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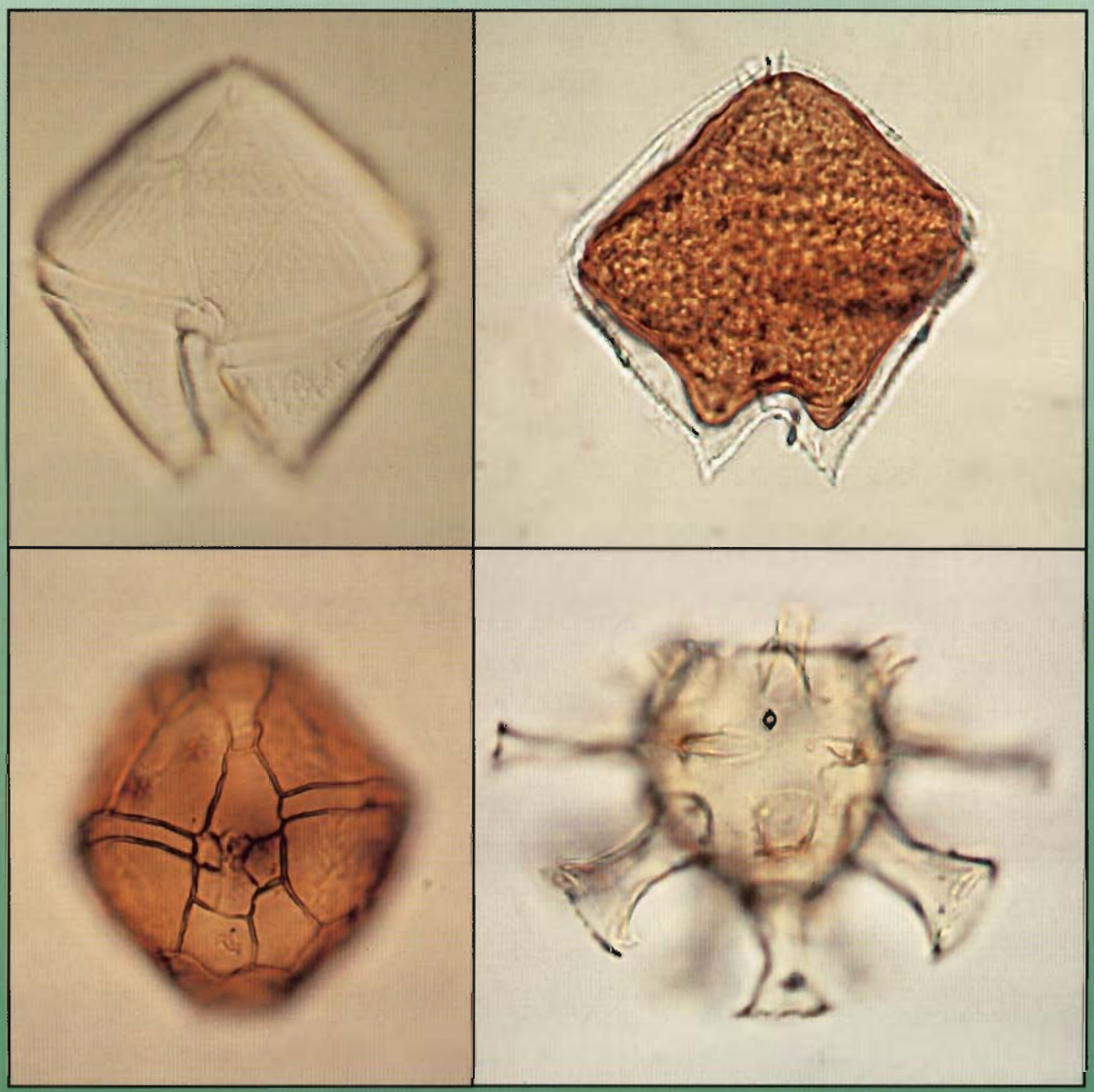
Abstracts from the Sixth International Conference on Modern and Fossil Dinoflagellates Dino 6, Trondheim, June 1998

Edited by Morten Smelror



Trondheim

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Eksempler:

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Illustrasjoner

Figurer (i form av fotografier, tegninger osv.) leveres separat, på egne ark, dvs. de skal ikke inkluderes eller monteres i brødteksten. Det skal henvises til dem i teksten som "fig. 1" osv., og på papirutskriften av manuskriptet skal det i venstre marg angis hvor i teksten figurene ønskes plassert. Strekfigurer, kartutsnitt o.l. figurer skal være trykkeferdige fra forfatterens hånd. Skal rapporten inneholde fargebilder, bør originale lysbilder (dias) leveres med manuskriptet.

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Forsidebilder

Protoperidinium obtusum
resent, California

Protoperidinium obtusum
resent, California

Leptodinium mirabile
Øvre Jura, Alaska

Hystrichosphaeridium tubiferum
Øvre Kritt, Montana

(Foto: William R. Evitt)

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Abstracts from the Sixth International Conference on Modern and Fossil Dinoflagellates Dino 6, Trondheim, June 1998

Edited by Morten Smelror

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Contents

Addition (due to late delivery):

Preface

The present volume contains abstracts of the presentations given at the **"Sixth International Conference on Modern and Fossil Dinoflagellates"** in Trondheim, 7-12 June 1998. The first conference in this series was initiated back in 1978, when William R. Evitt proposed that the Geological Survey of America might devote one of its Penrose Conferences to fossil and living dinoflagellates (Sarjeant 1998). During the 20 years after the first meeting was arranged in Colorado Springs in April 1978, the Dino-Conferences have visited Tübringen (Germany) in 1981, London (UK) in 1985, Woods Hole, Massachusetts (US) in 1989, Zeist (The Netherlands) in 1993, before ending up in Trondheim in the 20th year jubilee.

During the previous meeting in Zeist 1993, it was decided that Dino 6 should be held in Aberystwyth, Wales (UK) in 1997. However, in 1995 Bruce A. Tocher, the principle host of the planned Dino 6 conference moved to Trondheim, and since the University of Wales, Aberystwyth, was facing a downsizing (and finally termination) of the dinoflagellate research activities, Bruce proposed to bring Dino 6 to Trondheim. During an informal lunch meeting at the 7th IPC in Houston, June 1996, a group dinocysts workers, namely Robert A. Fensome, Sarah P. Damassa, Jane Lewis, Bruce A. Tocher and Morten Smelror, agreed to this change and to reschedule the conference for the summer of 1998. During the winter 96/97 Bruce left Trondheim (for a new career in Statoil, Stavanger) leaving the Dino 6 responsibility to the current committee.

Trondheim has a more than 235 year long tradition in marine biological research, dating back to the days when bishop Gunnerius of Nidaros spent his days exploring the flora and fauna of the fjord on expense of his ecclesiastical duties. Today Trondheim is a national centre for marine science and technology, and the present organising committee of Dino 6 was naturally established by joining forces from four different central research institutions in the city as follows:

Kari Grøsfjeld	Geological Survey of Norway (NGU)
Eric Monteil	IKU Petroleum Research (IKU Sintef Group)
Egil Sakshaug	NTNU Museum of Natural History and Archaeology, TBS
Morten Smelror	NTNU Museum of Natural History and Archaeology
Karl Tangen	Oceanographic Company of Norway (Oceanor)

The main objective of the **Conferences on Modern and Fossil Dinoflagellates** is to bring together scientists with various backgrounds, but related research interests in studies of dinoflagellates, in order to enhance the exchange of knowledge and experience between them. Focus is put on themes of interest to both biologists and geologists (evolution/systematics; productivity, ecology and distribution in recent and ancient seas etc.), but as seen from the contents of the present abstracts, the wide diversity of dinoflagellate research is also well taken care of. The slogan of the previous meeting at Zeist was "Dino 5 - Is Alive! " No doupt the baby born 1978 is still alive, it has aslo been gaining som considerable weight since 1993. The Dino 5 conference was attended by some 120 participants, and 26 oral contributions and 45 posters were presented (Zonneveld & Versteegh 1994). As at today around 190 participants have registered for Dino 6, and the present volume contains the abstracts of 101 announced oral and 65 announced poster presentations. Dino 5 proved to be alive - Dino 6 is definitely alive and kicking!

The Dino 6 organising committee owe special thanks to several colleagues for taking responsibilities av co-convenors of special sessions and organisers of the two workshops connected to the conference. These are:

Robert A. Fensome	G.S.C., Bedford Institute of Oceanography
J.F.R. (Max) Taylor	University of British Columbia, Vancover

who are convenors and principle chairmen of the session on **"Dinoflagellate evolution and systematics"**,

Martin Head	University of Toronto
Niels E. Poulsen	GEUS, Copenhagen
Anne de Vernal	University of Quebec and Montreal

who will organise and chair the **"Workshop on Neogene and Quaternary dinoflagellates"**, and

Helmut Willems	University of Bremen
Dorothea Janofske	University of Bremen
Karin A.F. Zonneveld	University of Bremen

who will organise and hold the workshop/short course on **"Calcareous dinoflagellates"**.

Financial support for the conference was kindly provided by the Norwegian Research Council, Amerada Hess Norge A/S, Amoco Norway Oil Company, A/S Norske Shell, Norsk Hydro Produksjon a.s., Phillips Petroleum Company Norway, Saga Petroleum ASA and Statoil a.s. Leica Mikroskopi AS kindly lent out microscopes for use during the conference workshops. We would also like to thank the city of Trondheim for giving the official conference reception. A special thank is due to Inger Marie Growen for compiling the present abstract-volume. Finally we wish to thank the participants of Dino 6, trusting that you will all actively contribute to make this a scientifically stimulating, valuable and memorable conference.

Kari Grøsfjeld Eric Monteil Egil Sakshaug Karl Tangen Morten Smelror

Trondheim 25.05.1998

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Zonneveld, K.A.F. & Versteegh, G.J.M. 1994. Dino 5 - 5th International Conference on Modern and Fossil Dinoflagellates. - Rev. Palaeobot. Palynol. (Special Issue) 84: 1-199.

High resolution reservoir subdivision based on palyno-ecostratigraphy of Upper Jurassic paralic deposits from the Dutch Central Graben

Abbink, O.A., Oosting, A.M. & Brinkhuis, H. 1998. High resolution reservoir subdivision based on palyno-ecostratigraphy of Upper Jurassic paralic deposits from the Dutch Central Graben. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 11.

Oscar A. Abbink, Anja M. Oosting and Henk Brinkhuis
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The high resolution, subseismic subdivision (metre to tenths of metre scale) of reservoir sediments is one of the key-factors in understanding a hydrocarbon play. However, this subdivision is often below biostratigraphical resolution, in particular, if paralic conditions prevailed during deposition.

The Callovian - Oxfordian (Upper Jurassic) paralic deposits from the Central Graben, offshore The Netherlands, form an important economic target for hydrocarbon exploration. Samples of three wells penetrating these deposits were studied for their palynological content. The terrestrial component of the palynological associations is abundant, while the marine component is low to absent.

«Standard» palynostratigraphical techniques provide an age-breakdown on substage level. In order to achieve a higher stratigraphical resolution, the palaeo-ecological characteristics of the encountered palynomorph groups and species are used. Changes between palynomorph groups show that the variations between the terrestrial and the marine elements are useful on subseismic scale. These variations are suggested to represent sea-level changes. Variations in palaeovegetation patterns are reflected by changes in the quantitative distribution of the (palaeo-) ecological-based sporomorph categories, "sporomorph ecogroups " (SEGs). Variations between the SEGs are thought to reflect sea-level changes in non-marine settings. Variations in both the relative abundances and the species diversity of the dinoflagellate cysts assemblages provide 1) recognition of specific floodings and 2) characteristics of the depositional environment of the flooding within the paralic settings.

This study, along with other geological information show that sea-level changes are the most important cause for changes in palaeo-environment on this subseismic scale. Sea-level changes are considered isochronous and may be correlated to existing standard curves. Therefore, the subdivision of the studied sections into sea-level induced depositional sequences which can be recognized palynologically provides required framework for hydrocarbon geology. In addition, the recorded differences in depositional environment allow for the recognition of differences in reservoir architecture in the recognized units.

Modern dinoflagellate cyst assemblages in recent marine environments of the Western Indian Ocean

Abidi, N. 1998. Modern dinoflagellate cyst assemblages in recent marine environments of the Western Indian Ocean. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 12.

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Dinoflagellate cyst analyses are carried out on 96 recent sediment samples from the Western Indian Ocean (25°N - 45°S / 35° - 80°E). Thirty-four taxa have been identified. Dinoflagellate cyst concentrations and assemblages show a great spatial variability. Their distribution is probably controlled by the surface water nutrients content (phosphate and nitrate) and preservation. Statistical and empirical analyses, allowed to differentiate clearly four dinocysts or group of dinocysts which correspond to different oceanographic environments: *Nematosphaeropsis labyrinthus* characterise the oceanic upwelling domain, when it is predominant. *Spiniferites ramosus* indicates the eutrophic zones where the influence of upwelling is attenuated. *Impagidinium*, particularly *Impagidinium aculeatum* reflects oligotrophic conditions and more oxygenated bottom water. An equivalent proportion of these taxa, characterise a mesotrophic environment. The good correlation between the dinocyst concentrations in the bottom sediments, and motile dinoflagellates lead to consider dinoflagellate cysts as excellent indicators for superficial water paleoproductivity.

Organic-walled Protoperidinioid cysts as a proxy for productivity in the Northern Arabian Sea

Ammerlaan, C.A.F., Huiskamp, F.P., van den Bos, G., Brinkhuis, H., Reichart, G.J. & Zachariasse, W.J. 1998. Organic-walled Protoperidinioid cysts as a proxy for productivity in the Northern Arabian Sea. - NTNU Vitensk. mus. Rapp. bot. Ser. 1998-1: 12-13.

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The organic walled dinoflagellate cyst content in piston core NIOP 478 from the north-eastern Arabian Sea (off the Pakistan coast) was studied in order to gain insight in productivity variations and monsoon intensity during the Late Pleistocene and Holocene.

The most striking feature in the Arabian Sea region are the yearly reversing winds, the NE-winter and the SW-summer monsoon. During the SW-monsoon, coastal upwelling occurs along the Somali and Oman coast, and oceanic upwelling occurs in the central Arabian Sea. No coastal upwelling takes place during the NE-monsoon, although along the Pakistan coast the surface waters are still relatively nutrient-rich. At depths between 150-1200 m an Oxygen Minimum Zone (OMZ) extends over most of the

Arabian Sea. The rapid decline of oxygen with depth is related to poor ventilation and high productivity in the surface waters. (Zonneveld 1996).

Core NIOP 478 is taken within the OMZ and as a result preservation of organic matter is excellent. Most Protoperidinioids are heterotrophic and usually predate on diatoms. This, and a positive correlation of Protoperidinioid cyst-concentrations with the Total Organic Carbon (TOC) suggests that Protoperidinioid cyst concentrations are a good proxy for primary production. The dinoflagellate cyst assemblage in a large part of the studied interval is dominated by high percentages of Protoperidinioid cysts, which indicates that primary production was generally high throughout the studied interval.

At the end of the last Glacial, strong fluctuations occur in both TOC and Protoperidinioid cyst concentrations. These fluctuations appear to occur throughout the Arabian Basin as these fluctuations are found in various cores throughout the basin (Reichart 1997). Dinoflagellate cysts which are sensitive to different monsoon regimes indicate that the SW-monsoon intensity was relatively low in this period (Zonneveld 1996).

