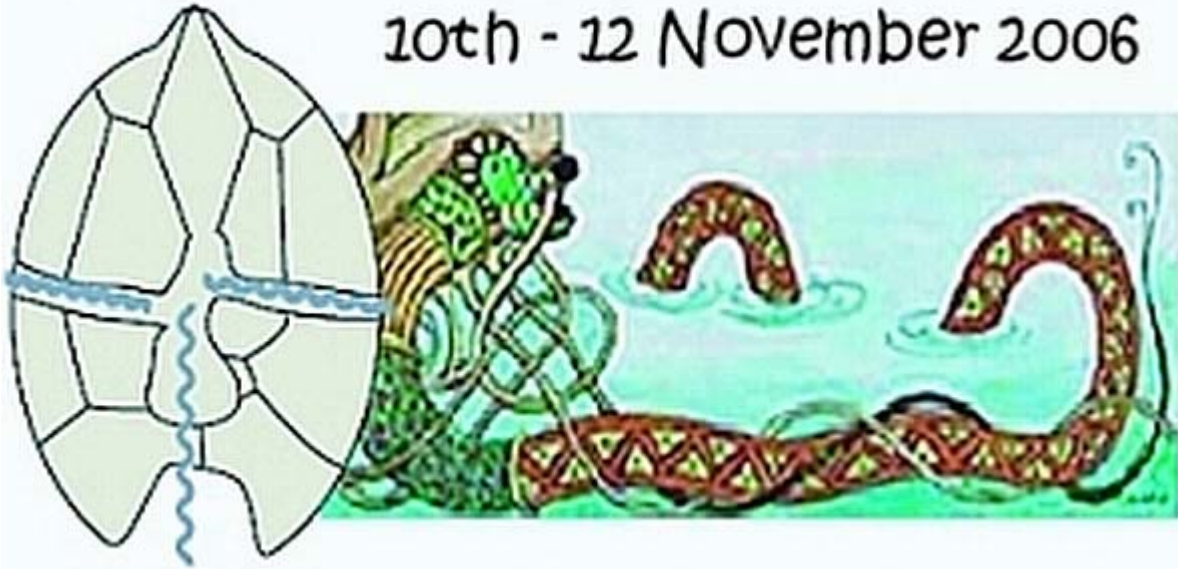
**2006 international workshop on dinoflagellates and  
their cysts: Their ecology and databases for  
paleoenvironmental reconstructions**

10<sup>th</sup>-12<sup>th</sup> November 2006, Copenhagen, Denmark

N. E. Poulsen (ed.)



# Workshop on dinoflagellates and their cysts: their ecology and databases for palaeoenvironmental reconstructions. 10th - 12 November 2006



## **Preface**

The 2006 international workshop on dinoflagellates and their cysts: their ecology and databases for palaeoenvironmental reconstructions took place 10 - 12 November 2006 in Copenhagen, Denmark. The host was the Geological Survey of Denmark and Greenland (GEUS), and the workshop was organized by Niels E. Poulsen (GEUS).

The workshop addressed many aspects dinoflagellates and their cyst related to taxonomy, phylogeny, morphology, distribution, ecology, proxies in palaeoceanography, biogeography, palaeoenvironmental reconstructions, and served as a forum for exchange of new research results, ideas, microscopy observation of other problematic species and specimens as well as questions concerning databases.



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## Programme

<b>Friday 10<sup>th</sup> November 2006</b>		
<b>9:00–10:00</b>	<b>Registration</b>	
<b>Oral session 1. Chair: Fabienne Marret</b>		
<b>Time</b>	<b>Author</b>	<b>Title</b>
10:00	Niels Poulsen	Welcome
10:05	<u>Jens Matthiessen</u> & Henk Brinkhuis	Neogene Dinoflagellate Cysts from Lomonosov Ridge, Central Arctic Ocean
10:30	Ekaterina Novichkova	Dinoflagellate cysts from the White Sea. New observations.
<b>11:05</b>	<b>Coffee/tea Break</b>	
<b>Oral session 2. Chair: Laurent Londeix</b>		
11:35	<u>Tatiana Klyuvitkina</u> , Ye.I. Polyakova & H.A. Bauch	Paleogeographical evolution in the Laptev Sea region under postglacial sea level rise
12:00	<u>Stijn De Schepper</u> & Martin J. Head	Pliocene–Pleistocene dinoflagellate cyst biostratigraphy and palaeoecology of the eastern North Atlantic (Rockall Trough)
<b>12:30</b>	<b>Lunch</b>	
<b>14:00</b>	<b>Poster session</b>	
<b>Oral session 3. Chair: Sofie Lindström</b>		
<b>Time</b>	<b>Author</b>	<b>Title</b>
15:00	Taoufik Radi & Anne de Vernal	Dinoflagellate cyst assemblages vs. productivity and accuracy of reconstructions
15:25	Anne de Vernal & Taoufik Radi	The use of regional vs. hemispheric dinoflagellate cyst databases for reconstruction of sea-surface conditions
<b>15:50</b>	<b>Discussion forum. Chair: Annemiek Vink</b> <b>Environmental reconstructions, development of dinoflagellate cyst image databases and databases for palaeoceanographic purposes, sampling and preparation methods</b>	
<b>17:00</b>	<b>Microscopy observations</b>	
<b>17:30</b>	<b>Workshop reception</b>	
<b>18:00</b>	<b>Workshop dinner</b>	

<b>Saturday 11<sup>th</sup> November 2006</b>		
<b>Oral session 4. Chair: Marianne Ellegaard</b>		
<b>Time</b>	<b>Author</b>	<b>Title</b>
09:30	<u>Karin A.F. Zonneveld</u> , Andreas Mackensen & Karl-Heinz Baumann	Stable oxygen isotopes of <i>Thoracosphaera heimii</i> (Dinophyceae) in relationship to temperature; a culture experiment.
09:55	<u>Monika Kodrans-Nsiah</u> & Karin A.F. Zonneveld	Species-selective aerobic degradation of dinoflagellate cysts – results of a 1-year natural experiment
10:20	Sofie Lindström	Two Late Triassic (Rhaetian) dinoflagellate cysts from southern Sweden, <i>Suessia</i> sp. A and <i>Lunnomidinium scaniense</i> , and their implications on the evolution and subdivision of the Family Suessiaceae
<b>10:45</b>	<b>Coffee/tea Break</b>	
<b>Oral session 5. Chair: Jens Matthiessen</b>		
11:15	Massimiliano Tardio, <u>Marianne Ellegaard</u> , Francesca Sangiorgi & Graziano Di Giuseppe	<i>Peridinium umbonatum</i> – a freshwater cyst with an antapical archeopyle
11:40	André Rochon <sup>1</sup> & Éric Potvin	Cyst–theca relationships of <i>Islandinium minutum</i>
12:05	Laurent Londeix	<i>Spiniferites</i> morphologies and sea surface salinities
<b>12:30</b>	<b>Lunch</b>	
<b>14:00</b>	<b>Microscopy observation: <i>Spiniferites</i> spp.</b>	
<b>15:00</b>	<b>Round table discussion on <i>Spiniferites</i>. Chair: Rex Harland</b>	
<b>Oral session 6. Chair: Anne de Vernal</b>		
<b>Time</b>	<b>Author</b>	<b>Title</b>
15:30	<u>Sandrine Solignac</u> , Anne de Vernal & J. Giraudeau	Similarities and differences in the distribution of coccolith and dinoflagellate cysts in surface sediments from the North Atlantic
15:55	<u>Kenneth Mertens</u> , <u>Stephen Louwye</u> , L. Vankerckhoven, H. Vanneste & A. Foubert	Dinoflagellate cysts and coccoliths as paleoceanographical indicators in the Gulf of Cadiz
16:20	<u>Ulrike Holzwarth</u> , Oliver Esper & Karin Zonneveld	Distribution of organic-walled dinoflagellate cysts in shelf surface sediments of the Benguela upwelling region in relationship to environmental conditions
<b>16:55–18:00</b>	<b>Plenary business talks on future work and dino-consortium. Special issue. Next workshop when and where?</b>	

## Sunday 12<sup>th</sup> November 2006

### Oral session 7. Chair: Karin Zonneveld

Time	Author	Title
09:30	<u>Fabienne Marret</u> , Peta Mudie, Ali Aksu & Richard N. Hiscott	New dinoflagellate cyst evidence contradicts the Noah's Flood hypothesis
09:55	<u>Sofia S. Ribeiro</u> & Ana Amorim	A five-year survey on the seasonal occurrence of dinoflagellate cysts in surface sediments from a warm-temperate region (Cascais Bay, Portugal)
10:20	<u>Aurélie Penaud</u> , Frédérique Eynaud, Jean-Louis Turon, Sébastien Zaragosi & Fabienne Marret	Paleohydrology of the northern Bay of Biscay: what could dinoflagellate cysts tell us about the last interglacials (MIS 5 and MIS 7)?
<b>10:45</b>	<b>Coffee/tea Break</b>	
<b>Oral session 8. Chair: Stephen Louwye</b>		
11:15	<u>Ilham Bouimetarhan</u> , Karin Zonneveld & Lydie Dupont	Holocene dinoflagellate cyst and pollen analysis off Senegal: a palynological approach to land–sea correlation
11:40	<u>Vera Pospelova</u> & T. F. Pedersen	Dinoflagellate cyst evidence for Late Quaternary climate and marine productivity changes along the California Margin.
<b>12:05</b>	<b>Discussion forum and microscopy observation</b>	
<b>12:30</b>	<b>Lunch</b>	
<b>14:00</b>	<b>Discussion forum and microscopy observation</b>	
<b>17:30–18:00</b>	<b>Closure</b>	