From ~20.5 until ~15.1 ky CalBP cysts derived from oligotrophic dinoflagellates (e.g. *Impagidinium* spp.) occur in the cyst assemblage, while the Protoperidinioids are relatively scarce. This indicates a lowered primary production, which is confirmed by the TOC in this part of the core. The NE-monsoon dinoflagellate cyst-group indicates that the NE-monsoon intensity was high in comparison to the SW-monsoon during this interval.

At approximately ~15 Cal ky BP an increase in the TOC and the concentration of the SW-monsoon cyst group occurs. Initially only the concentration of *Spiniferites* spp. increases, from ~13.6 ky CalBP an increase in the concentration of *Protoperidinium* spp. occurs which is interrupted between ~12.5 ky CalBP and ~11.6 ky CalBP when the importance of the SW-monsoon decreases and NE-monsoon-indicating dinoflagellate cysts become more abundant. This period correlates with the occurrence of the Younger Dryas when weak SW-monsoon intensity is reported from various records (Zonneveld 1996). Protoperidinioid cyst numbers indicate a further increase in production after 11 ky CalBP. Meanwhile, the TOC-record indicates constant organic carbon levels with low SW-monsoon intensity.

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Toxic and potentially toxic dinoflagellates from the Mexican Caribbean Sea

Almazán Becerril, A. &. Hernández-Becerril, D.U. 1998. Toxic and potentially toxic dinoflagellates from the Mexican Caribbean Sea. - NTNU Vitensk. mus. Rapp. bot. Ser. 1998-1: 14.

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Some species of the dinoflagellate genera *Dinophysis* and *Prorocentrum* can produce powerful toxins that affect human health by consumtion of poisoned shellfish (Diarrhetic Shellfish Poisoning, DSP), whereas *Gambierdiscus toxicus* has been associated with Ciguatera fishfood poisoning, in tropical areas. In the Mexican Caribbean, there is no taxonomic study of phytoplankton and benthic microalgae. Material recently collected from various points along the coasts of the Mexican Caribbean: plankton by net (54 µm), sediment and epiphytes from large macroalgae and other plants, was used to study the toxic, potentially toxic and associated dinoflagellates. We recorded the presence of the toxic species *Coolia monotis*, *Dinophysis hastata, D. rotundata, D. sacculus, Gambierdiscus toxicus, Prorocentrum lima,* and *P. mexicanum*, plus other associated species: *Prorocentrum hoffmanianum* and *Pyrodinium bahamense* var. *bahamense*. Some of these species are planktonic forms: *Dinophysis* spp. and *P. bahamense* var. *bahamense*, whereas other are benthic and epiphyte forms: *C. monotis, G. toxicus, P. lima* and *P. hoffmanianum*, all distributed in shallow coastal areas and coastal lagoons. Most of the species have been studied by light and scanning electron microscopy. No cases of Ciguatera or DSP have been properly documented in detail in this region, although unofficial reports point to several cases of Ciguatera by consumption of fish.

Palaeoceanographical changes in the northwest North Atlantic since ca. 20 ka based on dinocyst assemblages

Bertini, A., de Vernal, A., Hillaire-Marcel, C. & Bilodeau, G. 1998. Palaeoceanographical changes in the northwest North Atlantic since ca. 20 ka based on dinocyst assemblages. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 14-15.

Adele Bertini, Anne de Vernal, Claude Hillaire-Marcel & Guy Bilodeau
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Late Glacial and Holocene sediments of the northwest North Atlantic core MD 95 - 2033 collected on the slope south of Newfoundland - Canada (44°39.87 N - 55°37.21 W, water depth = 1412 m; length = 29.68 m) have been examined for their palynomorph con-tent. Dinoflagellate cyst assemblages allow to recognize two regional ecozones which have been previously described on a regional scale (de Vernal et al. 1993): ecozone I (Late-Glacial, > 10 Ka), characterized by dominant *Brigantedinium* spp., and ecozone II (Holocene, < 10 Ka), characterized by the dominance of *Operculodinium centrocar-pum*, and by the significant occurrence of *Spiniferites elongatus*, *Bitectatodinium tepikiense* and *Alexandrium excavatum*. The use of transfer functions based

on the best analogue method led to reconstruct changes in sea-surface conditions including the tem-perature in February and August, the salinity in August, and the seasonal extent of sea-ice cover. On the whole, the Late Glacial was marked by temperature in August ranging 4 to 9 °C, and by freezing winter conditions with extensive sea-ice cover spanning 2-4 months/year, and up to 8 months/year during a particularly cold phase. Throughout the late glacial, the salinity was particularly low, ranging 25 to 30 psu. The Late Glacial-Postglacial transition which occurred regionally at about 10 000 years B.P., is marked by a sharp increase of sea-surface salinity (from 25 to 32 psu) and temperatures in August (up to 18 °C) and February (up to 6 °C). The base of the Postglacial is characterized by a maximum occurrence peak of *Alexandrium excavatum*. This episode corresponds to the establishment of optimum temperature in August. Throughout the Holocene, there are fluctuations in the percentages of *Bitectatodinium tepikiense*, *Operculodi-nium centrocarpum* and *Peridinium faeroense*, in addition to a decreasing trend of *Alexandrium excavatum*. The assemblages permit to reconstruct a trend of decreasing temperature and increasing salinity from the lower part of the Holocene to recent. Beyond this trend, the reconstructions indicate large amplitude fluctuations of temperature (5 °C) and salinity (2 psu), suggesting that major climatic and/or hydrographic changes may have occurred during the Holocene, at least on a regional scale.

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Biostratigraphic and palaeoecological significance of *Galeacysta etrusca* in the "lago-mare" facies from the Mediterranean area (Neogene)

Bertini, A. & Corradini, D. 1998. Biostratigraphic and palaeoecological significance of *Galeacysta etrusca* in the "lago-mare" facies from the Mediterranean area (Neogene). - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 15-16.

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In the Mediterranean area, evaporitic conditions of the so-called "salinity crisis" (Messinian) were followed by a freshwater to brackish episode known as "lago-mare". Palynological analyses carried out in the sediments of the "lago-mare" facies collected in Italy, have pointed out the occurrence of peculiar dinocyst assemblages characterized by the occurrence of *Galeacysta etrusca*. The latter had a widespread geographic distribution as testified by its occurrence in deposits from Northern (Torre Sterpi, Piedmont), Central (Cava Serredi, Tuscany; Maccarone, Marche) and Southern Italy (Eraclea Minoa, Sicily). However, it had a very short stratigraphical distribution, restricted to the upper part of the Messinian.

In the "lago-mare" assemblages, *Galeacysta etrusca* usually occurs in large abundance. It

is often associated with a "pitted" *Impagidinium*. Specimens of *Galeacysta* show large morphological variations with respect to the ornamentation, which probably relate to variations in environmental conditions. The co-occurrence of different species is possible, but should be demonstrated.

Taxa with morphologies similar to *Galeacysta etrusca* were reported in the Pannonian sediments of the Paratethys. This led to the question of the origin of the species in the "lago-mare" facies, which might be related to migration from the Paratethys.

A comparison between the Paratethyan and the Mediterranean taxa with respect to their respective morphologies, geographic and stratigraphic distribution offers the opportunity to unravel dispersal events and phylogenetic relationships between the different forms of *Galeacysta* as recorded in the two basins.

Preliminary palynological study (with emphasis on dinoflagellate cysts) on a composite Barremian-Aptian section near Kremenki (Russian Platform)

Biagianti, F., Leereveld, H., Baraboschkin, E.J. & Coccioni, R. 1998. Preliminary palynological study (with emphasis on dinoflagellate cysts) on a composite Barremian-Aptian section near Kremenki (Russian Platform). - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 16-17.

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A few years ago well exposed and nearly continuous Aptian sections were discovered on the Russian Platform, along the Volga River between the cities of Uljanovsk and Saratov. The lithological succession is principally composed of black clays, silty clays and oil shales with siderite, phosphorite and carbonate concrections. In the lower part of the succession (at the base of the *Deshayesites deshayesi* ammonite Zone) an interval (5 m) of laminated black shales with huge carbonate concretions is present. This interval may be considered to be a local equivalent of Oceanic Anoxic Event IA, which is recognised on a global scale. Lately a possible analogue of magnetostratigraphic Chron M0 is recognised in the biostratigraphically determined Barremian/Aptian boundary interval. Although the ammonite and belemnite biostratigraphy has been thoroughly investigated the exact position of the Barremian/Aptain boundary is still problematic, i.e. in the interval between the last occurrence of the Upper Barremian belemnite *Oxytheuthis lahuseni*, and the first occurrence of the Aptian ammonite *Deshayesites forbesi*.

In the present study the potential of dino-

flagellate cyst stratigraphy is explored in refining the position of the B/A boundary in a composite section near the village of Kremenki (between Uljanovsk and Saratov). Furthermore information is provided on the nature of the palaeoenvironmental changes leading to anoxic conditions on the Russian Platform during the Early Aptian.

Galeacysta etrusca, a late Messinian "immigrant" from Paratethys to the Po Valley

Biffi, U. 1998. Galeacysta etrusca, a late Messinian "immigrant" from Paratethys to the Po Valley. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 17.

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An extensive palynological study has been carried out on the Messinian sediments from the Po Valley subsurface (bottom cores of 95 wells). The pre- and post-evaporitic sequences have been palynologically characterized and a palynozonation has been proposed, based on the *Galeacysta etrusca* Corradini and Biffi, 1988 "suite" occurrence. These assemblages, firstly described in the "lago-mare" sediments, are strictly controlled by the paleoenvironment. Preliminary remarks are proposed, basing on the comparison with the Ostracoda data from the same sequences and on the sedimentological evolution of the basin during the Messinian. The immigration from the Paratethys is discussed in terms of timing, water paths and paleoecological conditions of the Mediterranean in the post-evaporitic Messinian.

Marine and terrestrial palaeoenvironmental change in the eastern North Atlantic connected to Heinrich event 1

Boessenkool, K.P., Targarona, J., Zahn, R. & Brinkhuis, H. 1998. Marine and terrestrial palaeoenvironmental change in the eastern North Atlantic connected to Heinrich event 1. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 17-18.

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During the last glacial the Northern Hemisphere ice sheet collapsed several times; large amounts of icebergs were released into the northern North Atlantic. This is expressed in the sedimentary record as layers bearing Ice Rafted Debris (IRD), known as Heinrich events. Not only did they influence the surface water conditions throughout the North Atlantic, but they also had a large climatic impact on the surrounding continents. Through atmospheric and oceanic heat transport patterns, the largest impact is expected to have acted on the climate of regions downwind the North Atlantic: Europe and

NW Africa. For a better understanding of the impact of Heinrich events on the climate of these regions, high-resolution comparison is needed of records of palaeoceanographic conditions and of the climate on land at the time of their deposition, which is often hampered by dating problems.

In this study, a core from offshore south Portugal (SO75-6kl) is used to investigate the impact of the last Heinrich event (H1; 12-15 ka BP) on the climate of Iberia. It records IRD attributed to H1 between 14.3-13.5 ka BP. Dating problems are avoided by a combined study of dinoflagellate cyst assemblages, and of pollen and spores from the same samples. The latter group of fossils reflects the vegetation present on land, providing information on climate variables like temperature and precipitation, and on wind or water transport. The dinoflagellate cyst record is used to reconstruct surface water mass properties, such as Sea Surface Temperature and productivity. For the reconstruction of SSTs, many dinocyst-proxy records have previously been proposed (Edwards 1990 Targarona 1997). Here, some of these are discussed and compared to other palaeo-SST proxy data, such as oxygen isotope records.

The data of SO75-6kl are compared to the palynological records of a core from the Alboran Sea (W Mediterranean, Targarona 1997). Both dinocyst records indicate an onset of sea surface cooling earlier than the presence of IRD offshore Portugal. Productivity patterns are different in both cores due to different oceanographic settings. Coinciding in time with the cooling related to H1 is an increase in pollen from steppe vegetation in the Alboran Sea core that indicates increased aridity.

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Micro-reticulate cysts of gymnodinoid dinoflagellates: Morphology and genetic relationships

Bolch, C.J.S., Hallegraeff, G.M. & Hardiman, S. 1998. Microreticulate cysts of gymnodinoid dinoflagellates: morphology and genetic relationships. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 18-19.

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The microreticulate resting cyst of the chain-forming toxic dinoflagellate *Gymnodinium catenatum* Graham was first described from incubated field samples collected from the Ria de Vigo, Spain (Anderson et al. 1988). Since this first description in 1988, cysts with similar or identical microreticulate markings have been reported from an increasing number of ites world-wide (Hallegraeff & Fraga 1998), including areas where the plankton cells of *G. catenatum* have not been recorded such as the Baltic Sea (Ellegaard et al. 1994), the south China coast (Qi et al. 1997) and the Victorian coast of mainland

Australia (Sonneman & Hill 1997). The reported size range of these cysts is highly variable (Fraga & Hallegraeff 1998), with some sites showing distinctly bi-modal size distributions (Bravo & Ramilo 1997) or two distinct size morphotypes (Bolch & Hallegraeff 1990, Qi et al. 1997).

Recent intensive surveys of a number of ports in southeastern Australia, using improved sodium polytungstate cyst concentration methods (Bolch 1997), have shown a widespread distribution of three distinct size morphotypes of microreticulate cysts. The largest type (43-56 µm) is present in southeastern Tasmania, Southern Victoria and Port Lincoln, South Australia, and corresponds with the toxic chain-forming species *G. catenatum*. The "small-form" (17-28 µm) is rare (usually <0.5 % of cysts present) but widespread, being found at several sites ranging from northeastern Australian ports, around the southern coast of Australia to southwestern Australia. The "intermediate-form" (36-43 µm) has so far only been recorded at one site in NSW, representing 1.4 % of the total cysts present. Germination of the "intermediate-form" cysts resulted in typical chain-forming cells similar to those of *G. catenatum*. However, germination experiments with the "small-form" cysts released small vegetative cells of a non-chain-forming Gymnodinoid dinoflagellate which is morphologically distinct from *G. catenatum*. Furthermore, germination was found to be through a sulcal oriented breach (chasmic archeopyle) rather than through a roughly cingular oriented breach as in *G. catenatum* and the "intermediate-form". Comparison of DNA sequences of the D1-D2 region of the 28S rDNA obtained from cysts and from cultured cells show that this small gymnodinoid is genetically distinct from typical toxic *G. catenatum*.

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Low salinity dinoflagellate cysts from the Baltic Sea

Brenner, W. 1998. Low salinity dinoflagellate cysts from the Baltic Sea. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 20.

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The Baltic Sea is one of the world largest brackish water bodies. Its surface salinity changes from about 20 psu in the western part to nearly freshwater in the northeast. Based on the recent distribution of cyst producing dinoflagellates, it is possible to line out a rough framework of salinity dependent occurrence of dinoflagellate cysts. Except assemblage change a markably variability in process morphology of cysts as *Operculodinium centrocarpum* or *Lingulodinium machaerophorum* can be find in the low salinity environment. Similar distributions of dinoflagellate cyst assemblages as today present horizontally in the Baltic Sea are also present vertically in the investigated sediment cores, indicating the salinity changes during the postglacial development. The succession starts with freshwater assemblage of various organic walled micro-fossils of the Ancylus-Lake-Phase about 9 000 B.P. at the base of the cores. Followed by the marine transgression of the Litorina-Sea-Phase with a rapide increase of salinity. The last 2000 years (Lymnea-Sea- and Mya-Sea-Phase) are marked by a decrease in salinity.

Astronomical forcing, timescales and dinoflagellate cysts

Brinkhuis, H., De Boer, P.L., Hilgen, F.J., Lourens, L.J., Santarelli, A., Versteegh, G.J.M. & Zachariasse, W.J. 1998. Astronomical forcing, timescales and dinoflagellate cysts. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 20-21.

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It has long been realized that many longer and shorter termed climate oscillations are ultimately controlled by astronomical forcing, most notably by the variations of the earth's orientation and orbit around the sun (Adhemar 1842, Croll 1864, Gilbert 1895, Milankovitch 1941). Now known as Milankovitch cycles, these cycles are governed by the interaction of gravitational forces in the rotating Sun-Earth-Moon system as well as by the gravitational interactions with the other planets in our Solar System invoking changes in the eccentricity, obliquity and precession of the Earth, with main periods of 400, 100, 41, 23, and 19 kyr respectively (Berger 1977). These variations are climatically important since they affect both the seasonal as well as the latitudinal distribution of solar insolation (Berger & Loutre 1993).

Since astronomical cycles influence climate and oceanography, and these in turn the sediment composition, it is not surprising that sedimentation patterns can be related to the former. Because amplitudes and phases of the main astronomical cycles of the past 12 Ma can be accurately calculated (Laskar 1990), an accurate age-assessment of sediments deposited over the last millions of years is possible if one knows which sedimentary cycle corresponds to which Milankovitch cycle. Essential to this method is (1) the availability of adequate "time control" based on e.g. magneto-, isotope- and/or biostratigraphy in order to place datum points along sequences, and (2) a long enough time span represented (in outcrop/ cores) to provide a reliable sampling of the cycles involved. Such requirements are met by Quaternary and Neogene cores and outcrops in and along the semi-enclosed, land-locked Mediterranean Sea, an area particularly sensitive to (astronomically-induced) climate change. The geochronological application of these cycles has resulted in the construction of an Astronomical Polarity Time Scale (APTS) for the Quaternary to Late Miocene (e.g. Hilgen 1991a, b, Krijgsman et al. 1995, Lourens et al. 1996). Much of this work was and is carried out within the frame of the IPPU, by a team guided by Frits Hilgen over the last decade. Utrecht palynologists played their part in the establishment of the APTS, and the analysis of phase-relationships (Versteegh 1994, Santarelli 1997) through quantitative study of high-resolution records of sporomorphs and dinoflagellate cysts.

In this presentation, the contribution of palynology and dinocyst palynology in particular, by the Utrecht group in the research field will be discussed. Attention will foremost be placed on the development and reliability of the various paleoenvironmental proxies (sea-level, run-off, SST, etc.).

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High resolution dinoflagellate analysis across the Cretaceous/ Tertiary boundary: Testing the impact model

Brinkhuis, H., Smit, J. & Fensome, R.A. 1998. High resolution dinocyst analysis across the Cretaceous/Tertiary boundary. Testing the impact model. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 21-22.

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Acid resistant, organic-walled, dinoflagellates were not pushed to extinction at or near the Cretaceous/Tertiary boundary (KTB). This aspect makes this plankton group wellsuited for high-resolution, cross-KTB paleoenvironmental analysis, including the testing of the model(s) of the global environmental consequences of the proposed KTB giant impact event.

Quantitative analysis of organic-walled dinoflagellate assemblages from closely spaced samples across the KTB at El Kef (NW Tunisia), Caravaca (SE Spain) and Stevns Klint (E Denmark) allows for reconstructions of sea surface temperature (SST) trends. The combined dinoflagellate-based SST curves indicate relatively stable warm conditions during the latest Maastrichtian in contrast to strongly fluctuating and on average cooler conditions during the earliest Danian. In detail, the results indicate cooling across the KTB, immediately followed by an interval of pronounced warming, the latter recorded in all studied sections. Two more cooling pulses may be recognized in the overlying interval followed by a gradual return to stable, relatively warm conditions. Our data furthermore show that these KTB-related climatic changes invoked distinct migration among dinoflagellates, recordable in both hemispheres.

Recent models predict periods varying between several months to 8-13 yr of global cooling ("impact winter") and reduced solar transmission as a direct result of the Chicxulub KTB impact, followed by relatively long-term, excess CO_2-related, global warming. Our results generally conform with such models, but suggest that the impact-related cooling phase may have lasted longer, and that marked climatic instability continued to some 100 000 yrs following the KTB event(s).

The sole "extinction event" among organic-walled dinoflagellates apparently associated with the KTB is the disappearance of the *Dinogymnium* group (the dinogymnioids). This suggests that (1) organic-walled, cyst-producing dinoflagellates can survive periods of environmental stress, and (2) that the KTB event(s) was (were) relatively short-lived. For many years specialists have been debating whether dinogymnioids represent a cyst-stage or a resistant motile-stage - perhaps a discarded pellicle. Our study again demonstrates that while neither extinctions nor morphological changes occur among confirmed dinoflagellate cysts, dinogymnioids disappear from the record.

Update on *Spiraulax jolliffei* (Murray et Whitting) Kofoid, *Gonyaulax fusiformis* Graham and *G. birostris* Stein

Carbonell-Moore, M.C. 1998. Update on *Spiraulax jolliffei* (Murray et Whitting) Kofoid, *Gonyaulax fusiformis* Graham and *G. birostris* Stein. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 22-23.

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Until recently, *Spiraulax jolliffei* was lumped together with some species of *Gonyaulax*. However, Carbonell-Moore (1996) showed that *Spiraulax* was a different genus than *Gonyaulax*. The separation of the two genera is based on the fact that in *Spiraulax* Kofoid the first apical plate is very short, allowing plate 1" to touch 2a. In *Gonyaulax* Diesing these two plates are separated by the first apical plate. In addition, the ventral pore found in *Gonyaulax* is not found in *Spiraulax*. *Gonyaulax fusiformis* Graham was demonstrated to be a different organism than *Spiraulax* jolliffei and also a different species than *G. birostris* Stein. The organism described by Murray & Whitting (1899) as *Gonyaulax jolliffei* was shown to be the same *Spiraulax jolliffei* based upon similarities in cell size, shape and habitat. The plate number discrepancy is considered an omis-

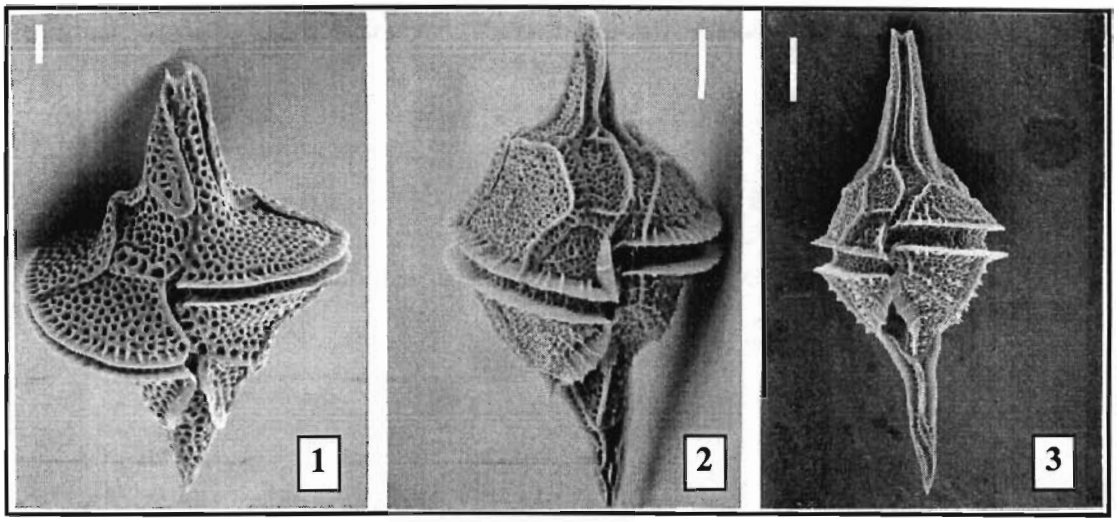

Fig. 1-3. Scanning electron photomicrographs of *Spiraulax jolliffei* (1), *Gonyaulax fusiformis* (2) and *G. birostris* (3). Scale bars : 10 μm. (From Carbonell-Moore 1996)

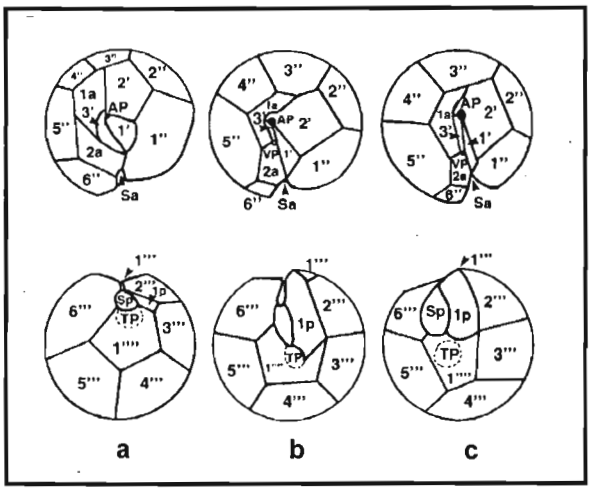

Fig. 4. Plate pattern diagrams of the species discussed here. (a) *Spiraulax jolliffei*, (b) *Gonyaulax fusiformis*. (c) *G. birostris*. (Top row: epithecas, bottom row: hypothecas) (From Carbonell-Moore 1996)

sion, a not so rare event within the literature. *Gonyaulax birostris* is maintained based upon the analysis of many thecas from different parts of the world. *Gonyaulax glyptorhyncus* (Murray et Whitting) and *G. highlei* (Murray et Whitting) are considered synomyns of *G. birostris*. The above SEM's of the three species illustrate well the differences found in the three organisms.

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Biogeography of freshwater dinoflagellate species

Carty, S. 1998. Biogeography of freshwater dinoflagellate species. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 24.

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The major compendia of freshwater dinoflagellate species (Schiller 1933-37, Kiselev 1954, Bourrelly 1970, Starmach 1974, Popovsky & Pfiester 1990) include distributions which suggest that some species are cosmopolitan and others seem to have a more restricted distribution. Extensive collecting in several American states finds that many species are widespread, more than documented in the literature, and that even rarely collected thecate species such as *Sphaerodinium fimbriatum, Thompsodinium intermedium, Durinskia baltica, Kansodinium ambiguum* and *Woloszynskia reticulata* may be more widespread than suggested by the literature. Some species, such as *Lophodinium polylophum* which is quite distinctive yet has only been reported three times, may have brief planktonic stages. The requirement that naked dinoflagellates be examined alive to make identifications may explain why few appear on regional species lists.

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Dinoflagellate cysts of the Miocene Nankang Formation in the Shuinantung section, Northeastern Taiwan

Chen, G.H. & Liew, P.M. 1998. Dinoflagellate cysts of the Miocene Nankang Formation in the Shuinantung section, Northeastern Taiwan. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 24-25.

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The samples collected from the Nakang Formation along the Shuinantung section were prepared through the palynological processes. Various pollen, spores, and aboundant well preserved dinoflagellate cysts (dinocysts) were extracted in the Kuanyinshan Member. About 35 species of 27 genus are included.

The dinocysts are dominated by diverse skolochorate cysts and the age of the assemblage indicates the age of late Middle Miocene. The assemblage of the dinocysts indicates the dinocysts were deposited in temperate climate and neritic environment. This result is in agreement with the pollen

data (Mei & Shaw 1983) and fauna data (Huang et al. 1990) of this area. The assemblage are close to that of temperate area like Southern Japan (Matsuoka 1985) and southeastern Korea (Yun 1981). The investigation on the effects of the Kuroshio current (Huang 1989) are left to be finished.

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Early Tertiary dinoflagellate cysts from New Zealand

Crouch, E.M., Brinkhuis, H., & Visscher, H. 1998. Early Tertiary dinoflagellate cysts from New Zealand. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 25-26.

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Dinoflagellate cyst studies from the Tertiary of New Zealand have predominantly been carried out by Graeme Wilson (eg. Wilson 1967, 1988). The Tertiary of Australia has also been the focus of significant dinoflagellate cyst studies, including those by Cookson & Eisenack (1967) and Stover (1973). However, Australasia remains a region that lacks extensive detailed quantitative palynological studies, and therefore offers abundant opportunities for innovative palynological research.

One such research area is the Late Paleocene-Early Eocene global warming interval, which is associated with major changes in oceanic environments, other marine biotic systems and floral diversity. Worldwide, dinoflagellate cyst assemblages were affected by this global warming interval and experienced significant assemblage variations, evolutional changes and distinctive migrational patterns. Numerous palynological studies from the Northern Hemisphere (eg. Bujak & Brinkhuis in press) have documented these variations, however equivalent detailed studies from the Australasian region have not been carried out thus far.

The study aims to document the pattern and magnitude of the dinoflagellate cyst assemblage variations from shallow marine sediments in New Zealand across the Late Paleocene-Early Eocene transition. Palynological assemblages from shallow marine deposits offer the unique possibility of a direct correlation of contemporaneous changes in marine and terrestrial biological records. Therefore, reconstructions of environmental changes that occurred in New Zealand across this interval will be achieved from examining both the dinoflagellate

(marine) and miospore (terrestrial) records.

The results obtained from New Zealand sequences will be compared with comparative studies from the Northern Hemisphere, with the aim of contributing to a global identification of causal connections between the Late Paleocene-Early Eocene environmental changes in the marine and terrestrial biospheres.

This poster presents an introduction into the diversity of Early Tertiary dinoflagellate cysts from New Zealand, along with preliminary palynological results from shallow marine sequences collected in New Zealand.

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Phylogenetic analyses of plastid 16s rRNA sequences from the dinoflagellates *Gyrodinium aureolum, Gymnodinium galatheanum* and *Gymnodinium breve* reveal that their plastids are related to haptophytes

Dahlberg, O.L., Klaveness, D., Tengs, T., Shalchian-Tabrizi, K., Rudi, K. & Jakobsen, K.S. 1998. Phylogenetic analyses of plastid 16s rRNA sequences from the dinoflagellates *Gyrodinium aureolum, Gymnodinium galatheanum* and *Gymnodinium breve* reveal that their plastids are related to haptophytes. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 26-27.

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Although plastid sequences from most major phyla are represented in rRNA databases, no sequence information has until now been reported from the dinoflagellate plastids. The three dinoflagellates *Gyrodinium aureolum, Gymnodinium galatheanum* and *Gymnodinium breve* have plastids with no evidence of nucleomorphs and possess 19-hexanoyloxy-fucoxanthin as their major carotenoid. By starting out with single cell PCR on *G. galatheanum* we have managed to obtain full length plastid ssu rRNA from *G. galatheanum, G. aureolum* and a partial sequence from *G. breve*. The dinoflagellate sequecens turn out to be quite different in sequence composition from other plastid 16S rRNA sequences. Also, the *G. galatheanum* sequence is not as closely related to those of *G. aureolum* and from *G. breve* as one could expect from 18S rRNA we have generated.

However, both parsimony analysis and several distance methods demonstrate that these dinoflagellate plastids are evolutionary related to the haptophyte plastids.