### **Poster session**

<b>Author</b>	<b>Title</b>
<u>Andrea Fischel</u> , Claus Heilmann-Clausen, Antoon Kuijpers & Marit-Solveig Seidenkrantz	Palynomorph evidence of a cold Medieval Warm Period at Disko Bugt, Greenland
<u>Alexandra Kraberg</u> & K., H. Wiltshire	PLANKTON*NET
Ekaterina Novichkova	Dinoflagellate cysts from the White Sea. New observations.
<u>Kari Grøsfjeld</u> & Jochen Knies	Modern dinoflagellate cyst assemblages from various environmental settings within the Arctic realm
<u>Marion Kohn</u> & Karin A.F. Zonneveld	Isotope analysis on calcareous dinoflagellates to reconstruct the sea-surface temperature of the last 60ka years off NW Africa
<u>Nicolas Van Nieuwenhove</u> , Henning A. Bauch & Jens Matthiessen	Surface ocean properties of the Norwegian Sea during MIS5e, based on dinoflagellate cysts and foraminiferal assemblages
<u>Stijn De Schepper</u> & Martin Head	New dinoflagellate cyst and acritarch taxa from the Pliocene and Pleistocene of the eastern North Atlantic (DSDP Site 610)
<u>Tatiana Klyuvitkina</u> , Ye.I. Polyakova & H.A. Bauch	Paleogeographical evolution in the Laptev Sea region under postglacial sea level rise

## ***Participants***

Name	Institute
Alexandra Kraberg	AWI Bremerhaven
Ana Amorim	Instituto Oceanografia Faculdade Ciências de Lisboa
Andre Rochon	ISMER-UQAR
Andrea Fischel	Aarhus Universitet
Anna Pienkowski-Furze	University of Alberta
Anne de Vernal	Universite du Québec a Montreal GEOTOP-UQAM
Annemiek Vink	Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)
Aurélie Penaud	UMR/ CNRS 5805 "EPOC"
Ekaterina Novichkova	Institute of Oceanology, Moscow
Fabienne Marret	University of Liverpool
Ilham Bouimetarhan	Bremen university, RCOM
Jens Matthiessen	AWI Bremerhaven
Kari Grøsfjeld	NGU
Karin Zonneveld	Universität Bremen
Katarzyna Kamila Sliwinska	Aarhus Universitet
Kenneth Mertens	University of Ghent
Koen Verhoeven	Universiteit Gent
Laurent Londeix	Université Bordeaux 1
Marianne Ellegaard	University of Copenhagen
Marion Kohn	University of Bremen
Monika Kodrans-Nsiah	University of Bremen
Nicolas Van Nieuwenhove	IFM-Geomar
Niels Poulsen	GEUS
Rex Harland	U.K.
Sandrine Solignac	GEOTOP-UQÀM-McGill
Sofia Santos Ribeiro	Universidade de Lisboa
Sofie Lindström	GEUS
Stephen Louwye	Ghent University
Stijn De Schepper	Universität Bremen
Taoufik Radi	Université du Québec à Montréal
Tatiana Klyuvitkina	Moscow State University
Ulrike Holzwarth	University of Bremen
Vera Pospelova	University of Victoria



## Abstracts

### **Holocene dinoflagellate cyst and pollen analysis off Senegal: a palynological approach to land-sea correlation**

Ilham Bouimetarhan <sup>\*1</sup>, Karin Zonneveld <sup>1</sup> & Lydie Dupont <sup>2</sup>

<sup>1</sup> Department of Geosciences, University of Bremen, P.O. Box 330440, D-28359 Bremen, Germany.

<sup>2</sup> MARUM, University of Bremen, P.O. Box 330440, D-28334 Bremen, Germany.

<sup>1</sup>Corresponding author: [bouimetarhan@uni-bremen.de](mailto:bouimetarhan@uni-bremen.de)

Organic-walled dinoflagellate cysts and pollen are used to obtain information about the last 3.5 ka paleoenvironmental history of the NW African region. So far, twenty-eight samples from core GeoB9503 (16°03.99'N, 16°39.15'W; 49 m water depth and 791 cm length) were analyzed for their palynological content. Core GeoB 9503 has been retrieved from the Senegal mud-belt in front of the Senegal River during R/V Meteor cruise M65-1.

The dinoflagellate cyst assemblages record high concentrations and are taxonomically diverse, usually dominated by a temperate species association characteristic for high nutrient availability in upper waters.

The pollen analysis records a transition from a Saharan to Sahelian to fresh water component, suggesting changes in hydrologic conditions and atmospheric circulation activity.

A correspondence was found between high percentages of Saharan pollen and peaks of dinoflagellate cyst abundance reflecting high nutrient availability. This suggests that enhanced productivity could be related to either an increased nutrient input from the land (wind-blown) as well as an increase of wind induced upwelling. Furthermore, high relative abundances of river and swamp pollen correspond to increased relative abundance of dinoflagellate cyst species that are characteristic for river discharge regions along the western African margin, suggesting a high river discharge.

### **Pliocene–Pleistocene dinoflagellate cyst biostratigraphy and palaeoecology of the eastern North Atlantic (Rockall Trough)**

Stijn De Schepper<sup>1</sup> & Martin J. Head<sup>2</sup>

<sup>1</sup>Cambridge Quaternary, Department of Geography, University of Cambridge, Downing Place, Cambridge CB2 3EN, United Kingdom,  
Present address: Fachbereich-5, Geowissenschaften, Universität Bremen, Postfach 330 440, D-28334, Germany

<sup>1</sup>Corresponding author: [sdeschepper@uni-bremen.de](mailto:sdeschepper@uni-bremen.de)

<sup>2</sup>Department of Earth Sciences, Brock University, 500 Glenridge Avenue, St. Catharines, Ontario L2S 3A1, Canada

An independently calibrated dinoflagellate cyst biostratigraphy for Pliocene–Pleistocene (4.0–0.5 Ma) deposits recovered from eastern North Atlantic Deep Sea Drilling Project (DSDP) Hole 610A has been established. Assemblages are taxonomically diverse, and the highest and/or lowest occurrences of 21 dinoflagellate cyst and 8 acritarch taxa have been recognised and calibrated to a newly defined age model using graphic correlation. This age model is largely tied to marine isotope stratigraphy and magnetostratigraphy, as well as new data on the range of the calcareous nannofossil *Reticulofenestra pseudoumbilicus* for the lower part of the hole.

The first signs of intense climatic cooling occur at Marine Isotope Stage (MIS) M2 (3.3 Ma, Pliocene), where ice-rafted detritus is recognised for the first time in Hole 610A. Within a short interval spanning this event, dinoflagellate cysts and the  $\delta^{18}\text{O}$ -record from the planktonic foraminifera *Globigerina bulloides* have been examined from the same samples in order to obtain a directly calibrated dinoflagellate cyst-based temperature index. Several other environmental indices (e.g. productivity, flux or transport indices) were calculated from the dinoflagellate cyst record as a means to interpret the palaeoecological variability within MIS M2. Multivariate and cluster analyses were applied to distinguish between cold, warm and intermediate assemblages.

The same palaeoecological techniques were then applied to the entire Plio-Pleistocene section. A cooling of the climate is reflected by a decrease in the number of species, which starts from c. 3.0 Ma onwards. Heat transport to the north via the North Atlantic Current (NAC) is apparently reflected also in the abundance of *Operculodinium centrocarpum* sensu Wall and Dale (1996). At around 2.85 and 2.7 Ma, peaks in this species' abundance may indicate increased NAC heat transport associated with the closure of the Isthmus of Panama.

The most significant changes in the dinoflagellate cyst flora are recorded in the Gelasian Stage, coincident with the intensification of the Northern Hemisphere glaciations. In this interval, the cool-tolerant *Habibacysta tectata* is dominant, possibly reflecting an important ocean-wide reorganisation. An explanation could be the cessation of warm and saline surface-water transport to northern latitudes via the NAC and an associated shutdown of deep-water production in the Greenland–Norwegian Seas.

Poster

**New dinoflagellate cyst and acritarch taxa from the Pliocene and Pleistocene of the eastern North Atlantic (DSDP Site 610)**

Stijn De Schepper<sup>1</sup> & Martin J. Head<sup>2</sup>

<sup>1</sup>Cambridge Quaternary, Department of Geography, University of Cambridge, UK  
Present address: Fachbereich-5, Geowissenschaften, Universität Bremen, Germany

<sup>1</sup>Corresponding author: [sdeschepper@uni-bremen.de](mailto:sdeschepper@uni-bremen.de)

<sup>2</sup>Department of Earth Sciences, Brock University, Ontario, Canada

A palynological study of Pliocene and Pleistocene deposits from DSDP Hole 610A in the eastern North Atlantic has revealed the presence of several new organic-walled dinoflagellate cyst taxa. A new species of the genus *Impagidinium* first appeared in the Pleistocene, an interval characterised by a paucity of first appearances of cyst species. New varieties of *Operculodinium? eirikianum* and *Melitasphaeridium choanophorum* occur in a few samples near the Mammoth Subchron within the Pliocene (Piacenzian Stage), and may be morphological adaptations to the changing climate at that time. In addition, the stratigraphic utility of small acritarchs in the late Cenozoic of the northern North Atlantic region is emphasized, and three stratigraphically restricted acritarch species are described, two belonging to a newly described genus and another to the genus *Cymatiosphaera*.