Marine dinoflagellate cysts as indicators of cultural eutrophication, industrial pollution, and short term climatic change

Dale, B. 1998. Marine dinoflagellate cysts as indicators of cultural eutrophication, industrial pollution, and short term climatic change. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 27-28.

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For many years now there has been mounting public concern over possible detrimental effects on the natural environment caused by human activities (e.g. eutrophication, industrial pollution, and climatic change as a result of the enhanced "greenhouse effect"). This concern may be expected to increase further in the coming years, as the human population increases, and the natural sciences will be challenged by the awesome task of monitoring global change. The natural environment consists of extremely complex systems that preclude the possibility of "total" environmental monitoring - there is increasing need therefore to explore the possibility of developing "state of the environment" indicators, as an alternative.

This presentation summarizes our attempts so far to explore the possibility for using marine cysts as indicators of eutrophication, industrial pollution, and short term climatic change:

1) **Cultural eutrophication** - initially one core from the inner Oslofjord covering the reported development of cultural eutrophication from the mid-1800's to the present was analysed for cysts. A eutrophication signal was described consisting of a doubling of total cyst concentration, presumed to reflect overall increased production, and a marked increase in *Lingulodinium machaerophorum* (= *Gonyaulax polyedra*) from <5 % to around 50 % of assemblages (Dale & Fjellså 1994, Dale 1996). Results from three more cores confirm this basic signal, and suggest that *G. polyedra* is a summer-blooming species that is able to exploit the extra nutrients (from sewage) that "prolong" the growth period in an otherwise nutrient limited system (Dale et al. in press). The cyst signal offers a sensitive method to assess the effects of improved sewage treatment around the inner Oslofjord.

2) **Industrial pollution** - a study of one core inside and one outside the heavilly polluted Frierfjord provided the first cyst signals of marine industrial pollution (Sætre et al. 1997). These consist of decreased total cyst concentrations, presumed to reflect decreased production of at least cyst-forming dinoflagellates, and systematic changes in assemblages with increases and subsequent decreases in pollution. These included a marked shift toward more heterotrophic species, possibly reflecting reduced light penetration in the euphotic zone, or increased production of prey for the heterotrophs. These results provide a robust model for using cysts as indicators of the effects of this type of pollution (Dale et al. 1996).

3) **Short-term climatic change** - we are studying up to 12m long cores from the inner Oslofjord, using both cysts and

pollen to help archaeologists to identify Viking age sediments. High sedimentation rates in the small inner basins are providing high resolution coverage of the past 2000 years. The cysts show assemblage shifts that clearly reflect climatic change - these include the main known warm period (the Medieval Warm Interval), and the colder Little Ice Age, but they show much more systematic variation around these than has so far been recorded. Cysts thus have a potential for providing extremely detailed records of short-term climatic change that will be important for the assessment of human influences on climate.

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Recent dinoflagellate cysts from the Portuguese coast: comparing biological and paleontologically relevant information

Dale, B., Dale, A.L., & Ferriera, A.A. 1998. Recent dinoflagellate cysts from the Portuguese coast: comparing biological and paleontologically relevant information. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 28-29.

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In 1995, a series of recent sediments (upper 1-2 cm) were collected from a variety of environments (lagoons, estuaries, harbours and bays), as the basis for a first cyst suvey along the Portuguese coast. Samples are being studied both for biological (Ferriera) and more paleontologically relevant information (Dale & Dale), allowing us to compare these different approaches and results. Samples for biological studies were prepared by wet sieving only, to avoid damage to living cysts, while those for paleontoligically relevant studies were given standard palynological treatment with HCl and HF. In both cases, cysts were analysed and counted, and results expressed as

percentage abundances of assemblages. The main objectives of the biological study included identifying which cyst-forming species are present, but with special interest for toxic species, since human poisoning related to shellfish consumption has been known in this region since 1946. More than 70 cyst types were recorded, including three groups of toxic or potentially toxic species: *Gymnodinium catenatum, Pyrodinium bahamense*, and *? Alexandrium* spp. As expected, fewer cyst types were recovered after palynological treatment, with both calcareous and agglutinated forms (e.g. *Alexandrium* spp.) removed. The assemblages from Portugal were similar to warm temperate assemblages elsewhere, confirming the ecological models being developed for comparison with paleopalynology. The cyst survey revealed the presence of some species of dinoflagellates not previously recorded in traditional plankton surveys - most notably *P. bahamense*, discovered for the first time on the eastern side of the Atlantic ocean.

Current thinking: Biogeography of North Atlantic Paleogene dinoflagellates

Damassa, S.P. & Williams, G.L. 1998. Current thinking: Biogeography of North Atlantic Paleogene dinoflagellates. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 29-30.

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The distribution of modern marine dinoflagellates is influenced by variables such as latitude, surface currents, and water mass characteristics (e.g. temperature and salinity). Fossil dinoflagellates presumably were subject to the same controls; however, one undeniable complication is that fossil assemblages are represented only by the encysted stage. The North Atlantic Ocean is an ideal setting in which to study large-scale (as opposed to local or regional) variations in fossil dinoflagellate distribution and to assess some of these controls. Consequently, we have evaluated assemblages from over four hundred samples from eighteen Deep Sea Drilling Project (DSDP) cores of Eocene-Oligocene age at various latitudes, on both the western and eastern margins of the North Atlantic. Limited stratigraphic control, based on planktonic foraminifera and calcareous nannoplankton data, restricts us to dividing the Eocene-Oligocene into five time intervals, as follows: Ypresian (NP 12-13), Lutetian-Bartonian (NP 15-17), Priabonian (NP 18-20), Rupelian (NP 21-23), Chattian (NP 24-25).

Within the DSDP data set, species distributions have been assessed both stratigraphically and geographically. For example, species restricted to high latitude localities during the Priabonian include *Phthanoperidinium geminatum, Svalbardella cooksoniae,* and a species of *Lentinia;* species restricted to low latitude localities during the same interval include *Hemiplacophora semilunifera* and *Homotryblium plectilum.* High latitude Chattian species include *Chaenosphaerula magnifica, Thalassiphora reticulata,* and an undescribed species of *Palaeocystodinium,* while low latitude Chattian taxa include *Cerebrocysta mediterranea, Heteraulacacysta campanula,* and a species of *Impagidinium.* The well-

known species, *Deflandrea phosphoritica,* has a "cosmo-North" Atlantic distribution throughout the Eocene-Oligocene interval, but seems to reach its maximum geographic extent during the Priabonian.

Paleogene marine sediments in the North Atlantic region sensu lato are not restricted to the present coastline of the North Atlantic Ocean; such sequences also occur in both western Europe and eastern North America. To develop a more comprehensive model of dinoflagellate distribution patterns for the Eocene-Oligocene, we have merged our DSDP data with that of on-shore marine sections reported in the literature and indexed by PALYNODATA (compiled by a consortium of several oil companies and the Geological Survey of Canada). We have compiled a biogeographic atlas for some sixty-five species. Results confirm both the provinciality and sensitivity to oceanic parameters of many Eocene-Oligocene dinoflagellates, even though they represent the encysted, rather than motile, stage of these organisms.

Organic-walled dinoflagellate cysts as tracers of sea-surface temperature, salinity and seasonality in high latitude marine environments

De Vernal, A., Turon, J.-L., Rochon, A., Matthiessen, J. & Kunz-Pirrung, M. 1998. Organic-walled dinoflagellate cysts as tracers of sea-surface temperature, salinity and seasonality in high latitude marine environments. - NTNU Vitensk. mus. Rapp. bot. Ser. 1998-1: 30-31.

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Sea-surface conditions in high latitude marine environments provide important constraints in the climate system dynamics. The temperature and salinity determine the water density, and therefore play a determinant role on the thermohaline circulation of the ocean. Moreover, the seasonal sea-ice cover controls the albedo, and thus modulate the energy budget at the earth's surface. The development of micropaleontological approaches for the reconstruction of sea-surface conditions in high latitude marine basins is therefore most relevant for paleoclimate modelling purpose. In this perspective, a collaborative project was undertaken about ten years ago with the aim to establish a reference dinoflagellate cyst data bases for middle to high latitude of the North Atlantic and adjacent neritic, polar and subpolar environments. The ultimate goal of the project was to develop transfer functions based on dinoflagellate cyst assemblages in order to estimate changes in sea-surface conditions from the

study of cored sediments. The updated data set that is now available includes close to 500 reference stations representative of a wide range of sea-surface conditions with respect to sea-ice cover (0-12 months/ year), temperature (up to 25 °C), salinity (20-36 psu) and seasonality. The analyses of the dinoflagellate cyst assemblages in surface sediment samples reveal relatively high cyst concentrations especially along the continental margins (up to $10^5/cm^3$). The distribution pattern of species and assemblages show close relations with the salinity, the temperature of the warmest and coldest months, and the seasonal duration of the sea-ice cover. Such parameters no doubt exert an important role on the populations inamuch they modulate the life cycle and dormancy period of dinoflagellates. On these grounds, transfer functions using the best analogue method were developed. They permit to reconstruct the following parameters with a reasonable degree of accuracy, i.e. within the range of interanual variation: temperature in February (± 1.2 °C) and August (± 1.6 °C), salinity (± 0.7 psu), sea-ice cover extent (± 1.1 months/year)

The transfer functions based on dinoflagellate cysts are original as compared to other ones, notably to those using planktonic foraminifera. (1) They permit reconstructions in the polar bioclimatic domain north of the 6 °C summer isotherm where planktonic foraminifera are characterized by quasi-monospecific assemblage dominated by *Neogloboquadrina pachyderma* left-coiling. (2) Unlike planktonic foraminifera that exclusively occupy the open ocean domain, dinoflagellates occur in a wide range of salinity and thus constitute tracer of both temperature and salinity in estuarine to oceanic environments. (3) The organic-walled dinoflagellate cysts are well preserved in sediment, in contrary to siliceous or carbonate microfossil that can be affected by dissolution. (4) Dinoflagellate cysts mainly relate to a primary productivity and therefore reflect the conditions in the photic zone, which is not necessarily the case for planktonic foraminifera that are heterotrophic and often inhabit mesopelagic layers.

On the basis of dinoflagellate cyst assemblages, new paleoceanographical data sets are now available. As an example, we performed reconstructions of sea-surface conditions during the last glacial maximum at the scale of the northern North Atlantic (cf. de Vernal et al., EOS, AGU Fall meeting 1997), which yields some constraints for paleoclimate model experiments. As another example, records from circum-Arctic regions illustrate that warmer than present sea-surface conditions prevailed during a mid-Holocene interval and that high frequency oscillations of temperatures occurred at least on regional scales during the Postglacial.

Dinocyst assemblages in surface sediment and nutrient (NO_3, PO_4 and SiO_2) distribution in upper water masses from the northern North Atlantic

Devillers, R. & de Vernal, A. 1998. Dinocyst assemblages in surface sediment and nutrient (NO_3, PO_4 and SiO_2) distribution in upper water masses from the northern North Atlantic. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 32.

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In order to examine the relationships between the nutrients within surface waters and the distribution of organic walled dinoflagellate cyst assemblages, we have developed a data base including about 200 stations from diverse locations of the northern North Atlantic and adjacent basins (Baffin Bay, Gulf and Estuary of St. Lawrence, North Sea, Norwegian-Greenland Sea). Nutrient data were compiled from the World Ocean Atlas NODC data set (1994 CD-Rom version). They include the concentrations of silicate, phosphate and nitrate, in February and August, within the surface water layer. Dinoflagellate cyst data from the surface sediment samples include the percentages of 27 taxa (cf. data archived at GEOTOP).

Principal component analyses were performed on the dinocyst data set, showing an opposition between the dominant Peridinioid (*Brigantedinium* spp., *Algidasphaeridium minutum*, *Peridinium faeroense*, *Selenopemphix quanta*) and most Gonyaulacales. Correlation analysis between the nutrient parameters and the principal components reveals that significant relation links the dinocyst assemblages and the nitrate and phosphate concentrations, especially in February, whereas there is no relation with silicate concentration. The higher nutrient concentrations correspond to assemblages dominated by Gonyaulacales.

Canonical correlation analysis was also performed. As principal components they reveal a significant relation between the overall dinocyst and nutrient assemblages.

The preliminary results summarized above tend to demonstrate relationships between the nitrate and phosphate availability and the dinoflagellate assemblages. However, such results have to be considered with caution because in our database the distribution of nutrients correlates with the sea-surface temperature and salinity, which play determinant roles on the dinocyst assemblages. Further analyses are underway in order to distinguish the respective effects of temperature, salinity and nutrients on the dinocysts assemblages.

High resolution palynological analysis across the S1-sapropel in three cores from the eastern Mediterranean

De Vries, C., Bieringa, T., Boessenkool, K.P.,Targarona, J., Brinkhuis, H., Rohling, E., De Lange, G.J. & Versteegh, G.J.M. 1998. High resolution palynological analysis across the S1-sapropel in three cores from the eastern Mediterranean. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 33.

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Recent models suggest that both the onset and termination of the formation of the S1-sapropel are diachronous across the eastern Mediterranean. In addition, it has been postulated that run-off increase is responsible for the onset of S1, while its termination may be related to temperature changes (Targarona 1997). These suggestions are based on only a few available palynological studies from cores in the Adriatic and the eastern Mediterranean. By investigating three additional cores from this area, two from the central eastern Mediterranean, viz. One from off southern Greece (UM35), and one from the Antalya basin (off western Cyprus; MD 81-LC31), in addition to one from the Karpathos Basin, in the Aegean Sea, off northeastern Crete (MD81-LC21), we aim to test this model, and to further contribute to a better understanding of S1-formation.

Using a closely spaced set of samples from both cores across the S1 interval, we have generated dinoflagellate cyst-based SST and productivity proxies, and sporomorph based run off and "summer rainfall" proxies. These are compared to available other, principally geochemical data (e.g. Van Santvoort et al., 1996), foraminifer distribution patterns and a variety of other existing data.

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Morphological and molecular data for an assessment of the taxonomy of calcareous cyst producing dinoflagellates

D'Onofrio, G., Montresor, M., Bianco, L., Busico, E. & Marino, D. 1998. Morphological and molecular data for an assessment of the taxonomy of calcareous cyst producing dinoflagellates. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 34.

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The sub-family Calciodinelloideae (family Peridiniaceae) comprises a number of extant species, many of which produce calcareous cysts with a rather wide morphological diversity. The three genera included in this subfamily, *Scrippsiella*, *Ensiculifera* and *Pentapharsodinium*, can be distinguished by the number and/or shape of their cingular plates.

With the aim of clarifying taxonomic affinities and phylogenetic relationships, we combined morphological information of both motile and resting stage with nucleotide sequence analysis of the ribosomal DNA internal transcribed spacers (ITS1 and ITS2). Fourteen different morpho-species have been examined using *Heterocapsa triquetra* (family Heterocapsaceae) as the outgroup. Molecular data confirm the monophyletic origin of the genus *Scrippsiella*. Within this clade two main clusters, each including several species, can be identified. The first one includes species which share a common morphology of the vegetative stage, but produce markedly different cysts. The second cluster comprises five morphotypes very similar for both vegetative and cyst stage mor-phology, all attributable to a "*Scrippsiella trochoidea*-complex". Species of the genera *Ensiculifera* and *Pentapharsodinium* are grouped together in another monophyletic cluster. Within the latter clade, *P. trachodium* is the first to branch out and is the common ancestor of the clade.