## The use of regional vs. hemispheric dinocyst databases for the reconstruction of sea-surface conditions

Anne de Vernal, & Taoufik Radi

GEOTOP UQAM-McGill  
Université du Québec à Montréal, BP 8888, succ. Centre Ville, Montréal, Qc, H3C 3P8

<sup>1</sup>Corresponding author: [devernal.anne@uqam.ca](mailto:devernal.anne@uqam.ca)

With the enlargement of reference modern databases, the definition of the geographical area to be used for statistical treatments and application of transfer function is a critical issue. The assessment of the relationships between environmental parameters and the distribution of taxa in assemblages can be made using multivariate technique such as canonical correspondence analyses (CAA). However, CAA as other multivariate techniques gives different results depending upon the geographical area selected. For example, in the northeast Pacific, the most determinant parameter identified from CAA is productivity, whereas sea-ice is more important when adding the Bering Sea. As another example, salinity appears determinant in the North Atlantic, but secondary when the hemispheric database is considered. Results obtained on regional subsets of a standardized dinocyst database including 1171 sites from the North Pacific, North Atlantic and Arctic oceans demonstrate that dinocysts are responding to a combination of parameters, which are weighted differently depending upon the regional hydrography. Therefore, any transfer function approach using calibration techniques (for example, neural network, partial least square, Imbrie and Kipp) should be used with caution, and only when the calibration dataset adequately accounts for changes in the assemblages and the environmental parameters to be reconstructed. By using approaches based on similarity, such as the modern analogue technique (MAT), the problem is not as acute since there is no calibration or assumption of quantitative relationships between assemblages and a given parameter. MAT supposes that a given assemblage of taxa in the fossil record is most likely to have occurred under a combination of environmental conditions characterizing similar modern assemblages of taxa. Inasmuch as close modern analogues can be identified, reconstruction by interpolation can be made. Therefore, the number of reference sites is critical and the accuracy/reliability of reconstruction should be improved by higher diversity of assemblages representing the largest possible combination of environmental variables. Theoretically, the enlargement of the reference database from regional to hemispheric scales should favour better paleoceanographical reconstructions. Validation tests indicate comparable performance for the reconstruction of salinity, temperature and sea-ice cover using regional or hemispheric data sets. In general, the root mean square error of precision (i.e., the standard deviation of the residual between the observed and estimated values) is similar to the standard deviation of the observed values. Two examples of reconstruction have been worked out using regional vs. hemispheric dinocyst databases. The first example is from a 25 000-years sequence of the northwest North Atlantic (HU91-045-094). At this site, the use of North-Atlantic-Arctic or hemispheric databases yield almost identical results and most analogues are found in the Arctic-Atlantic basin. The second example is from a 23 000-years sequence in the Gulf of Alaska (PAR-87A10), northeast North Pacific. In this case, the use of Pacific or Hemispheric databases yields very distinct reconstructions, especially for the glacial stage characterized by assemblages having their modern analogues in the Arctic and North Atlantic.

Poster

### **Palynomorph evidence of a cold Medieval Warm Period at Disko Bugt, Greenland**

*Andrea Fischel*<sup>1</sup>, *Claus Heilmann-Clausen*<sup>1</sup>, *Antoon Kuijpers*<sup>2</sup> & *Marit-Solveig Seidenkrantz*<sup>1</sup>

<sup>1</sup>University of Aarhus, Denmark

<sup>2</sup>Geological Survey of Denmark and Greenland (GEUS)

<sup>1</sup>Corresponding author: [AndreaFischel@gmx.de](mailto:AndreaFischel@gmx.de)

Palynomorphs (mainly dinoflagellate cysts) are here used as evidence for significant late Holocene climate variability in the West Greenland region. We studied an 850cm long piston core (DA00-02P) collected in Egedesminde Dyb, a 990m deep submarine valley in Disko Bugt, West Greenland, during a cruise with *R/V DANA* in 2000. The core was dated using 11 calibrated C-14 dates and represents the interval 3600 cal. yr BP to 660 cal. yr BP. A total of 19 species of palynomorphs, including 14 dinoflagellate cysts, 4 acritarchs and 1 sporomorph were identified in the study. The lowermost part of the core, 3600 cal. yrs BP to 3300 cal. yrs BP, is dominated by temperate water dinoflagellate cysts indicating a high influx of relatively warm and saline Atlantic Water into the Disko Bay, through the inflow of Irminger Sea Water (ISW) via the Irminger Current (IC) and West Greenland Current (WGC). At app. 3300 cal. yrs BP arctic species of dinoflagellate cysts and acritarchs increase in abundance, indicating the onset of the Neoglaciation. The cool climate continued until 2300 cal. yr BP, followed by 600 years of a return to warmer surface-water conditions as indicated by an increase in temperate species. This period corresponds to the European Roman Warm Period, and can be connected to a higher input of nutrient-rich, saline Atlantic Water (ISW) into the Labrador Sea.

After 1700 cal. yrs BP palynomorphs show a rapid increase of arctic species, indicating a higher influx of Polar Water and a decreased influx of ISW during the Dark Ages and as well during the following Medieval Warm Period. The cold signal is nearly constant throughout several centuries until the onset of the Little Ice Age, when an increase in temperate species indicates a smaller increase in the Atlantic Water influx.

Acknowledgements: Lucia Roncaglia (formerly GEUS) is thanked for help during the study.

Poster

### **Modern dinoflagellate cyst assemblages from various environmental settings within the Arctic realm**

Kari Grøsfjeld & Jochen Knies

Geological Survey of Norway, N-7491 Trondheim

<sup>1</sup>Corresponding author: [kari.grosfjeld@ngu.no](mailto:kari.grosfjeld@ngu.no)

Several surface samples in the region inshore and offshore Svalbard have been investigated for their content of dinoflagellate cysts. The main purpose of this investigation is to obtain more detailed knowledge about cyst assemblages in different environmental settings within the Arctic marine realm.

The c. 100 km-wide West Spitsbergen Current (WSC) transports relatively warm (6-8° C) and salty (35.1 to 35.3‰) waters, keeping the eastern Fram Strait permanently free of ice. This is reflected by the cyst composition in the sediments lying beneath these waters. The fact that the WSC is confined over the continental slope is reflected by a change in dinoflagellate cyst composition at c. 400 m water depth. At depths greater than 400 m the sediments contain species, with *Operculodinium centrocarpum* dominant, that are characteristic for currents of the Gulf Stream System. At shallower depths, the species compositions are dominated by heterotrophic dinoflagellate cyst taxa reflecting a restricted influence of the WSC. Most of these samples are

dominated by *Islandinium minutum*, which usually comprises >50% of the taxa in the assemblage. Other samples are dominated by *Brigantedinium* spp. or *Pentapharsodinium dalei*. The West Spitsbergen inshore area is free of sea-ice during several months of the year. However, the degree of glaciation in the various fjord areas along the coast varies significantly. River run off and glacial melt water account for the bulk of the freshwater input. Therefore, an explanation for the frequent high-percentage occurrence of *Islandinium minutum* may be sought in the characteristics of the hinterland and its input and not exclusively in the extent and duration of the sea-ice cover.

The results emphasize that dinoflagellate cyst analysis is a useful tool for reconstructing past environmental conditions in the Arctic. It should be stressed that these are preliminary results. More samples will be analysed, and detailed investigations will be carried out in particular fjords. This will hopefully provide us with a better knowledge about which set of parameters is likely to control the distribution of assemblages, at least those dominated by particular species.

### **Distribution of organic-walled dinoflagellate cysts in shelf surface sediments of the Benguela upwelling region in relationship to environmental conditions**

Ulrike Holzwarth<sup>1\*</sup>, Oliver Esper<sup>2</sup> & Karin Zonneveld<sup>1</sup>

<sup>1</sup> Research Center Ocean Margins, University of Bremen, P.O. Box 330440, D-28334, Germany

<sup>2</sup> Alfred-Wegener-Institute for Polar and Marine Research, Columbusstrasse, D-27568, Germany  
Corresponding author: holzwarth@rcm-bremen.de

To obtain insight in the relationship between the spatial distribution of organic-walled dinoflagellate cysts and local environmental conditions, fifty-eight surface sediment samples from the coastal shelf off SW Africa were investigated on their dinoflagellate cyst content with special focus on the two main river systems and the active upwelling cells that characterise this region. To avoid possible overprint of the “ecological signal” by species-selective preservation, samples have been selected from shelf sites where high sedimentation rates or low bottom water oxygen concentrations prevail.

Multivariate ordination analyses have been carried out to investigate the relationship between the distribution patterns of individual species to environmental parameters of the upper water column and sediment transport processes.

The main environmental parameters in the region show onshore-offshore gradients. This pattern is reflected in the dinoflagellate cyst associations with high relative abundances of heterotrophic dinoflagellate cyst species in neritic regions characterised by high chlorophyll-*a* and low salinity concentrations in surface waters. Photoautotrophic dinoflagellate cyst species, notably *Protoceratium reticulatum* dominate in the more oceanic area. Differences in the distribution of photoautotrophic dinoflagellate cyst species can be related to sea surface salinity and sea surface temperature gradients and to a lesser extent to chlorophyll-*a* concentrations.

Apart from longitudinal gradients the cyst distribution clearly reflects regional characteristics. Six groups of species could be distinguished characteristic for (1) coastal regions (*Protoperidinium conicum*, *Polykrikos kofoidii*), (2) vicinity of upwelling cells (*Echinidinium aculeatum*, *Echinidinium* spp., *Echinidinium transparantum*, *Protoperidinium* spp. and *Spiniferites* spp.), (3) river mouths (*Lejeunecysta oliva*, *Protoperidinium americanum*, *Protoperidinium oblongum* and *Protoperidinium subinermis*), (4) slope and open ocean sediments (*Dalella chatamensis*, *Impagidinium patulum* and *Protoceratium reticulatum*), (5) the southern Benguela region (south of 24°S) (*Spiniferites ramosus*) and (6) the Northern Benguela region (north of 24°S) (*Nematosphaeropsis labyrinthus* and *Pyxididopsis reticulata*).

No indication of overprint of the paleoecological signal by lateral transport of allochthonous species could be observed.

Talk and Poster

## Paleogeographical evolution in the Laptev Sea region under Postglacial sea level rise

Tatiana S. Klyuvitkina<sup>1\*</sup>, Ye.I. Polyakova<sup>1</sup> & H.A. Bauch<sup>2</sup>

<sup>1</sup>Geography Department, Moscow State University, Vorobievsky Gory, Moscow, Russia

Corresponding author: [t.klyuvitkina@mail.ru](mailto:t.klyuvitkina@mail.ru)

<sup>2</sup>Mainz Academy of Sciences, Humanities and Literature, c/o IFM-GEOMAR, Kiel, Germany

We carried out investigations of recent and fossil aquatic palynomorph assemblages from the Laptev Sea sediments dating back to approximately 17.5 cal. ka.