The coupled morphological and molecular approach supports the taxonomic value of some morphological characters, such as singular plate number that separates *Scrippsiella* from the other two genera. On the other hand, it questions the validity of other morphological characters, such as the presence of the spine on the transitional plate that separates *Ensiculifera* from *Pentapharsodinium*.

Species diversity of planktonic dinoflagellates in the NE Atlantic and North Sea

Dodge, J.D. 1998. Species diversity of planktonic dinoflaggellates in the NE Atlantic and North Sea. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1:34-35.

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Species diversity or species richness hitherto has scarcely been employed in ecological studies of dinoflagellates. Most work has concentrated on listing and enumerating the species present and noting their seasonality etc. In analysing my data on the planktonic dinoflagellates of the eastern Atlantic, from the equator to the Arctic, collected over the past 25 years, it was noted that the total numbers of species recorded through the area

showed a clear pattern as shown in Fig. 1. High species diversity was found in warmer and more oceanic waters and lower diversity in colder and also more neritic areas.

Since the numbers of celles counted in the various samples areas was quite varied a detailed study was carried out comparing the increase in species listed in relation to the number of cells examined in order to try to derive a formula which could enable different areas to be compared. In addition, a study was made of the effect on species counted of a variety of collecting and sampling methods, time scales of sampling etc. Other factors include the problems of identification, lumping of difficult species (as in the *"Diplopsalis"* group of genera) as against splitting; high magnification microscopy using SEM which reveals very small dinoflagellates but is less helpful than lower power light microscopy for the larger species.

The sea is never static and few areas are isolated by hard barriers. Consequently, unlike land plants, we can never be sure that we have an 100 % species list. In any case it is necessary to take seasonal and depth variations into account in any attempt to define the species diversity of an area. Numerous formulae have been used to express species diversity in comparable terms. And whilst

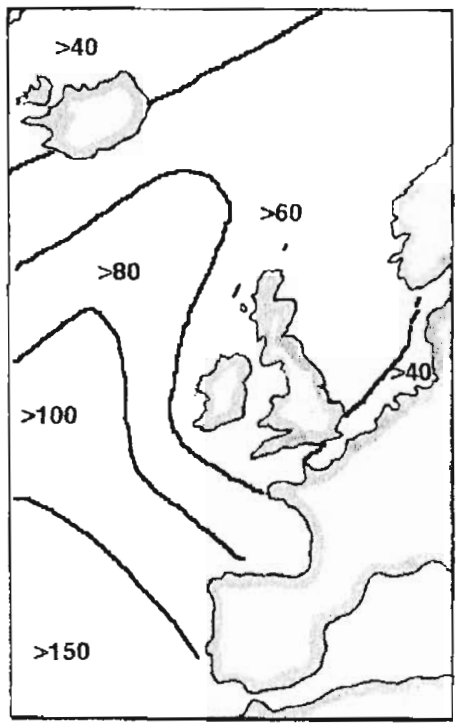

Fig. 1. The total number of species recorded in the NE Atlantic and North Sea.

these might be of value within a limited area or restricted pattern of sampling none at present available seems appropriate to the large scale of the present study.

The present results will be discussed in light of the considerations mentioned above and the potential value of these data in identifying and assessing environmental changes in the seas and oceans will be discussed.

Dinocyst assemblages from very organic-rich mudstones: Latest Jurassic - Earliest Cretaceous, the Danish Central Graben

Dybkjær, K. 1998. Dinocyst assemblages from very organic-rich mudstones: Latest Jurassic - Earliest Cretaceous, the Danish Central Graben. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 36.

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The main oil-producing source rock in the Danish Central Graben is the latest Jurassic - earliest Cretaceous Farsund Formation. The formation consists of laminated, organic-rich dark grey to black clay-stones, siltstones and thin turbiditic sand-stones. It is widely distributed in the Danish and Norwegian offshore areas, and is equivalent to the Kimmeridge Clay Formation in the UK sector of the North Sea.

Within the Farsund Formation, several "hot" intervals occur, characterized by high Gamma Ray responses. The uppermost of these intervals, displaying the most distinct gamma-response, was defined as an informal lithostratigraphic unit, called the Hot Unit (Jensen et al. 1986). The sediments constitute excellent hydrocarbon source rocks, displaying organic carbon contents in the range 3-8 %, occasionally exceeding 15 % TOC (Ineson et al. in press).

A palynological study of the type well, Bo-1, shows that the Hot Unit represents the time interval from the Late Volgian to the Early Ryazanian, largely within the Early Ryazanian *Kochi* chronozone, but with a maximum age range between the *Preplicomphalus* and the *Stenomphalus* chronozones. Palynofacies analysis shows a clear predominance among the organic particles of amorphous organic matter, dinoflagellate cysts and prasinophycean green algae (*Tasmanites*, *Cymatiosphaera* and *Pterospermella)*.

Further studies has shown that the Hot Unit is largely synchronous within the Danish Central Graben and can be correlated on a very detailed scale with the type well, 7/12-3A, for the Norwegian Mandal Formation (Vollset and Doré 1984).

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Modern and near modern dinocysts from Florida Bay

Edwards, L.E., 1998. Modern and near modern dinocysts from Florida Bay. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 37.

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Florida Bay is currently the subject of intense ecological study. This shallow bay lies south of mainland Florida between the Everglades and the Florida Keys. Numerous agencies are working to restore it to its "natural" conditions, only no one knows exactly what these conditions were. Some conditions cannot be restored: sea level has risen. Other conditions, such as natural sheet flow across the Everglades, can be restored or can be simulated. Four shallow cores, dating back less than 200 years, and 22 modern sediment samples are used to compare "then" and "now."

Preservable dinocysts in typical modern Florida Bay samples consist of about 70 percent *Spiniferites* species, 10 to 15 percent each of *Polysphaeridium zoharyi* and *Operculodinium* spp. and minor amounts of *Lingulodinium machaerophorum, Nematosphaeropsis rigida,* and *Tectatodinium pellitum.* Specimens of *Tuberculodinium vancampoae* and the *Congruentidiaceae* are extremely rare. Samples taken near an area of freshwater input near Little Madeira Bay contain higher percentages of *P. zoharyi* (25 to 40 percent), at the expense of *Spiniferites.* Absolute abundances of dinocysts are low, generally 10 to 100 cysts per gram.

Many downcore assemblages resemble either typical Florida Bay or Little Madeira Bay assemblages, but a significant number have no obvious modern analog. Downcore assemblages contain higher relative abundances of dinocysts, compared to other plant debris, than modern samples. Absolute abundances of dinocysts are higher, generally 100 to 1000 cysts per gram.

In the majority of the cores, absolute abundances of dinocysts appear to fluctuate in response to increases and decreases in sediment supply. However, in the most inshore core, absolute abundance peaks appear to represent increased production of the cysts P. zoharyi. In all cores, individual abrupt changes in relative or absolute abundances provide potentially synchronous correlation horizons.

Modern Florida Bay consists of nearly emergent mudbanks and shallow basins. The configurations of these banks and basins in the past seem to be important factors in the downcore assemblages.

Complex sedimentologic and ecological factors are at work, and the study of the dinocysts will aid in the overall understanding of the history of Florida Bay.

A review of coccoid dinoflagellates: Blastodiniales, Phytodiniales, Pyrocystales

Elbrächter, M. 1998. A review of coccoid dinoflagellates: Blastodiniales, Phytodiniales, Pyrocystales. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 38.

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Dinoflagellate genera (*Thoracosphaerales* excluded) are reviewed in which the asexual vegetative stage is dominated by a coccoid phase and in which the asexual motile stage - if present - is only a transitory stage for distribution and/or reproduction. Traditionally, these genera are grouped in three orders: Blastodiniales, Phytodiniales, Pyrocystales. The few members of the Pyrocystales apparently are a monophyletic group derived from, or even included as a family into the order Gonyaulacales.

In both the Blastodiniales and Phytodiniales there are genera, e.g., *Oodinium, Protoodinium* in the former and *Stylodinium* in the latter, in which the coccoid stage and/or the flagellated stage have an amphiesma with thecal plates. Other genera have no thecal plates in their amphiesma. The latter may have evolved from athecate ancestors. Alternatively, they may have evolved from thecate ancestors by reduction of the thecal plates. It is likely that the Blastodiniales and Phytodiniales as circumscribed now are polyphyletic taxa. The importance of the nuclear structure in defining the order Blastodiniales will be discussed.

Fine structure and flagellar apparatus of *Gymnodinium catenatum* (?) from Denmark.

Ellegard, M. & Moestrup, Ø. 1998. Fine structure and flagellar apparatus of *Gymnodinium catenatum* (?) from Denmark. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 38-39.

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Cysts conforming to the description of cysts of the toxic dinoflagellate *Gymnodinium catenatum* Graham were reported from Northern Europe in 1993 (Ellegaard et al. 1993). Further studies of cysts and the vegetative stage (established in culture from germinated cysts) (Ellegaard & Oshima, submitted; Ellegaard et al. submitted) have revealed differences between strains from Denmark and strains from Australia and Spain, where *Gymnodinium catenatum* has been known longer and has been the cause of poisoning of shellfish.

In order to aid in determining the taxonomic position of the Danish *Gymnodinium catenatum* (?) relative to *Gymnodinium catenatum* Graham, the fine structure, particularly of the flagellar apparatus, of the Danish *Gymnodinium catenatum* has been studied and compared to ongoing studies of the fine structure of *Gymnodinium catenatum* from Australia (Rees & Moestrup, personal communication).

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effects on growth of a non-chainforming strain of *Gymnodinium catenatum* (Dinophyceae) established from a cyst from recent sediments in the Sound (Øresund), Denmark. - J. Phycol. 29: 418-426.

Ellegaard, M. & Oshima, Y. (submitted) *Gymnodinium* cf. *catenatum* (Dinophyceae) in Denmark - comparisons with strains from Spain and Australia with respect to toxicity and molecular characteristics.

Ellegaard, M., Kulis, D. & Anderson, D.M. (submitted) Cysts of Danish *Gymnodinium* cf. *catenatum* (Dinophyceae): studies on encystment, excystment and toxicity.

Palynostratigraphy and palynofacies of the Upper Cretaceous sediments of SE Sirte Basin, Libya

El-Mehdawi, A.D. 1998. Palynostratigraphy and palynofacies of the Upper Cretaceous sediments of SE Sirte Basin, Libya. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 39.

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Core samples from the Upper Cretaceous sediments of SE Sirte Bassin, yielded very rich, diverse and well preserved palynological material. Sixteen environmentally and stratigraphically controlled palynomorph associations are recognised, cover the Late Cenomanian to Early Maastrichtian. Several depositional environment associated with fluctuation in relative sea-level. A major drop in sea-level during the Coniacian-Santonian is identified.

Unlike those described elsewhere, the studied pre-Campanian sediments are characterised by new peridinioid and gonyalacoid dinocyst assemblages. Campanian sediments are characterised by peridinioid dinocyst assemblages intermediate between those provinces established by Lentin & Willians, 1980 and previously undescribed taxa. This in turn would suggest a dinocyst association unique to the SE Sirte Basin.

Three new peridinioid genera and one new gonyalacoid species of dinoflagellate cysts from the Upper Cretaceous sediments of SE Sirte Basin, Libya

El-Mehdawi, A.D. 1998. Three new peridinioid genera and one new gonyalacoid species of dinoflagellate cysts from the Upper Cretaceous sediments of SE Sirte Basin, Libya. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 39-40.

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Three new peridinioid dinoflagellate cyst genera, *Jaludinium*, *Khazinidinium* and *Sirtedinium* with their respective type species *J. granulostriatum* sp. nov., *K. africanaesae* sp. nov. and *S. granulostriatum* sp. nov., and one new tabulated ceratioid species of the genus *Odontochitina* called as *O. tabulata* sp. nov. are described. These new taxa have very short stratigraphic ranges and are recorded from the Campanian, Coniacian-

Santonian and Upper Santonian-Lower Campanian sediments respectively, of the Rakb Formation subcropping in the southeast Sirte Basin, Libya.

The known diagnosis of the genus *Odontochitina* is emended.

Assemblages of calcareous and organic-walled dinoflagellate cysts of the the Late Quaternary Agulhas Current (South Atlantic) in relation to climatic change

Esper, O., Schneider, R., Zonneveld, K. & Willems, H. 1998. Assemblages of calcareous and organic-walled dinoflagellate cysts of the the Late Quaternary Agulhas Current (South Atlantic) in relation to climatic change. - NTNU Vitensk.mus. Rapp. bot. Ser.1998-1: 40.

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As it has become more and more apparent that atmospheric patterns and ocean circulations are not independent systems but are linked together through complex interactions at the ocean surface, it is possible to give statements about changes in global climate by analysing the variations of ocean current systems. One of the most important systems for the northern hemisphere is the so-called thermohaline circulation of the Atlantic Ocean, which is responsible for the heat transport from the southern hemisphere to the North Atlantic. To reconstruct this system for the Late Quaternary with its glacial/interglacial cycles, and to understand the fluctuations in the heat flux, it is neccesary to look at several key areas, such as the region of the Agulhas Current in the eastern South Atlantic, where warm Indian Ocean water enters the South Atlantic.

The aim of the present study is to reconstruct the palaeoenvironment and palaeoceanology of this current for a timespan covering the last three deglaciations (150 000 ky BP to Recent). To do so, assemblages of calcareous and organic-walled dinoflagellate cysts (dinocysts) were analysed in core GeoB 3603-2 from the southeastern Cape Basin offshore South Africa. Ecological information as well as information on transport and preservation of dinocysts is used to establish detailed reconstructions of the Agulhas Current.

Variations in dinocyst associations are interpreted in terms of changing environmental parameters in the upper water column, such as water temperature, salinity, and trophic conditions. Changes in the composition of organic-walled dinocyst assemblages suggest a relative increase in bioproductivity during glacial periods, possibly related to a decrease of Indian Ocean water influx into the South Atlantic. The calcareous dinocysts have their highest abundances during the terminations from glacials to interglacials, which could be related to the formation of stable water masses as a result of the decrease of wind stress off south-west Africa (Charles & Morley 1988).

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Charles, C.D. & Morley, J.J. 1988. The paleoceanographic significance of the radiolarian *Didymocyrtis tetrathalamus* in eastern Cape Basin sediments. - Palaeogeography, Palaeoclimatology, Palaeoecology 66: 113-126. Elsevier Science Publishers B.V., Amsterdam.

Sea-surface conditions off Portugal during the last-interglacial period inferred from dinoflagellate cysts: correlation with pollen data.

Eynaud F., Sanchez-Goni M.F., Turon J.L. & Shackleton N.J. 1998.-Sea-surface conditions off Portugal during the last-interglacial period inferred from dinoflagellate cysts : correlation with pollen data.-NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1 : 41.

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The deep-sea core MD952042 (37°48'N; 10°10'W, 3146 m depth), located in the Tagus abyssal plain off the Portuguese Margin, has been recovered during the first IMAGES coring program. This core, mainly constituted of calcareous hemipelagic clay (Lancelot et al. 1998) provides a high resolution paleoceanographic record from isotopic stages 6 trough 1. Seven meters belonging to the last interglacial complex (isotopic stage 5) have been analysed at 10 to 4 cm resolution. We report here the palynological results obtained with the combined study of dinoflagellate cysts and pollens. This allows us to establish a direct correlation between oceanic and continental environmental changes during this period. Thirty four taxa of dinoflagellate cysts were identified in the studied section, with cell concentrations varying between 1 000 and 17 000 cysts/ cm^3. Dinocyst assemblages are alternatively dominated by the species Lingulodinium machaerophorum and specimens of the ge nus Brigantedinium, associated with cysts of Bitectatodinium tepikiense and Impagidinium species. Cold periods are characterized by maximum percentages of Brigantedinium spp. in association with high percentages of steppic pollens, reflecting increasing activity of the Portuguese upwelling cell. Distinct peaks of B. tepikiense and Nematosphareopsis labyrinthus mark also these cold phases and have been interpreted as southward penetrations of cool North Atlantic oceanic waters (in relation with Heinrich events). At the opposite, warm periods of the last interglacial complex (substages 5e, 5c, 5a) show maximum development of the tropical Impagidinium species, with also maximum occurence of the cosmopolite species Operculodinium centrocarpum, and are associated with the development of the Mediterranean vegetation. L machaerophorum percentages reach quasi-monospecific values during these intervals and are systematically associated with Ericaceae pollens which reflect high pluviosity on the proximal continent.

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Handbook for dinoflagellate cysts: Chorate, proximochorate and proximate cysts with apical archeopyle

Fauconnier, D. & Masure, E. 1998. Handbook for dinoflagellate cysts: Chorate, proximochorate and proximate cysts with apical archeopyle. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 42.

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The second volume realized by the group of French speaking palynologists (A.P.L.F.) deals with dinoflatellate cysts with apical archeopyle (66 genera and more than 600 species).

This book has several features such as:

- keys for the indentification of genera with apical archeopyle, and for each genera:
- characteristics of the type species for individual genera (basionum, measurement, geographical localisation, age of type material)
- descriptions for each genus
- differenciation of other accepted species, provisionally species and problematical species
- keys for the identification of genera and species
- bibliography for each genus
- illustrations of type specimens
- illustrations showing the differenciations of processes for each genus

A restudy of dinoflagellate cyst holotypes has resulted in taxonomic revisions, new emendations, reattributed species.

This volume will be published in 1998, in the "Mémoires Elf Aquitaine".

Early evolution of the Gonyaulacaceae

Feist-Burkhardt, S. 1998. Early evolution of the Gonyaulacaceae. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 42-43.

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Fossil dinoflagellate cysts belonging to the family of the Gonyaulacaceae play a major role in Mesozoic dinoflagellate cyst assemblages. The first representatives of the Gonyaulacaceae appear in a relatively early phase of dinoflagellate cyst radiation, quite exactly at the Early/Middle Jurassic boundary. After a rapid radiation during the Aalenian and Bajocian they are the dominant group of dinoflagellate cysts in the Middle and Upper Jurassic.

In this contribution gradual developments and sudden appearances of new morpho-

logical features in this critical time of early evolution of Gonyaulacaceae are presented. Step by step the development of different archaeopyle types, particularities in patterns and expression of paratabulation and different types of wall relationships are demonstrated.

New methods in light microscopy and their application to fossil dinoflagellate cysts

Feist-Burkhardt, S. & Pross, J. 1998. New methods in light microscopy and their application to fossil dinoflagellate cysts. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 43-44.

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Conventional light microscopy is clearly the tool most widely used in the investigation of palynomorphs. However, the delicate morphological features found in many dinoflagellate cysts are not resolved with traditional optical methods, and the documentation of palynological objects is further hampered by the low depth of field inherent in the optical system. Electron microscopy offers an enormous information gain in comparison to conventional light microscopy and also avoids the depth of field problem. On the other side, it necessitates delicate, time-consuming preparation techniques, and the study of conventional strew mounts is not possible.

We therefore examined the application of confocal laser scanning microscopy (CLSM) to fossil dinoflagellate cysts (Feist-Burkhardt & Pross 1998 in press). This technique uses a fine laser beam which excites fluorescence from the study objects to scan the target in serial cross sections, thus generating views of single optical planes of the object studied. Out-of-focus information, i.e. scattered light from parts other than the spot illuminated by the laser beam, is rejected from the optical system by a pinhole aperture. The fluorescence is measured by a photomultiplier and displayed on a monitor. In this way high quality images and three-dimensional reconstructions of microscopical objects are provided.

The CLSM investigation of strew mounts of Paleogene and Jurassic dinoflagellate cysts revealed strong autofluorescence in most of the examined specimens. The generated autofluorescence images showed details previously not visible in embedded material. This information gain is due to a much higher contrast and slightly higher optical resolution of CLSM compared to conventional light microscopy. The scanning process, however, causes bleaching and a slow decrease of the autofluorescence in the observed specimens. For that reason prolonged observation times should be avoided.

The application of CLSM to embedded type specimens of former workers promises new insights in their morphologies and possibly forms the key to the answering of morphological and systematic questions. Thus CLSM may be able to close the gap between conventional light microscopy and electron microscopy in the investigation and docu-

mentation of palynomorphs.

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High-resolution dinoflagellate cyst biostratigraphy: The lower Middle Jurassic of SW Germany

Feist-Burkhardt, S., Pross, J. & Wille, W. 1998. High-resolution dinoflagellate cyst biostratigraphy: The lower Middle Jurassic of SW Germany. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 44.

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In Southwest Germany the earliest Aalenian ammonite zone of *Leioceras opalinum* is represented by up to 130 m of claystone, the so-called "Opalinuston". 32 core samples from a borehole at Überkingen near the Aalenian type locality along with samples from other localities nearby formed the subject of a detailed dinoflagellate study.

More than 50 dinocyst species were discovered, only half of them as yet described. These species can be attributed to seven families two of which - the Nannoceratopsiaceae and Phallocystaceae - had their main radiation already in the Late Liassic. In the Opalinuston the latter family is the most diverse with 20 species. Three species of *Scriniocassis* (Scriniocassiaceae) are very typical for these measures. The base of the sequence which coincides with the base of the Middle Jurassic is marked by the first occurrence of *Kallosphaeridium* spp., the earliest representatives of the Gonyaulacaceae. This family will become the dominant dinoflagellate cyst group from the Bajocian onward.

Stratigraphically the most interesting species are *Nannoceratopsis triangulata* PRAUSS 1987 and the Peridiniacean "*Morgenrothia iunior*" (undescribed). Both are restricted to the latest Toarcian *levesquei* and the earliest Aalenian *opalinum* zones. The second species has a very marked acme at the stage boundary. *Phallocysta* (?) *frommernensis* BELOW 1987 is characteristic for the middle part of the Opalinuston. At a regional scale it seems feasible to subdivide the *opalinum* zone into three units by dinoflagellate cysts.

Dinoflagellate evolution: Progress and problems

Fensome, R.A. & Taylor, F.J.R. 1998. Dinoflagellate evolution: Progress and problems. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 45.

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Dinoflagellates are protists distinguished by: 1) the possession of two flagella, one usually wavy and ribbon-like, almost encircling the cell, and the other a more conventional flagellum trailing the cell posteriorly; and/or 2) a nucleus (dinokaryon) with chromosomes continuously condensed, lacking histones, and associated with closed mitosis. These organisms occur as a major component of the marine plankton today, and as fossils, sometimes abundantly, in rocks going back at least 240 million years. since the first "DINO" meeting (a Penrose conference), which brought together geologists and biologists working on dinoflagellates, the understanding of both relationships among fossil and living dinoflagellates and the evolutionary history of the group has progressed significantly. For example, we now have a far better understanding of plate relationships and how the various tabulation patterns evolved. Also, we now have a comprehensive phylogenetic classification scheme encompassing fossil and living dinoflagellates, which can itself evolve as our knowledge advances.

Ultrastructural evidence from living cells suggest that dinoflagellates are part of an "alveolate" lineage (including also cilliates andapicocomplexans) that diverged probably in the late Precambrian. Biogeochemical evidence of dinosteranes (Talyzina et al. 1997) indicate that the dinoflagellate lineage was possibly isolated by the Early Cambrian. Regardless of their earlier history, the fossil record demonstrates that dinoflagellates underwent a major radiation in the early Mesozoic. At this time, major groups such as the Peridiniphydidae and the Dinophysiphycidae first appeared.

Of course, many questions await resolution. For example the Paleozoic history of dinoflagellates remains largely an empty book: only one Paleozoic fossil species, *Arpylorus antiquus,* is reasonably dinoflagellate-like, but biogeochemistry may reveal a dinoflagellate affinity for some acritarchs. How do the "naked" gymnodinialeans fit into the story - both molecular phylogeneric and morphological evidence indicates that they are polyphyletic: maybe some are from lineages that never developed thecal plates and others are from lineages that have lost their plates. Does the synchronous appearance of dinoflagellates and sclerac-tinian corals in the Triassic and certain morphological similarities between the Triassic *Suessia* and the extant symbiont *Symbiodinium* indicate early co-evolution between corals and dinoflagellates? Maybe we will make progress toward ansvering such intriguing questions at DINO6.

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Gonyaulax by any other name would be as neat - but very confusing

Fensome, R.A., Jansonius, J., Lentin, J.K., Skog, J.E. & Williams, G.L. 1998. *Gonyaulax* by any other name would be as neat - but very confusing. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 46-47.

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The "Bard", William Shakespeare, was of course correct when he said "That which we call a rose by other name would smell as sweet"; however, of objects did not have widely used names (nomenclature), and if those names didn't have consistent and clear meanings (taxonomy), Shakespeare may have been prompted to say "That which some of us call a "rose", and others of us call a "redtrollflower" and yet others of us call a "petalwidget" and ..., causeth great confusion. " Linnean nomenclature has provided a solid foundation for the stability of biological nomenclature for the last two centuries. The universality of Linnean nomenclature, variously governed by nomenclature codes such as the International Code for Botanical Nomenclature (ICBN) and the International Code for Zoological Nomenclature (ICZN), is arguably its greatest strength, and the maintenance of nomenclatural stability is of potential concern to all neontologists and paleontologists. So too is good taxonomic practice: though a more subjective pursuit than nomenclature and not governed by codes, taxonomy is aided by compendia and indexes.

Historically, living and fossil dinoflagellates were treated under either the ICBN or the ICZN, depending on the preference of individual authors. Since the 1960s, fossil dinoflagellates have been uniformly treated under the ICBN and, increasingly, most authors working with modern dinoflagellates are more plants than animals (indeed, they are neither), but for consistency. A "Bio-Code" has been proposed to encompass all organisms and to replace preexisting codes such as the ICBN and ICZN, but we are concerned that the complications surrounding the changeover would cause instability and even chaos in nomenclature. The BioCode, as currently proposed, would be a completely new Code, not a merging of previous Codes. In order not to threaten the stability of names already published, the BioCode must incorporate a strict limit to retro-activity - it would have to specify that it has no effect on names established prior to, say, the year 2000. But in doing that it would make it necessary to work with two Codes, the ICBN for nomenclatural acts prior to 2000, and the BioCode for such acts from 2000. In some cases for living dinoflagellates, the ICZN would be involved too. In our view this does not promote user-friendly nomenclatural rules or nomenclatural stability.

There are other matters of current nomenclatural importance, including recent significant changes to the ICBN. For example, names for new species of fossils must now be accompanied by descriptions in Latin OR English. Living "algae", including extant dinoflagellates, still require a Latin description. But where do we draw the line between

fossil and living forms? This poster highlights such current issues, as well as the current structure of botanical nomenclatural institutions and committees, and also indicates how individual scientists can have a voice in the process.

DINOFLAJ - a new web site for dinotaxonomists

Fensome, R.A., MacRae, R.A. & Willians, G.L. 1998. DINOFLAJ - a new web site for dinotaxonomists. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 47.

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The World Wide Web has great potential for the timely and efficient distribution of information in he area of dinoflagellate research. A new website, DINOFLAJ, is available for those who need to have the current suprageneric classification of dinoflagellates and index of fossil genera and species literally at their fingertips. The framework for the site is the dinoflagellate classification scheme of Fensome et al. (1993), presented with illustrations of major groups, diagnoses, and hypertext-linked glossary definitions. the suprageneric classification tree is linked to a searchable version of the fossil dinoflagellate generic, species, and subspecefic citations from the latest Lentin and Williams index (Williams et al. 1998). Each entry has hypertext links to any contained taxa, and most web browsers can display multiple windows, and therefore multiple taxonomic entries, at the same time, saving a great deal of page flipping.

This poster will introduce the current state of the site and demonstrate its usefulness. It will also briefly show some of the implementation details. Future plans are to include links to further illustrations, stratigraphic data, a reference database, and to external programs and other data sets. A CD-ROM version, for faster local file browsing rather than over the network, is also planned. Distribution details, including the uniform resource locator (URL) will be provided on the poster or cal be obtained by contacting the authors.

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Interpreting paleoenvironments in the Albian Pinda Formation, Cabinda, Angola, from ditch cuttings using ecologic groupings of dinocysts, spore/pollen and petrographic data

Gaponoff, S.L., Lomando, A. J. & Maguire, K. 1998. Interpreting paleoenvironments in the Albian Pinda Formation, Cabinda, Angola, from ditch cuttings using ecologic groupings of dinocysts, spore/pollen and petrographic data. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 48.

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The Albian Pinda Formation of offshore Cabinda, Angola, contains significant petroleum reserves. High frequency cyclic mixed carbonate and siliciclastic lithologies were deposited in shallow, normal to restricted marine and coastal plain settings. Often, core material is not available from wells drilled in this area. Ditch cuttings are subject to many drilling-related influences that can often adversely affect data acquisition. However, this study determined that palynology data from continuous 60' cuttings composites was useful in recognizing large scale sequential changes in environmental conditions. Defining ecological grouping of dinocysts and comparing them with the spore/pollen recovered gives accurate environmental determination in combination with petrography and wireline logs.

Palynology data was interpreted using two separate statistical approaches to illustrate transgressions, regressions and paleoecological events. The first compares changes in frequency of taxa occurrence within six defined ecological groups: total Normal Marine, total *"Aptea"* types, total *Spinifearites*, total *Subtilisphaera*, total Leiosphaers, and total Spore/Pollen. The second approach, Detrended Correspondence Analysis (DCA), a cluster analysis technique, compares presence/absence with relative abundance of respective taxa, resulting in paleoecologically related groups.

Results provide excellent correlation between environmental determinations from statistical palynology approaches and facies interpretations from thin section petrography, and provide decisive evidence in ambiguous lithologies. This type of interdisciplinary approach strengthens our recognition of paleobiological and lithological responses to paleoenvironmental and facies variations across the Pinda shelf. Improved confidence in a variety of geologic applications is achieved, which include regional studies, paleoreconstructions, sequence stratigraphy and correlation across listric faults. Positive results from this study suggest that sampling at smaller continuous composited intervals such as 10, 20 or 30' could yield results that would facilitate higher resolution for interpreting paleoenvironments.

A study of Holocene shifts in the position of the Polar Front offshore southeast Greenland, based on dinoflagellate cyst associations

Gelder, M.-J. van, Boessenkool, K.P., Troelstra, S.R. & Visscher, H. 1998. A study of Holocene shifts in the position of the Polar Front offshore southeast Greenland, based on dinoflagellate cyst associations. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 49.