According to data of M. Kunz-Pirrung (1998, 2001) distribution of main aquatic palynomorph groups from the surface sediments clearly reflect the strong salinity gradient in the surface waters of the Laptev Sea.

For the goal of reliable reconstruction of paleo conditions in the Laptev Sea we used CD-ratio – is ratio between freshwater chlorophyte algae and marine dinoflagellate cysts. In the surface sediments of the Laptev Sea CD-ratio values decreased from the coast to the shelf break. It is in a good accordance with the modern surface water salinity and submarine valleys of the main rivers. Thus, CD-ratio can be used as indicator of riverine outflow to the Laptev Sea shelf.

AH-ratio is ratio between autotrophic species of dinoflagellate cyst and heterotrophic ones. Distribution of AH-ratio values in the surface waters of the Laptev Sea good correlates with salinity gradient and reflect the inflow of relatively warm Atlantic waters. Therefore, AH-ratio can be used as indicator of inflow of Atlantic waters to the Laptev Sea shelf and continental slope.

As a result of postglacial sea level rise the shallow Laptev Sea was rapidly flooded. During the Early to Middle Holocene the sea level raised from approximately -50 m to the modern position of the coastline. According to changes in the dinoflagellate cysts species composition and values of CD and AH-ratios the following major events in the development of paleoenvironmental conditions were established:

On the Western Laptev Sea continental slope time interval 17.5–13.3 cal. ka was characterized by low concentration of dinoflagellate cysts on the continental slope and predominance of euryhaline cold-water species *Islandinium minutum*, *I. cezare* and *Brigantedinium simplex*. This period probably was characterized by extremely sea-ice conditions. The first appearance of autotrophic species was marked 13.3 cal. ka.

According to our data the outer western Laptev Sea shelf (60 m depth) was already inundated around 12 cal. ka. but had a strong fluvial-estuarine (Anabar-Khatanga River) imprint until 11.2 cal. ka.

A pronounced changes in dinoflagellate cyst assemblage composition between 11.2 and 7.0 cal. ka are characterized by a strong increase in total concentration and proportions of Atlantic-water species (e.g. *Operculodinium centrocarpum*) along with the appearance of relatively warm-water indicative species (*Spiniferites elongatus*, cyst of *Pentaparsodinium dalei*) and high values of AH-ratio. This allows us to assume the relatively warm-water summer temperature and enhanced influence of warm Atlantic water. Since 7.0 cal. ka influence of relatively warm Atlantic water in the Laptev Sea strongly decreased. Modern-like conditions were established approximately 7.0 cal. ka.

Eastern Laptev Sea shelf was rapidly inundated between 11.3 and 10.3 cal. ka and paleoenvironmental conditions were characterized by high precipitation of river-loaded matter, primarily riverine plankton. The following time interval 10.3 – 9.2 cal. ka on the outer shelf was marked by predominance of the Atlantic-water dinoflagellate cyst species. The high relative abundances of these species as well as appearance of relatively warm-water indicative species

and high values of AH-ratio in the outer Laptev Sea shelf was probably caused by enhanced influence of Atlantic-water at the continental margin or decrease in sea ice cover. 8,9–8,5 cal. ka. the shallow inner Laptev Sea shelf was inundated. High abundances of freshwater algae and high CD-ratio values give evidence for zone of marginal filter of Lena River at the time 8.6–8.8 cal. ka. at the depth 32 m. According to our data modern-like environments on the outer eastern Laptev Sea shelf were reached around 8.6 cal. ka, on the inner shelf around 7.4 cal. ka.

Obtained results allowed us to compile final schemes of the development of hydrographical parameters since 17.5 cal. ka to the modern time for Eastern and Western parts of the Laptev Sea and compile maps of the southward retreat of the coastline under the postglacial sea-level rise.

This research was funded by Otto Schmidt Laboratory for Polar and Marine Sciences, and through RFBR (Project N 06-05-65267) and INTAS (Project N 03-51-6682).

### **Species-selective aerobic degradation of dinoflagellate cysts – results of a 1-year natural experiment**

Monika Kodrans-Nsiah<sup>1</sup> & Karin A. F. Zonneveld

University of Bremen, Geosciences, Klagenfurter Str., Bremen 28359, Germany

<sup>1</sup>Corresponding author: [mknsiah@uni-bremen.de](mailto:mknsiah@uni-bremen.de)

Organic-walled dinoflagellate cysts undergo species selective decomposition in oxic environments while they preserve very well under anoxia. To obtain information about the degradation rate of individual species we have carried out an experiment in a natural environment. We have exposed material with different dinoflagellate cyst compositions to oxic and anoxic conditions at two sites in the Eastern Mediterranean namely in the Urania and Bannock Basins. These basins contain anoxic brains overlain by oxygen rich intermediate and surface waters. Sediments collected from (a) Namibian shelf, (b) S1 sapropel and (c) modern eastern Mediterranean sediments were analysed on their dinoflagellate cyst content.

After 15 months sub-samples from Namibian shelf and sapropelic material that were exposed to oxygen rich waters showed a considerable reduction in cysts concentration compared to their sub-samples that were exposed to anoxic conditions and to their original concentration. Exposure to anoxic conditions did not have any clear effect. Our experimental results confirm previous findings that *Brigantedinium* spp., *Echinidinium granulatum* are very sensitive to oxygen exposure whereas *Spiniferites* spp., *Lingulodinium machaerophorum* and *Echinidinium* spp. appear to be moderately sensitive. Resistant against aerobic decay are *Nematosphaereopsis labyrinthus*, *Operculodinium israelianum* and *Impagidinium aculeatum*. Additionally a positive relationship was found between dinoflagellate cysts degradation speed and oxygen concentration in the water.

Poster

### **Isotope analysis on calcareous dinoflagellates to reconstruct the sea-surface temperature of the last 60ka years off NW Africa**

Marion Kohn<sup>1</sup> & Karin A.F. Zonneveld

University of Bremen, Geosciences, Klagenfurter Str., Bremen 28359, Germany

<sup>1</sup>Corresponding author: [mkohn@uni-bremen.de](mailto:mkohn@uni-bremen.de)

There is a clear relationship between the oxygen isotope composition of *Thoracosphaera heimii* cysts and temperature so that dinoflagellates are a useful tool to reconstruct palaeotemperatures

of the upper water column, particularly the deep chlorophyll maximum. In comparison to dinoflagellates other calcareous proxies that are used to calculate sea-surface temperatures (SST) have several disadvantages. The production of their calcareous material might take place in different depths in the water column, can show ontogenic induced variability, is sensitive to (selective) dissolution or can be geographically determined by seasonal production. Since *T. heimii* form immotile vegetative cysts and the motile phase last a few minutes to a few hours their vertical movement in the photic zone is rather limited. It seems that they are more robust against dissolution than other calcareous dinoflagellates and they are widespread in temperate to tropical regions.

Although the relationship between  $\delta^{18}\text{O}$  of *T. heimii* and seawater temperature has recently been established by means of culture experiments the proxy has not been tested in a time series. To test the proxy we aim to compare the results with results from other SST proxies measured on similar samples. This will be done for Core GeoB8507. It is located north-east of the Canary Islands off NW-Africa. The focus is on the last 60ka years especially the changes between glacial and interglacial. Therefore *T. heimii* has to be separated by using a density/size separation method until it can be measured with a mass-spectrometer.

Metabolic, biological and kinetic effects can hamper SST quantification as well as verify or optimise the paleotemperature equation used to species-specific characterisations. Thus those so called vital effects can override the environmental signals. To investigate whether and how they influence the stable oxygen isotopic composition of the vegetative, photosynthetic dinoflagellate cyst *T. heimii* two unicellular strains are cultured under different temperatures and illuminations using gradient boxes and under different pH values. Additionally alkalinity will be measured. To figure out how *T. heimii* can be used as a paleoenvironmental proxy it might be helpful to know the possible carbon source for calcite precipitation.

Poster

## PLANKTON\*NET

Alexandra Kraberg<sup>1</sup> & K., H. Wiltshire

AWI Bremerhaven

<sup>1</sup>Corresponding author: [akraberg@awi-bremerhaven.de](mailto:akraberg@awi-bremerhaven.de)

PLANKTON\*NET (e.g. <http://www.awi.de/Plankton-Net>) is a communal online database project with currently 6 European and 1 US partner, that aims to provide comprehensive information including images, taxonomic descriptions and keys on marine and freshwater plankton. PLANKTON\*NET is based on a number of distributed websites that contain partners' data sets but also host collections on behalf of 'external' contributors.

PLANKTON\*NET has just gone through a major upgrade to enhance the main features e.g. search functions, but also to increase user friendliness. It is now possible to enter collections of images and modify content remotely. PLANKTON\*NET operates a rights system whereby registered users can be given separate rights to enter modify or publish information. This rights system is not only a means of facilitating faster data input by experts but also serves as a basic means of quality control.

In the course of a recently funded project the current PLANKTON\*NET resources will now be linked so that content from all local sites and external resources can be harvested and viewed via an online portal. In addition the underlying database system will also be extended to contain environmental data providing a comprehensive system for the archival of all data related to the distribution of not only planktonic but any type of organism or different life stages of the same species.

## Two Late Triassic (Rhaetian) dinoflagellate cysts from southern Sweden, *Suessia* sp. A and *Lunnomidinium scaniense*, and their implications on the evolution and subdivision of the Family Suessiaceae

Sofie Lindström

Geological Survey of Denmark and Greenland, Øster Voldgade 10, DK-1350 Copenhagen K, Denmark.  
Corresponding author: [sli@geus.dk](mailto:sli@geus.dk) or [sofie.lindstrom@geol.lu.se](mailto:sofie.lindstrom@geol.lu.se)

During a palynological investigation of the cored Höllviken-2 well from SW Scania in southern Sweden a new dinoflagellate cyst, *Suessia* sp. A, was found in a well preserved and diverse Rhaetian assemblage. The terrestrial palynoflora is dominated by spores and pollen grains typical of the Rhaetian, including *Riccisporites tuberculatus*, *Rhaetipollis germanicus*, *Limbosporites lundbladii*, *Semiretisporis gothae*, *Triancoraesporites ancorae*, *T. reticulatus*, *Lunatisporites rhaeticus*, and *Ovalipollis ovalis*. Dinoflagellate cysts constitute 5 % of the total assemblage, that apart from *Suessia* sp. A also contains *Lunnomidinium scaniense* var.  $\beta$  and rare specimens of *Beaumontella ?caminuspina*. Rhaetian dinoflagellate cysts have previously been reported from NW and SW Scania by Lindström (2002) and Lindström & Erlström (2006). Mass occurrence of dinoflagellate cysts, mainly the shublikodiniacean *R. rhaetica* and *D. priscum*, is characteristic of the latest Rhaetian (Lindström & Erlström, 2006), while the suessiacean *S.* sp. A and *L. scaniense* so far have only been found in strata of early to middle Rhaetian age (Lindström, 2002; Lindström & Erlström, 2006; Lindström, personal observation).

To date the Suessiaceae family is regarded to comprise six fossil genera; *Noricysta* Bujak & Fisher 1976, *Suessia* Morbey 1975, *Wanneria* Below 1987, *Lunnomidinium* Lindström 2002, *Beaumontella* Below 1987 and *Umbriadinium* Bucefalo Palliani & Riding 1997, and one extant genus, *Polarella* Montresor, Procaccini & Stoecker 1999. Bucefalo Palliani & Riding (2000) subdivided the then known suessiacean genera (i.e. excluding *Polarella* and *Lunnomidinium*) into two subfamilies, the Suessioideae and Umbriadinioideae. The subdivision was based on morphological differences, mainly regarding the ornamentation. The nonparatabular *Noricysta* was grouped together with the parasutural *Suessia* and *Wanneria* into the Subfamily Suessioideae, which hence became stratigraphically restricted to the Late Triassic (Bucefalo Palliani & Riding, 2000). The two remaining genera, *Beaumontella* and *Umbriadinium*, both exhibiting intratabular ornamentation, were assigned to the Subfamily Umbriadinioideae with an essentially Early Jurassic stratigraphic distribution (Bucefalo Palliani & Riding, 2000).

The epicystal *Lunnomidinium* has intratabular ornamentation in some of its plate series and does not fit within anyone of these subfamilies (Lindström, 2002). With its general form and intratabular protuberances *Lunnomidinium* resembles the Jurassic heterocapsacean genera *Parvocysta* Bjaerke 1980 and *Susadinium* Dörhöfer and Davies 1980, but differs from these in having more plate series, more plates in each series, and an epicystal archeopyle instead of an apical intercalary archeopyle. The new species *Suessia* sp. A exhibits traits that can be found in both *Wanneria*, *Suessia*, *Noricysta*, and *Lunnomodinium*. It has serated parasutural crests, sometimes reduced to just a row of grana, intratabular grana, a predominantly subpentagonal outline in dorso-ventral view, and what appears to be an disintegration type archeopyle involving various numbers of paraplates on the epicyst.

The morphologies of these two dinoflagellate cysts have implications on the evolution and subdivision of the Family Suessiaceae. This lineage of dinoflagellates was very successful during the Late Triassic, but appears to have suffered greatly in the events associated with the Triassic–Jurassic transition.

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## ***Spiniferites* morphologies and sea surface salinities**

Laurent Londeix

Département de Géologie et Océanographie, UMR EPOC-Université Bordeaux 1,  
avenue des Facultés, 33405 Talence cedex France  
Corresponding author: [l.londeix@epoc.u-bordeaux1.fr](mailto:l.londeix@epoc.u-bordeaux1.fr)

The evaluation of environmental parameters from the morphology of organisms is the ambition of every scientist trying to reconstruct (paleo-) environments. The *Spiniferites* genus shows a very wide specific diversity (more than one hundred species) as well as intraspecific variability (more than 32 subspecies, of which 17 only for *S. ramosus*, the type species of the genus).

Does sea surface salinity influence the morphology of at least some species of this genus? It seems that yes, and among the taxa concerned, *Spiniferites cruciformis* is a good example. This taxon is endemic of residual basins of the Paratethys (e.g. Black sea, Caspian sea,...) and is presently known to tolerate high seasonal thermal contrasts with low salinity, but with weak seasonal salinity contrast: winter temperatures = 8,5 (10,3° C); summer temperatures = (26,5) 27,5° C; winter salinities = 12,5 (12,9) 17 ‰; summer salinities = 12,7 (12,9) 19 ‰ (mean values are between brackets). In a core from the Marmara Sea, we have documented the influence of Mediterranean Sea surface water vs. hyposaline Black sea surface water since ca 22 ka cal BP to Present. To be more accurate in our reconstructions, we attempted to use a further typology of the various *S. cruciformis* morphotypes. This has proved fruitless, and any peculiar morphology seems to be linked to a peculiar salinity range. The main conclusion evidenced, is that decreasing salinities lead to various aberrant morphotypes of the taxon (questionably a species) *S. cruciformis*, independently of thermal variations.

Such an observation has also been noted in Burdigalian (Lower Miocene) sediments from the stratotypic area (SW France). Under a warm (subtropical) context and with surficial hyposaline waters due to the relative proximity of an estuary, the answer of *Spiniferites* species was the development of specimens "losing their head", with unusual morphologies, for which any specific attribution was became illusive.

Astonishingly, in sediments from hyposaline laguna of Aquitanian (Lower Miocene) strata of the same area, *Spiniferites* specimens are very few and outnumbered by *Polysphaeridium zoharyi*.

In the examples of the Marmara Sea and the Burdigalian sequences, *Spiniferites* specimens are very abundant, whereas they are dominant. Not in the Aquitanian sequence example. At present, we can propose a quantified estimation of the sea surface salinity only for the Marmara sea sequence, with salinities ranging from 12.5 to 19 ‰. The existence of a threshold under which the salinity would be too low for good development of *Spiniferites* spp. could be envisaged, however modern sediments record percentages of *Spiniferites* spp. up to 40-50% in environments with minimal sea surface salinities down to 2 ‰ or seasonal contrast up to 37 ‰. Nevertheless, in some cases of marine environments with low salinities, dominance is taken by genera such as *Lingulodinium*, *Polysphaeridium* (and/or *Homotryblium* in ancien sequences).

What about situations with relatively stable sea surface temperature and increased salinities? The Mediterranean Messinian salinity crisis is a good example for that.

Messinian salts of Sicily have provided dinoflagellate cyst assemblages in which *Spiniferites* spp. is dominant, prior to euryhaline taxa such as *Lingulodinium* or *Homotryblum*. But no unusual quantities of any aberrant morphologies were recorded.

Unfortunately, these assemblages seem to result of a mixing with other allochthonous dinoflagellate cyst assemblages and with probable Miocene reworking. So, interpretations need very high discernment, and paleosalinity reconstructions are not envisageable in such a context.

At present, no quantified relation appears between the morphology of *Spiniferites* specimens and sea surface salinity. The question is open, whether any regular morphologies (exuberant ornamentation, granular wall,...) are indicative of anormal salinity or strong seasonal salinity contrast. Nevertheless, it seems important from now on to plan in our data base a special rubric for specimens of *Spiniferites* with peculiar (atypical) ornamentation and another for specimens of that genus with a granular wall. In the same way, it seems important to distinguish *Spiniferites* specimens “undeterminable” because crumpled, broken, or damaged, and specimens “undetermined” because of an atypical morphology.

With such amendment of our processing in the determination of the *Spiniferites* specimens, may be we will be able to elaborate indexes depicting (perhaps indices quantifying) the sea surface salinity (or the seasonal contrast) by taking into account, simply, the number of atypical *Spiniferites* specimens vs. the total number of *Spiniferites* specimens.

In addition, on the basis of such observations, it is legitimate to wonder how realistic the elevation to a specific rank of some of the many species described within the *Spiniferites* genus. Conversely, does *Spiniferites ramosus* represent a unique species? That is very questionable, when considering this taxon is recorded from Jurassic strata to Present: the Mathusalen species in the dinoflagellate cyst pool, and may be among the living world!

## **New dinoflagellate cyst evidence contradicts the Noah's Flood hypothesis**

Fabienne Marret<sup>1\*</sup>, Peta Mudie<sup>2</sup>, Ali Aksu<sup>3</sup> & Richard N. Hiscott<sup>3</sup>

<sup>1</sup>Department of Geography, University of Liverpool, Liverpool, L69 7ZT, UK

<sup>1</sup>Corresponding author: [f.marret@liv.ac.uk](mailto:f.marret@liv.ac.uk)

<sup>2</sup>Geological Survey Canada Atlantic, Dartmouth, Nova Scotia B2Y 4A2, Canada

<sup>3</sup>Department Earth Sciences, Memorial University of Newfoundland,  
St. John's, Newfoundland, A1B 3X5, Canada

An exceptionally high-resolution and species-rich dinoflagellate cyst record from core M02-45 collected from the south-western Black Sea shelf provides strong evidence of a gradual reconnection between the Black (BS) and Mediterranean (MS) seas at the beginning of the Holocene. Two main assemblages, one dominated by brackish species, *Spiniferites cruciformis* and *Pyxidinospis psilata*, and freshwater algae and the successive one, characterised by euryhaline species (*Lingulodinium machaerophorum*, *Brigantedinium* spp., *Protoperidinium ponticum*) document a progressive change in sea-surface conditions, from low saline (~7-12) to present-day conditions. A first major pulse of marine waters is recorded at around 8.46 ka BP, with a maximum of *L. machaerophorum*. Its occurrence from the bottom of the core, dated at 9.3 ka BP supports the hypothesis that water levels were already high on the south-western shelf at that period. Fully present-day conditions are recorded at around 5.6 ka BP, when brackish species and morphotypes of *Spiniferites belerius*, *Spiniferites bentorii* and *L. machaerophorum* disappeared. The transitional period between the disappearances of brackish species and the establishment of present-day population is characterised by cruciformisation of *Spiniferites belerius* and *S. bentorii*, and higher abundance of specimens of *L. machaerophorum* with short and bulbous processes or acuminate thin processes. The strong morphological variability supports the theory that water conditions were changing rapidly, in terms of salinity and probably density.