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The surface circulation offshore southeast Greenland is characterized by the presence of the cold, low-salinity East Greenland Current (EGC), and the warmer, more saline Irminger Current (IC). The former originates from the Arctic and runs along the East Greenland coast. The latter is a branch of the North Atlantic Current (Gulf Stream), that turns counterclockwise in the area south of Iceland, and flows parallel to the EGC towards the south. As a result of their contrasting properties, the Polar Front develops along the boundary of these water masses. The position and intensity of this front play a key role in the development of the storm patterns over the North Atlantic Ocean, which in turn are important for the climate of Western Europe.

In this study, dinoflagellate cyst associations in surface sediment samples from the area off SE Greenland are compared to present-day properties of the overlying water masses, such as temperature and sea-ice cover in an approach similar to that of Matthiessen (1994). The samples originate from eight box-cores that were taken along three transects perpendicular to the SE Greenland coast.

Greenland ice core data show evidence for climate change during the Holocene, such as the Medieval Warm Period and the Little Ice Age (e.g. Meese et al. 1994). Using the dinoflagellate cyst record of selected cores from the area offshore SE Greenland, we aim at reconstructing Holocene surface water mass conditions, including the position of the Polar Front and input of meltwater. In this poster, preliminary results are presented and their implications are discussed.

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Dinoflagellate cysts reflecting surface-water conditions in the Voldafjorden, western Norway during the last 11 300 ^{14}C years

Grøsfjeld, K., Aarseth, I., Flatebø, T., Haflidason, H., Larsen, E., Sejrup, H.P., de Vernal, A. & Vestbø, M. 1998. Dinoflagellate cysts reflecting surface-water conditions in the Voldafjorden, western Norway during the last 11 300 ^{14}C years. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 50.

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Abundant dinocysts in a high resolution core in the deepest part of Voldafjorden, western Norway reflect the changes in the sea surface conditions during the last ca. 11 300 ^{14}C yr BP. The period from ca. 11 300 to 9 500 ^{14}C yr BP is generally characterized by "estuarine" type conditions and fairly low salinity, which was lowest during the Late Allerød and the Younger Dryas. From ca. 11 300 to 10,800 (Late Allerød) the dinocyst assemblages indicate cold temperate conditions with sea-surface temperatures which varied strongly both on an annual and interannual scale. From ca. 10 800 to 10 000 ^{14}C yr BP Arctic-type conditions, with sea-surface temperatures close to freezing and long lasting seasonal sea-ice cover, prevailed in the Voldafjorden. This period is correlative to the Younger Dryas, and notably to the Younger Dryas dinocyst assemblage zone in the Norwegian Trench. The boundaries to this climatically severe period are strongly marked, as they are elsewhere in the region. The Arctic conditions started and ended within a few decades. Particularly high resolution from ca. 10 000 to 9 500 ^{14}C yr BP provide a detailed study of the oscillations in the surface water conditions during the earliest Holocene. The period is characterized by very high concentrations of nutrients in the surface waters, offering optimal condition for the heterotrophic *Brigantedinium* spp. However, the estuarine conditions were punctuated by inflow of North Atlantic waters causing improved climatic conditions over a relatively short period of time. Possible surface-water cooling occurred around ca. 9 700 ^{14}C yr BP. This "climatic event" is probably contemporaneous with a strong cooling which have been widedly reported in terrestrial and lacustrine sediments in the North Atlantic region. It is probably also contemporaneous with the Erdalen glacial advance in Norway. The period from ca. 9 500 to 7 000 ^{14}C yr BP is characterized by brief inflow of temperate North Atlantic waters, causing a step by step amelioration of the surface-water conditions up to ca. 7 000 ^{14}C yr BP. At ca. 7 000 ^{14}C yr BP the inflow of temperate North Atlantic waters increased significantly. However, ecological conditions in the surface waters close to modern conditions were first established around 4 500 ^{14}C yr BP. Correlation with other regional dinocyst records indicates that the ecostratigraphy in the Voldafjorden is quite consistent with the one established in the Norwegian Trench (Rochon 1997), suggesting that fairly similar hydrographic conditions prevailed in the Norwegian Trench and the Voldafjorden during the last ca. 11 300 ^{14}C yr BP. Prior to ca. 7 000 ^{14}C yr BP the hydrographic regime in the in the Voldafjorden and the Norwegian Trench was substantially different from that in the Norwegian Sea. However, the assemblages postdating ca. 7 000 ^{14}C yr BP in these areas point to similar sea-surface conditions and predominance of temperate North Atlantic waters.

Dinoflagellate cyst events and biostratigraphic correlation of mid-Cenozoic deposits from the Colorado Basin, Argentina

Guerstein, G.R., Fensome, R.A., Williams, G.L. & Guler, M.V. 1998. Dinoflagellate cyst events and biostratigraphic correlation of mid-Cenozoic deposits from the Colorado Basin, Argentina. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 51.

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The Colorado Basin is a failed rift formed during the initial opening of the South Atlantic. The basin, situated mainly in offshore eastern Argentine between 38°S and 41.5°S, contains up to 7000 m of Cretaceous and Cenozoic sediments. Since equivalent strata do not outcrop onshore, age determinations must be based exclusively on subsurface sections, in which dinoflagellates have proven valuable in providing high resolution biostratigraphic control. This study involves cuttings samples from several petroleum exploration wells, including Phillips Petroleum Co. Cx1 in the western part of the basin, and Yacimientos Petrolíferos Fiscales (Y.P.F.) Ombucta x-1, drilled onshore, with age control based exclusively on last appearance datums (LADs). The samples have yielded mostly well-preserved dinoflagellate assemblages, including biostratigraphically important new forms as well as species with established ranges. The assemblages indicate an age range from Mid Eocene to Late Miocene.

In both sections the LAD of *Batiacasphaera micropapillata* indicates an age no younger than Mid Miocene. The presence of *Nematosphaeropsis rigida, Labyrinthodinium truncatum, Selenopemphix dionaeacysta* and *Hystrichosphaeropsis obscura* is also consistent with a Miocene age. Sediments interpreted as Oligocene in age yield *Pentadinium laticinctum* and some new forms, including a new species of *Cannosphaeropsis*, with an LAD at the Oligocene/Miocene boundary. The Eocene/Oligocene boundary is indicated by the presence of *Melitasphaeridium pseudorecurvatum* and *Emmetrocysta urnaformis.*

The comparison of the dinoflagellate cyst events selected in this work with detailed previous studies carried out by Gamerro & Archangelsky (1981) and Guerstein (1990) indicate that these events are remarkably consistent throughout the basin. Moreover, the Colorado Basin ranges closely accord with those presented by Palamarczuk & Barreda (in press) from the San Jorge Basin, southern Argentina.

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Exceptional dinoflagellate blooms in the coastal waters of Schleswig-Holstein, Germany from 1989 to 1997

Göbel, J. & Lu, D. 1998. Exceptional dinoflagellate blooms in the coastal waters of Schleswig-Holstein, Germany from 1989 to 1997. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 52.

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Since 1989, a helicopter has been used as the one of the major means to take phytoplankton samples for our "Early Algae Detection System". Almost every year several intensive dinoflagellate blooms have been observed in the Baltic and the North Sea along the coastal waters of Schleswig-Holstein, Germany. There are persistent blooms of *Heterocapsa triquetra*, *Prorocentrum minimum* and *Heterocapsa rotundatum* especially in the fjords and bays of the western part of the Baltic Sea. *Noctiluca scintillans*, *Ceratium furca* and *Ceratium macroceros* form red tides in the coastal waters of the North Sea. Blooms of *Gyrodinium* cf. *aureolum*, *Lepidodinium viride*, *Dinophysis* spp. and *Prorocentrum triestinum* also occur. Transportation of dinoflagellate blooms by currents from offshore water masses into the coastal waters is discussed.

Dinoflagellates and calcareous nannofossils across the asteroid-impact Cretaceous-Tertiary boundary, New Jersey and Alabama, USA

Habib, D. & Olsson, R.K. 1998. Dinoflagellates and calcareous nannofossils across the asteroid-impact Cretaceous-Tertiary boundary, New Jersey and Alabama, USA. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 52-53.

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The dinoflagellate stratigraphy of two areas in the eastern United States was studied in order to precisely date the Cretaceous-Tertiary (KT) boundary mass extinction event, and to correlate this stratigraphy with other biostratigraphic evidence, and also, with the geological evidence of the catastrophic event which closed the Cretaceous Period. The first area of study is located in New Jersey at the Bass River site. This section contains a two centimeter-thick well-represented ejecta layer at the boundary, derived from the asteroid impact crater located some 2500 km to the south in the Yucatan Peninsula of Mexico. The second area is in western Alabama, shere chaotically sedimented soft marls are considered to represent deposits of tsunami generated by the impact just across the Gulf of Mexico.

The dinoflagellates were unique at this period of time, since they did not participate

in the mass extinction which affected other groups of microplankton. Thus, their stratigraphy is based on the succession of first occurrence (FO) datums which range uninterruptedly across the KT boundary, as follows: FO *Palynodinium grallator* (uppermost Micula murus calcareous nannofossil zone, of Late to latest Maastrichtian age); FO *Cyclapophysis monmouthensis* (M. prinsii zone, of latest Maastrichtian age); FO *Manumielle seelandica* (KT boundary interval, of latest Maastrichtian or earliest Danian age); FO *Sensoniasphera inornata* (earliest Danian in the basal part of the P0 planktonic foraminiferal zone; FO *Menbranilarnacia tenella* (P0 zone); FO *Damassadinium californicum* (P0/P-alpha boundary interval); FO *Carpatelle cornuta* (thick-walled morphotype, NP1 nannofossil zone). In sections in western Alabama where there is a polarity-reversal magnetostratigraphy, dinoflagellates, nannofossils and foraminifera place the KT boundary within the reversal identified as C29R. Comparisons are made with the Tunisian KT boundary stratotype sections.

Transport of dinoflagellate cysts in ship ballast tanks

Hamer, J.P., McCollin, T.A. & Lucas, I.A.N. 1998. Transport of dinoflagellate cysts in ship ballast tanks. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 53.

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Ballast water and sediments have been sampled from over 40 vessels arriving in ballast at English and Welsh ports. Origins of the ballast water include north and south Europe, the Baltic, the Mediterranean, Africa, north and south America and the far east. Dinoflagellate cysts present in the sediment were enumerated and identified where possible. Cysts were recorded in over 80 % of samples, with densities ranging from 1.4 to 8125 cysts per ml of sediment. A total of 22 species were identified, representing 11 genera. A number of samples contained potentially toxic bloom forming species of the genus *Alexandrium*. Cysts of *Protoperidinium* and *Scrippsiella* species were most common. In addition, a number of species previously unrecorded from British coastal waters were present, these included *Gymnodinium catenatum*, *Scrippsielle hangoei* and *Pentapharsodinium tyrrhenicum*. Implications of the introduction of non-indigenous and potentially harmful species of dinoflagellates are discussed.

Marine phytoplancton caracteristics in Gabes Gulf coasts (south-east of Tunisia): Program survey results

Hamza, A. & El Abed, A. 1998. Marine phytoplancton caracteristics in Gabes Gulf coasts (south-east of Tunisia): Program survey results. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 54.

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Since March 1995 a network of phytoplanctonic survey was launched in the tunisian littoral. In the gulf of Gabes 15 stations were definited for sampling by fifteen and becoming weekly in period of warning.

The observations and results obtained along two years of survey for phytoplanctonic populations and essentially for dinoflagellates allowed us to disengage some details in this area:

- The coasts of gulf Gabes are marked by an eutrophication phenomenon; in effect, we noted a weak specific diversity, meanwhile the phenomena of red tide are numerous and regular.
- The toxic dinoflagellates are rare on these coasts; only *Gymnodinium* sp. witch comparable morphology of *Gymnodinium* cf. *nagasakiense* causes some mortalities in the ichtyofauna. The phycotoxine detected from shellfish contamined by this species are not identified.
- The north and southerly coasts of the gulf present some similar phytoplanctonic populations. They are especially rich in benthic and epiphytic species like *Prorocentrum mexicanum, P. lima, P. concavum* and *Ostereopsis* sp. This resemblance could be assigned to the particularity of the ecosystem in these beaches. These coasts are caracterised by spread meadows of phanerogams witch offer a favorable support for these microalgae.
- In the central zone of the gulf, beaches receive an important industrial phosphate casting; we noted some seasonal diversities in the dinoflagellate populations which testify that pollution do not affect directly the phytoplanctonic population in the beaches, but it seems to avert towards the open sea, certainly conveyed by the courantologie and particularly by the tide currents.
- We can also observe in this area some dinoflagellate species that spend an encystement stage before the phases of germination or more particularly before red tide episodes. It is the case of *Protoperidinium quinquicorne*, *Protoceratium reticulatum* and *Gonyaulax* sp.

A comparative ultrastructural study of *Gymnodinium fuscum* and *Gyrodinium spirale*

Hansen, G. 1998. A comparative ultrastructural study of *Gymnodinium fuscum* and *Gyrodinium spirale*. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 55.

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The distinction between the two large "naked" dinoflagellate genera *Gymnodinium* and *Gyrodinium* is solely based on the degree of cingular displacement which should be less or more than 20 % of the total body length, respectively (Kofoid & Swezy 1921). The displacement of the cingulum in a number of species is about 20 %, making the genus affiliation very difficult. Furthermore, culture studies have shown that the cingular displacement may be variable (Kimball & Wood 1965) and therefore not very useful in the taxonomic grouping of these species. The need for a better circumscription of the genera on e.g. ultrastructural data has often been addressed, the first step being examination of the type species *Gymnodinium fuscum* (Ehrenberg) Stein and *Gyrodinium spirale* (Bergh) Kofoid et Swezy (e.g. Steidinger 1989). The aim of this presentation is to fulfil this need. Field and cultured material of *Gymnodinium fuscum* from Australia, Denmark and USA has been examined by serial sectioning TEM and compared with a similar analysis made on field material of *Gyrodinium spirale* from Denmark. Significant differences between the two species were found with respect to the fine structure of the amphiesma, pusular complex, nuclear envelope and flagellar apparatus, warranting a basis for a better circumscription of *Gymnodinium* and *Gyrodinium*.

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Gyrodinum sp. from Pettaquamscutt River, Rhode Island - The "real" *Gyrodinium aureolum* Hulburt?

Hansen, G. 1998. *Gyrodinum* sp. from Pettaquamscutt River, Rhode Island - The "real" *Gyrodinium aureolum* Hulburt? - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 56-57.

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Gyrodinium aureolum was originally described by Hulburt (1957) from small embayments in the Woods Hole area. In 1966 the western coast of Norway experienced a massive bloom of a dinoflagellate identified as *G. aureolum* Hulburt (Braarud & Heimdal 1970). This species has since caused reoccurring blooms in western European waters (e.g. Partensky & Sournia 1986). Subsequently a similar species, originally described as *Gymnodinium nagasakiense* Takayama et Adachi, was found in the coastal waters of Japan (Takayama & Adachi 1984). This species is now generally accepted to be conspecific with the earlier described *Gymnodinium mikimotoi* Miyake et Kominami ex Oda (Takayama & Matsuoka 1991). Morphological and molecular data suggest that the European *Gyrodinium aureolum* and the Japanese *Gymnodinium mikimotoi* (= *G. nagasakiense*) are the same species (Engelen 1995). This implies the epithet *aureolum* can be "sinked" if the European and American *G. aureolum* are considered conspecific. However, some workers have pointed out that obvious differences exist between these two "species", requiring re-examination of *Gyrodinium aureolum* from the type locality (e.g. Steidinger 1989).