Arrivals of Mediterranean species (*Operculodinium centrocarpum* and *Spiniferites mirabilis*) are observed simultaneously in the southwest and southeast region of the BS at around 7 ka BP. Despite a different protocol for palynomorph preparation and presentation of data, previous studies from the northern shelf also document the arrival of euryhaline species at 7 ka BP, and marine influence prior to that age.

## Neogene Dinoflagellate Cysts from Lomonosow Ridge, Central Arctic Ocean

Jens Matthiessen<sup>1</sup> & Henk Brinkhuis<sup>2</sup>

<sup>1</sup>Department of Geosciences, Alfred Wegener Institute for Polar and Marine Research (AWI), Bremerhaven, Germany

<sup>1</sup>Corresponding author: [jmatthiessen@awi-bremerhaven.de](mailto:jmatthiessen@awi-bremerhaven.de)

<sup>2</sup>Geobiology–Botanical Paleoecology, Utrecht University, Faculty of Biology, Laboratory of Paleobotany and Palynology, Utrecht, the Netherlands

Organic-walled microfossils have been studied in the Neogene and Pleistocene sequences of IODP Expedition 302 holes to establish a palynomorph stratigraphy and zonation of the Central Arctic Ocean. Occurrences and abundances of palynomorphs are strongly variable throughout the sequences suggesting that paleoenvironmental conditions strongly changed in the past ~14 Ma. Assemblages usually have a low diversity and few stratigraphically important taxa are recorded in the holes. Compared to the initial shipboard studies that were conducted mainly on core catcher samples, the increased sample coverage (10 – 60 cm in the cored undisturbed sections) lead to a pronounced increase in the number of productive samples, allowing to considerably refining the shipboard biostratigraphy. In particular, the middle to late Miocene can be definitely identified for the first time in the paleoceanographic exploration of the Central Arctic Ocean enabling future studies on the paleoenvironmental links to the high latitude North Atlantic and North Pacific oceans. Pliocene and possibly early Pleistocene assemblages are relatively sparse probably related to a continuously deteriorating climate since 12- 14 Ma. Lower to middle Middle Miocene and middle to upper Pleistocene sediments are largely barren of palynomorphs probably caused by the combined effects of low cyst production and poor preservation. Comparison with other palynological studies suggests that the Arctic Ocean and adjacent high latitude basins show a comparable response to paleoenvironmental change at certain time intervals in the Neogene and Pleistocene.

## Dinoflagellate cysts and coccoliths as paleoceanographical indicators in the Gulf of Cadiz

Kenneth Mertens<sup>1</sup>, Stephen Louwye<sup>1</sup>, L. Vankerckhoven<sup>2</sup>, L. Vanneste<sup>1,3</sup> & A. Foubert<sup>4</sup>

<sup>1</sup>Research Unit Palaeontology, Ghent University, Belgium

<sup>1</sup>Corresponding author: [Kenneth.Mertens@ugent.be](mailto:Kenneth.Mertens@ugent.be)

<sup>2</sup>Paléobotanique-Paléopalynologie-Micropaléontologie, Université de Liège, Belgium

<sup>3</sup>National Oceanography Centre, University of Southampton, UK

<sup>4</sup>Renard Centre of Marine Geology, Ghent University, Belgium

The Cadiz region lies between the Iberian borderland and Morocco, west of the Strait of Gibraltar and the Western Mediterranean. Core GeoB9064-1 (35°24,91'N 6°50,72'W) is located in the southwest at a depth of 702 m, close to the Al Arraich mud volcano field 30 km off the Moroccan margin, and has a length of 544 cm. The core was sampled with a high resolution, and analysis was carried out using light microscopy and scanning electron microscopy.

Like most coastal regions, the southern Cadiz region is characterised by a coccolith assemblage dominated by the placoliths *Emiliania huxleyi* and *Gephyrocapsa muellerae*. The dinoflagellate cyst assemblage is dominated by *Lingulodinium machaerophorum*, with minor abundances of mostly *Spiniferites* spp., *Brigantedinium* spp. and *Impagidinium* spp.

Late Quaternary fluctuations are pronounced in this core, as shown by geochemical (TOC and CaCO<sub>3</sub>) and XRF analysis (K, Mg, Fe, etc.), but also in abundances of coccoliths (more particularly *Emiliania huxleyi*) and dinoflagellate cysts (*Lingulodinium machaerophorum*). These can be related to upwelling and/or bottom currents. The resulting paleoceanographical implications will be presented and discussed.

Talk and Poster

### Dinoflagellate cysts in the White Sea. New observations

Ekaterina A. Novichkova

P.P. Shirshov Institute of Oceanology, Nakhimovskiy prospect, 36, Moscow, Russia,

Corresponding author: [egolovkina@inbox.ru](mailto:egolovkina@inbox.ru)

Sediment trap samples from the Dvina Bay (the White Sea) have been analyzed for dinoflagellate cyst assemblages. The long-term (one year) sediment trap consisted of three layers. They were deployed 25, 80 and 83 m below the sea level. Dinoflagellate cyst with cell content found in all three samples. There were not big differences in assemblages. The predominantly species is *Operculodinium centrocarpum* (living cyst). Our previous investigations have shown that aquatic palynomorph assemblages from the surface sediments of the White Sea are composed of various organic-walled microfossils: dinoflagellate cysts, chlorococcalean algae, acritarchs and several groups of zoomorphs. Dinoflagellate cysts dominated in surface aquatic palynomorph assemblages are characterized by high proportions of predominantly subpolar species *Islandinium minutum*, *Operculodinium centrocarpum* and *Brigantedinium* sp. Two types of dinoflagellate cyst assemblages were established in the White Sea surface sediments: "cold-water" protoperidinioid species (*Islandinium minutum*, *Islandinium cezare*, *Spiniferites elongatus*) and other cosmopolitan assemblages represented by gonyaulacoid species *Operculodinium centrocarpum*, *Spiniferites ramosus*, and *Bitectatodinium tepikiense* (Polyakova, et al., 2003, Golovkina, 2004). Sediment trap samples have shown that we need more accurate annual observations for explaining of sediment dinoflagellate cyst associations forming.

## **Paleohydrology of the northern Bay of Biscay: what could dinoflagellate cysts tell us about the last interglacials (MIS 5 and MIS 7)?**

Aurélie Penaud<sup>1</sup>, Frédérique Eynaud, Jean-Louis Turon, Sébastien Zaragosi & Fabienne Marret

<sup>1</sup>UMR/ CNRS 5805 "EPOC"

<sup>1</sup>Corresponding author: [aurelie.penaud@voila.fr](mailto:aurelie.penaud@voila.fr)

The interglacial periods of the late Quaternary are commonly studied since they constitute direct analogues for our modern climate and could then bring answers to the key questions of its natural variability and future evolution. The aim of this work was basically to reconstruct the paleoenvironmental history of the last climatic cycles (3 at least) in deep-sea sediments of the northern Bay of Biscay, through the study of one of the longest cores ever retrieved in this area, core MD03-2692. On the basis of a multiproxy compilation, including analysis of dinoflagellate cyst assemblages, we discuss here the sequencing of paleoenvironmental and paleoclimatological changes that have marked the area. We especially focussed our investigations on Marine Isotope Stages (MIS) 5 and 7. The MIS 5, the Last Interglacial period, has been extensively studied but is described here for the first time in this area on the basis of dinoflagellate cyst assemblages. In the same way, our contribution is the first one to document dinoflagellate cyst assemblage evolution at high resolution throughout MIS 7 in North Atlantic.

Recurrent succession of species marking the beginning and the termination of the Interglacial Complexes (MIS 5 and MIS 7) revealed a coherent scheme of water mass migration during these key transitional periods. Moreover, our data bring major contribution to dinoflagellate cyst environmental requirements. In particular, we have attributed an ecology of cold cyst for *S. septentrionalis*, a species never discussed since its discovery by Harland (1977). We also noticed that in North Atlantic sediments, this species can be used as a biostratigraphical tracer until a major event of iceberg calving occurring during MIS 6, and dated around 150 kyr BP according to our age model.

The investigation of the warm intervals of MIS 7 and MIS 5 lead to a major result concerning *S. mirabilis*. If we admit that this species defines climatic optima as it was previously observed for the Last Interglacial, we can deduce the Penultimate Interglacial from the *S. mirabilis* peak centred on the MIS 7c, the second warm interval of the MIS 7. Therefore, this species enables to discriminate real Interglacial from the other warm substages over Interglacial Complexes.

### **Dinoflagellate cyst evidence for Late Quaternary climate and marine productivity changes along the California Margin.**

Vera Pospelova<sup>1</sup> & Thomas F. Pedersen

School of Earth and Ocean Sciences, University of Victoria, Victoria, Canada.

<sup>1</sup>Corresponding author: [vpospe@uvic.ca](mailto:vpospe@uvic.ca)

The palynological record of dinoflagellate cysts, foraminiferal organic linings, spores and pollen from Ocean Drilling Program Hole 1017E, California Margin, was analyzed at sub-millennial resolution. Over 50 dinoflagellate cyst taxa were identified in 87 samples. Changes in cyst abundance, composition of cyst assemblages and their diversity reflect major shifts in climate and ocean circulation in the region over the past ~40 kyr. Throughout the sequence, dinoflagellate cyst assemblages are dominated by upwelling-related taxa, indicating the continued influence of coastal upwelling on the California Margin during the Late Quaternary. The cyst record suggests that marine productivity was enhanced during the Holocene and Bølling, and to a lesser extent, during the Last Glacial Maxima and Dansgaard-Oeschger events, while an apparent reduction in productivity can be seen during the Allerød and Younger Dryas. Our results also indicate noticeable climate variability during the Holocene in this region. The palynological data are

consistent with – and thus reinforce – previous interpretations that were derived independently based on geochemical proxy analyses.

Modern dinoflagellate cyst assemblages from surface sediments collected at multiple sites across the North-eastern Pacific margin (43–25°N) demonstrate the applicability of these palynomorphs for reconstructions of environmental conditions. Combining the present cyst dataset with other published studies from the North-eastern Pacific, we have compiled “Pacific189” database. This database was used as a basis for quantitative reconstructions of (paleo)temperature and productivity, as shown by the validation exercise with the use of the best-analogue technique. “Pacific189” database is being applied for reconstructions of paleoenvironmental conditions during the last 40 kyr along the Californian margin, using sediment cores from ODP Holes 1017E and SBB893A.

## **Dinoflagellate cyst assemblages vs. productivity and accuracy of reconstructions**

Taoufik Radi & Anne de Vernal

GEOTOP UQAM-McGill

Université du Québec à Montréal, BP 8888, succ. Centre Ville, Montréal, Qc, H3C 3P8

<sup>1</sup>Corresponding author: [radi.taoufik@courrier.uqam.ca](mailto:radi.taoufik@courrier.uqam.ca)

In order to explore the reliability of dinocyst assemblages in marine sediment as productivity proxy, we used a reference “modern” dinocyst database including 1171 sites from the North Atlantic Ocean (n = 483), the Arctic Ocean (n = 401) and the North Pacific Ocean (n = 287). For each site, we compiled two sets of primary productivity data derived from satellite observations: (1) the dataset of Antoine et al. (cf. Global Biochemical Cycle, 1996), which results from the Coastal Zone Color Scanner (CZCS) program applied to observations from 1978 to 1989; (2) the NOAA data set from the MODerate resolution Imaging Spectroradiometer (MODIS) program using observations from 2002 to 2005. We performed Canonical Correspondence Analysis (CCA) with 57 dinocyst taxa and 8 sea- surface parameters (winter and summer salinity, winter and summer temperature, sea-ice cover, summer, winter and annual primary productivity). CCA results show that primary productivity is determinant on the distribution of dinocysts assemblage (including both autotrophic and heterotrophic taxa). This is valid at a hemispheric scale as well as at basin scale, in the North Atlantic and the North Pacific. However, in the Pacific the relationship between productivity and dinocyst assemblages is particularly strong. The CCA results also show that productivity is not correlated with the other hydrographic parameters considered in the analyses. On these grounds, we are convinced that productivity can be estimated quantitatively on using dinocyst assemblages. We thus tested the best analogue method, which relies on similarity between spectra and thus permits the use of the entire database. With the exception of the Arctic Ocean alone, which is characterised by overall low productivity, productivity can be estimated with an accuracy (Root Mean Square Error = RMSE) of 15-25%, depending upon the productivity database. The performance is best for winter productivity using the MODIS database. It is noteworthy that the RMSE for all productivity parameter estimated is better than the standard deviation of the differences between the two productivity values derived from the MODIS and CZCS datasets. The differences between these two datasets can be due in part to the differences in algorithms used by each program to generate productivity from chlorophyll concentration, but also to the large variations in productivity that has been recorded in some areas (notably around Iceland) between the 1980 and the 2000 decades. In any case, we conclude that dinocysts can be used to reconstruct productivity with uncertainties lower than the actual accuracy of primary productivity estimates from satellite observations.

## A five-year survey on the seasonal occurrence of dinoflagellate cysts in surface sediments from a warm-temperate region (Cascais Bay, Portugal)

Sofia S. Ribeiro & Ana Amorim

Instituto de Oceanografia da Faculdade de Ciências de Lisboa, Campo Grande 1749-016 Lisboa

<sup>1</sup>Corresponding author: [sribeiro@fc.ul.pt](mailto:sribeiro@fc.ul.pt)

A time-series study was conducted between January 2000 and November 2005, to assess the composition and seasonal variation of dinoflagellate cyst assemblages in Cascais Bay, Portugal. Cascais Bay is located c.a 40Km west of Lisbon, in the Eastern Atlantic, and south of a major coastal discontinuity, the Estremadura Promontory. During upwelling events along the W coast, upwelling plumes extend S or W of the Promontory, limiting inshore warmer waters in the bay. The river Tagus drains in the Bay c.a. 40 km E of the sampling site. Water salinity is approximately 34, and sea surface temperatures vary between 12°C (winter min.) and 21°C (summer max.).

During the survey, twenty-three surface sediment samples were collected with a simple sucking device. Sample preparation involved sonication, wet sieving (150µm onto a 25µm), and further concentration by centrifugation in a high-density solution of sodium metatungstate (2.016g.cm<sup>-3</sup>). Aliquots of the supernatant were mounted on microscopic slides with glycerine jelly and sealed with paraffin wax. For each sample, 356±79.6 (mean±SD) cysts were identified. Counts included both empty cysts and cysts with cell content, and results are expressed as relative abundance of the examined samples.

A total of 58 morphotypes were identified, belonging to 21 genera and three orders (Gonyalacales, Gymnodiniales and Peridinales). Cyst species richness was high in all samples, with a minimum of 24 morphotypes (Sep00) per sample and a maximum of 39 (Sep03).

Results indicate that the overall cyst production follows a seasonal pattern, with maximum abundance of cysts with cell contents occurring in late summer/ autumn. However, individual cyst morphotypes and dominance of taxonomic groups presented a variable year-to-year behaviour, associated with major shifts on the species composition of the community, and some species showing cyst “blooms” at time intervals larger than 5 years.

In 2003, calcareous Peridinales (mainly *Scrippsiella* spp.) were dominant. Peridinales non-calcareous dominated the assemblage in all the other years, especially due to cysts of the *Protoperidinium* genus.

To test the hypothesis that the assemblages' species composition was influenced by environmental and physical conditions at the sampling site, Detrended Canonical Analysis (DCA) and Canonical Correspondence Analysis (CCA) were performed.

The following variables were considered: sea surface temperature; chlorophyll a concentration; upwelling index; salinity; daylength; and river runoff. No direct relationship was found between these *in situ* environmental parameters and the dataset, probably due to the strong inter-annual differences observed. This suggests that even in coastal sites, cyst assemblages may reflect complex processes such as ocean currents/transport and not only the local environment.

## Cyst-theca relationships of *Islandinium minutum*

André Rochon<sup>1</sup> & Éric Potvin

ISMER-UQAR, 310 allée des Ursulines, Rimouski, QC , Canada, G5L 3A1

<sup>1</sup>Corresponding author: [andre\\_rochon@uqar.qc.ca](mailto:andre_rochon@uqar.qc.ca)

*Islandinium minutum* Head et al., 2001 is a brown spherical dinoflagellate cyst ornamented with numerous acuminate processes. It is found in relatively high numbers in Pleistocene and modern sediments throughout the Arctic (e.g. Beaufort Sea, Baffin Bay, Kara Sea, Laptev Sea, Labrador Sea) and also in cold temperate environments (e.g. Gulf of Maine and Gulf of St. Lawrence). It is an important species from a paleoceanographic perspective and it is used in conjunction with transfer functions as an indicator of sea ice. Up until now, the only information available on the ecology of the species was restricted to the cyst stage. The morphology of the cyst, in particular its apical archeopyle, suggests an affinity within the family *Protoperidiniaceae*, which is comprised of heterotrophic dinoflagellates.

We are reporting on successful excystment experiments using viable *I. minutum* cysts recovered in surface sediments from various locations in the Canadian Arctic Archipelago and northern Baffin Bay in 2004 and 2005. Surface sediment samples were sonicated and sieved through 100 and 20 µm mesh using filtered seawater. Cysts with cell content were isolated and washed in F/2-silica culture medium. The cysts were maintained at 5°C at a salinity of 32 in a Sanyo environmental chamber under a 12:12 light-dark cycle. Excystment usually took place between 4 and 7 days after isolation, although in certain cases it occurred up to 14 days after isolation. Nearly all cysts produced a single motile cell before dying, due to the lack of food, or prey. On two occasions, cell division occurred and two motile cells were produced.

The theca measures approximately ~40 µm in width, and ~47 µm in height. The cell is ovoid and has a low apical horn. The plate sutures are well defined and the plates are smooth and marked by randomly distributed pores. The first apical plate is in contact with 4 epithecal plates (*Orthoperidinium*-type). The epitheca is characterized by two 6-sided intercalary plates. The cingulum is not displaced and is marked by small lists. Most of the sulcus is located in the hypotheca, with only a small portion of it reaching into the epitheca. The left side of the sulcus is bordered by a protruding list. The plate formula is 4', 7'', ?c, ?s, 5''', 2''. The morphology, size and tabulation pattern closely resemble that of *Protoperidinium minutum*.

In the literature, some authors report on the cyst of *P. minutum* as being a spherical brown cyst covered with curved hollow spines with an intercalary archeopyle (Wall and Dale, 1968; Godhe et al., 2000, Pospelova et al., 2005). The cyst of *P. minutum* pictured in Fukuyo et al. (1977) is characterized by slender curved spines, with an intercalary archeopyle. Nehring (1994) illustrated a brown spiny cyst of *P. minutum*, but no description was provided in the text. He also provided a scanning electron micrograph of a cyst in another paper (Nehring, 1997), but the specimen illustrated differs from *I. minutum* in having less processes, different process types, and a different wall ornamentation, but there is no mention of the archeopyle type. Lan et al. (2003) also describe the cyst of *P. cf. minutum* as a brown spherical cyst ornamented with slender curved processes with an archeopyle described as a "like a long groove. Orlova et al. (2004) presented pictures of a brown cyst with curved processes, but without any description. The specimen illustrated by Persich and Garcia (2003) closely resembles that of *I. minutum*, but again, no description is provided. It is obvious there are discrepancies in the description of the cyst of *P. minutum* among authors. *Islandinium minutum*, differs from all these descriptions by its archeopyle, which corresponds to the loss of 3 apical plates (2', 3' and 4'), but also by its processes, which are always straight and not curved. It is possible that some authors may have misinterpreted the archeopyle shape of the cyst of *P. minutum* due to a lack of detailed observations, or that several motile/cyst species are involved. Although our work is still preliminary, we suggest that the motile cells produced by the excystment of *Islandinium minutum* corresponds to *Protoperidinium minutum* or a closely related species.

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## Similarities and differences in the distribution of coccolith and dinoflagellate cysts in surface sediments from the North Atlantic

Sandrine Solignac<sup>1</sup>, Anne de Vernal<sup>1</sup> & Jacques Giraudeau<sup>2</sup>

<sup>1</sup>GEOTOP-UQÀM-McGill, CP 8888, Succ. Centre-Ville, Montréal, QC, H3C 3P8, Canada

<sup>1</sup>Corresponding author: [solignac.sandrine@courrier.uqam.ca](mailto:solignac.sandrine@courrier.uqam.ca)

<sup>2</sup>Environnements et Paléoenvironnements Océaniques, UMR CNRS 5805, Université Bordeaux 1, Talence, France.

A modern coccolith assemblage database, covering the North Atlantic between 34° and 74°N and comprising 158 surface sediment samples, was established in order to study the distribution of the assemblages relative to the hydrographical parameters of the overlying water masses. Multivariate analyses conducted on these samples show that the major water masses are reflected in the modern coccolith record in the sediment. A general trend from warm to cold environments is clearly seen in the assemblages. The south-east of the study area, offshore from Portugal, is characterized by a higher species diversity and the occurrence of warm species such as *Gephyrocapsa* spp. In subpolar waters in the north-west, such as around Iceland, much fewer species are observed in the assemblages, with a distinct change of overwhelming dominance from *Emiliania huxleyi* to *Coccolithus pelagicus* as the sea-surface temperature gets colder. In addition to the sea surface temperature, which controls the greater part of the variability, coccolith assemblages respond as well to the interseasonal temperature differences and interannual temperature variability, the sea surface salinity and the depth of the mixed-layer, as exemplified by the unique assemblages from the Nova Scotia shelf (high relative abundances of *G. oceanica* and *C. leptoporus*).

Broadly similar results are obtained with multivariate analyses carried out on 338 dinoflagellate cyst assemblages from the same study area, with a gradual transition from *Lingulodinium machaerophorum*-dominated warm assemblages to *Impagidinium pallidum*-dominated cold assemblages, and distinct assemblages on the Nova Scotia shelf. However, an opposition between neritic and oceanic dinoflagellate cyst assemblages that does not appear in

coccolith assemblages highlights the slightly different ecological requirements of the two microfossil groups.

A database with the 82 sites common to both the coccolith and dinoflagellate cyst databases was then established. As for the 158-sample coccolith database, the distribution of the major coccolith assemblages observed among the 82 samples is spatially coherent and allows the identification of broad regions with similar associations of coccolith species. The same can be done based on the dinoflagellate cyst assemblages. However, due to the aforementioned ecological differences between the dinoflagellate cysts and coccoliths, the regions defined by assemblages are not entirely coherent between the two groups of microfossils and tend to overlap one another. For example, the neritic character of some dinoflagellate cyst species make it possible to differentiate the Iceland shelf samples from the open Iceland Sea samples, whereas no difference between these two regions appears in the coccolith assemblages. The overlapping coccolith/dinoflagellate cyst-defined regions thus allows a further subdivision of the study area and a finer correspondence with the overlying water masses. Such an improvement of the sediment record/water mass hydrology relationship is seen as well in the correlation coefficients between the main axes of variance and environmental parameters, as they are significantly higher than when coccolith or dinoflagellate cyst assemblages are analyzed separately.

### ***Peridinium umbonatum* – a freshwater cyst with an antapical archeopyle**

Massimiliano Tardio, Marianne Ellegaard<sup>1</sup>, Francesca Sangiorgi & Graziano Di Giuseppe

<sup>1</sup>University of Copenhagen

<sup>1</sup>Corresponding author: [me@bi.ku.dk](mailto:me@bi.ku.dk)

This paper will focus on a living dinoflagellate cyst in possession of an unusual, hypocystal (first antapical), polygonal, lightly peanut-shaped archeopyle. Almost all known archeopyles occur on the episome, being especially common on the dorsal side. This species, *Peridinium umbonatum* var. *umbonatum*, is living at present in Lake Nero di Cornisello, a low-alkalinity high mountain lake of the Adamello mountain range in the Italian Alps. The effects of pH, temperature, light and different freshwater medias on the germination and growth of *Peridinium umbonatum* var. *umbonatum* of Lake Nero di Cornisello (North-East Italian Alps) will also be discussed.

Poster

### **Surface ocean properties of the Norwegian Sea during OIS5e, based on dinoflagellate cysts and foraminiferal assemblages**

Nicolas Van Nieuwenhove<sup>1\*</sup>, Henning A. Bauch<sup>1,2</sup> & Jens Matthiessen<sup>3</sup>

<sup>1</sup> IFM-Geomar, Kiel, Germany,

\*Corresponding author: [nvannieuwenhove@ifm-geomar.de](mailto:nvannieuwenhove@ifm-geomar.de)

<sup>2</sup> Mainz Academy of Sciences, Humanities and Literature, Mainz, Germany

<sup>3</sup> Alfred Wegener Institute, Bremerhaven, Germany

The Nordic Seas are considered to be a crucial area in terms of climate-regulating processes. Although the last interglacial, Oxygen Isotope Stage 5e (OIS5e), is regarded as an analogue for Holocene climate, detailed dinoflagellate cysts studies have not been done on OIS5e from this region. Here, the well-established relation between dinoflagellate cyst assemblages and sea-surface parameters for the (sub)Arctic is applied on the last interglacial section using a sediment core from the eastern Norwegian Sea. Considering the long-term climate trend, combined data of

foraminifers, dinoflagellate cysts and iceberg-rafted debris (IRD) indicate that proper, peak interglacial conditions occurred only during the later phase of OIS5e, and only after IRD-input and, thus, surface freshening had come to an end. While dominance of *Operculodinium centrocarpum* indicates that inflow of warm North Atlantic water persisted in the area throughout this climatically optimal period, short-term fluctuations in the dinoflagellate cyst assemblages show that, oceanographically, the climatic optimum was not a period of entire stability. Moreover, like in the South-Icelandic basin (Eynaud et al., 2004), we find a relative abundance peak of *Spiniferites mirabilis* in the Norwegian Sea at the very end of the IRD-free interval. This finding denotes the occurrence of warmest surface waters during the latest phase of the last interglacial, just before the transition towards the much colder stadial OIS5d.

### **Stable oxygen isotopes of *Thoracosphaera heimii* (Dinophyceae) in relationship to temperature; a culture experiment**

Karin A.F. Zonneveld, Andreas Mackensen & Karl-Heinz Baumann

<sup>1</sup> Department of Geosciences, University of Bremen, P.O. Box 330440, D-28359 Bremen, Germany.

<sup>1</sup>Corresponding author: [zonnev@uni-bremen.de](mailto:zonnev@uni-bremen.de)

To establish a relationship between temperature and the stable oxygen isotopic composition ( $\delta^{18}\text{O}$ ) of vegetative cysts of the photosynthetic calcareous dinoflagellate cyst *Thoracosphaera heimii*, two unicellular cultures of *T. heimii* have been cultured under different temperatures by using a temperature gradient box.

There is a clear relationship between temperature variance and the isotopic composition of *T. heimii* cysts according to the relationship:  $T (^{\circ}\text{C}) = -6.827 (\delta^{18}\text{O}_c - \delta^{18}\text{O}_w) - 3.906$  ( $R = 0.921$ ), with  $c$  = calcite and  $w$  = water.

Within this study we are the first to discuss the possible vital effects that might cause an offset between the temperature – isotope relationship found for *T. heimii* calcite and that of equilibrium inorganic calcite precipitation. No indication for strong kinetic effects as result of fast calcite precipitation can be found. We observed a positive relationship between  $\delta^{18}\text{O}_c - \delta^{18}\text{O}_w$  and ambient mediumwater pH. We speculate that this might be the result of the presence of external carbonate anhydrase, which is common in photosynthetic dinoflagellates. The efficiency of this enzyme increases rapidly between pH 7.5 to 9, which could result in an increase in  $\text{CO}_2$  uptake relative to  $\text{HCO}_3^-$  with increasing pH. We furthermore discuss the possibility of *T. heimii*

υσινγ ρεσπιρατιπε χαρβον ασ λεαστ ασ παρτ οφ ιτσ χαρβον σουρχε φορ χαλχιτε πρεχιπιτατιον, ω ηιχη χαν βε βασεδ ον τηε λιγητ παλυεσ οφ  $\delta^{18}\text{O}_c - \delta^{18}\text{O}_w$  and  $\delta^{13}\text{C}_c - \delta^{13}\text{C}_w$  found in this and previous studies on the isotopic composition of calcareous dinoflagellates.

The results of this study as well as the broad geographic distribution of *T. heimii*, its stable position within the water column, its presence in the geological record since the Late Cretaceous and its resistance against dissolution compared to other plankton groups underlines the potential for a wide usability of the oxygen isotope composition of *T. heimii* as palaeotemperature proxy for the deeper parts of the photic zone.