A dinoflagellate culture (a gift from Lucie Maranda) established from a water sample collected in Narrow River, Rhode Island (ca. 200 miles to the south of Woods Hole) has been identified as a likely candidate for the "real" *Gyrodinium aureolum* Hulburt. Light-, scanning and transmission electron microscopical data of this species will be presented and compared with Japanese and European strains of *Gymnodinium mikimotoi*. It will be argued that *Gymnodinium mikimotoi* and *Gyrodinium aureolum* represent two distinct species belonging in separate genera and their affinity to either *Gymnodinium* or *Gyrodinium* will be briefly addressed.

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The thecal nature of siliceous dinoflagellate body fossils: Further evidence from the Sieblos lagerstätte, Hesse, Germany

Harding, E. 1998. The thecal nature of siliceous dinoflagellate body fossils: Further evidence from the Sieblos lagerstätte, Hesse, Germany. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 57.

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Siliceous dinoflagellate body fossils displaying a cinctioid tabulation have been described from Neogene deposits from several parts of the world (see Harding & Lewis, 1994), but until recently the nature of these microfossils was disputed: whilst some authors believed the silicification to be primary some have thought them secondarily mineralised, and where some texts indicate a thecal affinity, others have cited the remains as cysts. Some clarification of these contentious points was made by Harding & Lewis (1994) who identified primarily siliceous thecal remains in addition to suspected primarily silicified cysts.

Recently, examination of laminated organic-rich micritic sediments from the Early Oligocene Sieblos lagerstätte of Hesse (Germany), has provided further evidence to substantiate the theory that many of the siliceous dinoflagellate remains are thecal fossils. The predominantly freshwater sequence at Sieblos, which was previously mined for brown coal, contains evidence for sporadic marine influxes: indicated by calcareous nannoplankton and diatoms. It is in these marine laminae that the siliceous dinoflagellate fossils have been identified, most often preserved as internal and external moulds of the whole organism. Backscattered SEM work shows that in most instances the dinoflagellates occur concentrated in monospecific lenses or more continuous laminae. However, in some instances the fossils have become disaggregated into individual plates, which are also found in lamina-scale concentrations.

Whereas motile dinoflagellate thecae can be dissociated into individual plates, the dinocyst resting cyst cannot. Thus, finding lenses containing all of the plates found in a single motile dinoflagellate indicates that it is the thecal life cycle stage that is represented by these fossils, and not the cyst stage.

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Dinoflagellate cysts from sediment traps deployed in the Bellingshausen, Weddell and Scotia seas, Antarctica

Harland, R. & Pudsey, C.J. 1998. Dinoflagellate cysts from sediment traps deployed in the Bellingshausen, Weddell and Scotia seas, Antarctica. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 58.

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Dinoflagellate cysts have been recovered from six sediment trap moorings deployed in the Bellingshausen, Weddell and Scotia seas, Antarctica over periods of one to two years. These traps, mostly moored near the sea bed to sample the nepheloid layer, were located both within and without the maximum sea-ice limit. The numbers of cysts observed in the traps together with the composition of the assemblages reinforces the importance of the maximum sea-ice limit as a modern biogeographic boundary for the distribution of dinoflagellate cysts (Harland et al. in press). However there are also significant differences between the sediment trap assemblages and those recovered from core top samples at virtually the same sites. These differences, especially in the numbers of *Protoperidinium conicoides* (Paulsen 1905) Balech 1974, may reflect annual differences in the nutrient flux and primary productivity in the area and point to the complex dynamics of the processes involved in transporting cysts through the water column and across the benthic boundary layer into the sedimentary record. The understanding of these processes is paramount to the interpretation of the Pleistocene and Holocene temporal records of dinoflagellate cysts as proxies for climatic and oceanographic change. The dinoflagellate cyst thanatocoenosis, and consequently the temporal record, is always an integrated history composed of autochthonous and allochthonous elements unless proven otherwise.

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The Cenomanian-Turonian (Late Cretaceous) boundary event in the Western Interior Basin, United States of America: Application of high-resolution sample correlation with palynological interpretations and palaeoceanographic implications

Harris, A.J. 1998. The Cenomanian-Turonian (Late Cretaceous) boundary event in the Western Interior Basin, United States of America: Application of high-resolution sample correlation with palynological interpretations and palaeoceanographic implications. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 59-60.

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Material from latest Cenomanian to earliest Turonian strata from five sites (Blue Point, Arizona; Wahweap Wash, Utah; Pueblo, Colorado; Rebecca K. Bounds core, Kansas; and Bunker Hill, Kansas) along a transect have been analysed for their marine palynomorph and palynofacies assemblages.

At the time of deposition, the sites sampled are thought to have been palaeoenvironmentally very different in terms of shoreline proximity, bathymetry, and salinity (Kauffman 1985). Precise correlation of samples between the sites using a high-resolution chronostratigraphic framework (Kauffman 1988) has provided a valuable testing ground for palaeoenvironmental comparison using the dinoflagellate cyst and palynofacies assemblages. Previous palaeoenvironmental interpretations suggest that the Bunker Hill site had comparatively much higher levels of primary productivity, and this is reflected in the ratio of peridinioid to gonyaulacoid cysts. A number of dinoflagellate cyst species are noted to have palaeoenvironmental preferences in terms of salinity and bathymetry, and they are grouped for use as indicators of changes in water mass. These groups are substantiated by cluster analysis and integration with available lithological, macropalaeontological, micropalaeontological, and geochemical data.

A global oxygen depletion event is suggested to have occurred at the Cenomanian-Turonian boundary (e.g. Arthur et al. 1987). The results of this study show that the proportions of dinoflagellate cyst indicator species, ratio of peridinioid to gonyaulacoid cysts and relative abundance of amorphous organic matter follow very similar curves and suggest that burial of amorphous organic matter in the Western Interior Basin across the Cenomanian-Turonian boundary was related to primary productivity which increased with northward expansion of the warmer Tethyan water mass at times of third- and fourth-order transgression.

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A phylogenetic analysis for marine species of *Gymnodinium* from New Zealand

Haywood, A.J., Gray, R., Saul, D., Bergquist, P.L., & Bergquist, P.R. 1998. A phylogenetic analysis for marine species of *Gymnodinium* from New Zealand. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 60.

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A preliminary phylogenetic analysis for partial large subunit rDNA genes of marine species of the genus *Gymnodinium* shows that their ribosomal gene phylogeny is paraphyletic. Parsimony and maximum likelihood methods both yield trees with two distinct clades within the genus. Sequences for naked dinoflagellate genera that are currently classified outside the genus cannot be excluded from one of the clades without a statistically significant increase in treelength. Morphologically similar species from the northern and southern hemispheres are not genetically identical. This paper addresses the current molecular phylogeny in the context of the debate over the identification of `conservative' morphological characteristics, and examines the recent proposal to form a new genus from taxa traditionally classified as belonging to the genus *Gymnodinium* (Steidinger & Tangen 1996).

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Dinoflagellates and paleoenvironments of a Pliocene carbonate platform: The subsurface Great Bahama Bank

Head, M.J. & Westphal, H. 1998. Dinoflagellates and paleoenvironments of a Pliocene carbonate platform: The subsurface Great Bahama Bank. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 60-61.

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Neritic dinoflagellates from periplatform (slope) carbonates of the Clino borehole, located on the western, leeward margin of the Great Bahama Bank, record environmental fluctuations on the platform top (Westphal et al. in press). A lower Pliocene interval (3.6–4.2 Ma) represents highstand shedding of platform-top sediments onto the lower slope. At this time, the platform was open to marine circulation and ramp-like. Despite this open topography, abundant *Polysphaeridium zoharyi* suggests the presence of hypersaline, restricted-marine environments on the platform top. Terrestrial

palynomorphs are rare throughout and imply a platform top that was mostly or fully submerged.

By Late Pliocene times (about 2.1–2.3 Ma) the platform had become flat-topped and steep-sided, with the Clino site located on its upper slope. Samples characteristic of sea-level highstands and lowstands were selected for analysis. *Polysphaeridium zoharyi* is abundant only in lowstand samples. In highstand samples *Lingulodinium machaerophorum* replaces *P. zoharyi*, perhaps signifying somewhat less restricted waters on the platform top. This change in assemblages, along with apparent variations in cyst influx, suggests a fluctuating history of currents and salinities over the platform top in the late Pliocene. Two phases of emergence and vegetation of the platform top are reflected by anomalously high proportions of terrestrial palynomorphs in upper Pliocene lowstand samples. Palynology is therefore a sensitive indicator of short-term (4th-order) sea-level change on carbonate platforms.

Dinoflagellate concentrations show fluctuating increases that correlate positively with inferred carbonate compaction. Dinoflagellate concentrations might therefore be useful in the frequently difficult task of assessing compaction in fine-grained limestones.

Dinoflagellates are poorly known from tropical Pliocene carbonate platform environments, and several new species are reported.

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New goniodomacean dinoflagellate cysts with a compound hypotractal archeopyle from the Late Cenozoic of the North Atlantic region

Head, M.J. 1998. New goniodomacean dinoflagellate cysts with a compound hypotractal archeopyle from the Late Cenozoic of the North Atlantic region. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 61-62.

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Two new species of dinoflagellate are described from the Late Cenozoic of the North Atlantic region (Head in press). They are assigned to the goniodomacean genus *Capisocysta* Warny and Wrenn, 1997, whose archeopyle uniquely forms by the extensive and exclusive dissociation of hypocystal plates. *Capisocysta* sp. 1 is recorded from the upper lower Pliocene Coralline Crag Formation of eastern England, the lower and upper Pliocene of the subsurface Great Bahama Bank, and as a living cyst from Phosphorescence Bay, Puerto Rico. *Capisocysta* sp. 2 is reported from the Coralline Crag Formation of eastern England. *Capisocysta* provides the only unambiguous example of a hypocystal archeopyle in the order Gonyaulacales and the only example of a hypotractal archeopyle in the division Dinoflagellata.

The spherical, proximate cysts have preformed lines of weakness that occur exclusively on the hypocyst, where they follow plate boundaries. Upon excystment, these

sutures facilitate the separate release of plates 2–6''', ps, 1p, and 1''''. Sulcal plates ls and rs and postcingular plate 1''' typically remain attached to the epicyst, forming a distinctive hyposulcal tab. The single antapical plate in *Capisocysta* sp. 1 is represented in *Capisocysta* sp. 2 by two plates (left and right first antapical homologues) that are released separately.

Capisocysta has a tropical to warm temperate distribution today. It thrived and perhaps formed blooms in tropical carbonate platform environments of the Bahamas during the Pliocene, and might prove to be a useful indicator of very warm intervals within the Pliocene of higher latitude regions including the southern North Sea basin.

To facilitate discussion of these new species, several morphological terms have been modified or newly introduced to more accurately describe archeopyle position and extent in dinoflagellates.

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Neogene dinoflagellate cysts and acritarchs: Biostratigraphy and climate change

Head, M.J. & Poulsen, N.E. 1998. Neogene dinoflagellate cysts and acritarchs: Biostratigraphy and climate change. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 62-64.

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An overview of Miocene and Pliocene dinoflagellates and acritarchs is presented for the North Atlantic region, with emphasis on climatic change.

Dinoflagellates from ODP Leg 151 (Poulsen et al. 1996) and from two Danish boreholes, Karl-1 (North Sea) and Lille Tønde (southern Jylland) illustrate Miocene biostratigraphy, palaeoclimate, and palaeoenvironments from contrasting settings. At Site 907 on the Iceland Plateau, assemblages of Middle Miocene and undifferentiated Late Miocene to Pliocene age reflect nutrient-poor oceanic conditions and temperatures that were warmer than today. Sites 908 and 909 in the Fram Strait have assemblages dominated by terrestrial palynomorphs and plant fragments, resulting in relatively low dinocyst/pollen ratios. This indicates the influence of relatively nearshore depositional environments almost to the end of the Miocene. Throughout the Middle Miocene to Early Pliocene interval, warm water species indicate temperate conditions.

Both Danish boreholes are from the North Sea Basin, which became part of a large northern European sedimentary basin in the earliest Cenozoic. Sedimentation was marine and clastic-dominated. The base of the upper Miocene is locally developed as a low angle unconformity and marks a shift from predominating mud sedimentation during the Paleogene to deposition of sand/silt intercalations in the Neogene. A new Miocene biostratigraphy of the Lille Tønde borehole using dinoflagellates, foraminifers, and mol-

luscs (Laursen et al. in press) has revised correlations between the Northwest European stage boundaries and the global stratotypes. Overall, the northwestern European units are now shown to be slightly older than earlier believed. Miocene dinoflagellates of the Lille Tønde and Karl-1 boreholes were analyzed using the statistical method of Edwards (1992) to backtrack the palaeoenvironment. A range of inner neritic to outer neritic-oceanic environments were recognized at the two sites. Sea-surface temperatures were subtropical, the winter surface temperatures being above 10°C, with falling sea-surface temperatures in the late Miocene. The sea level maximum is probably near the Tortonian/Messinian (7.1 Ma) boundary. Palaeotemperatures were similar to those of the present day Atlantic off Portugal and southern France.

Dinoflagellates and acritarchs of the Pliocene are less well studied than those of the Miocene, but distribution patterns are emerging especially for the mid to higher latitudes. The climatic affinity of Pliocene dinoflagellates can be assessed by: 1) magnetostratigraphically-calibrated palaeogeographic distribution, 2) association with other fossils of known climatic affinities as well as other palaeoclimatic indicators, 3) calibration to the oxygen isotopic record, and 4) inference from modern climatic affinities in the case of extant cysts. These methods reveal that certain Pliocene taxa are strongly influenced by climate, thereby identifying them as potential climatostratigraphic markers.

Habibacysta tectata, *Filisphaera filifera*, and *Bitectatodinium tepikiense* represent an important cool-water Pliocene element in mid to high latitudes, with *H. tectata* probably being the most cold-tolerant. For example, *H. tectata* occurs persistently in the upper Pliocene of the marginal Arctic Ocean (ODP Site 911; Matthiessen & Brenner 1996) where it is associated with a cold interval characterized by abundant dropstones and impoverished calcareous nannofossil assemblages. Further south, *H. tectata* is persistent in deposits of similar age in the southern North Sea, but is notably scarce in the warm Ludhamian (ca. 2.3 Ma) and earlier stages (Head in press). In the Mediterranean this species occurs only in the coldest isotopic stages (Versteegh 1994).

Melitasphaeridium choanophorum, *Bitectatodinium raedwaldii*, and *Tectatodinium pellitum*, in contrast, are thermophiles. All three species occur in the mid Pliocene of the southern North Sea (Head 1997, in press) and their absence from post-2.6 Ma deposits in eastern England may be a response to widespread Northern Hemisphere cooling at 2.6 Ma. It is notable that *M. choanophorum* and *B. raedwaldii* both persisted to at least 2.3–2.1 Ma (late Late Pliocene) in the Bahamas where the climate remained very warm (Westphal et al. in press). These Bahamanian sediments also contain *Dapsilidinium pseudocolligerum*, a zonal marker for the uppermost Miocene in the eastern U.S.A. (de Verteuil & Norris 1996). The Bahamas and other low latitude sites evidently provided a warm refuge for selected thermophiles during the Late Pliocene.

An overview of the North Atlantic Pliocene dinoflagellate record shows the lower Pliocene containing many biostratigraphic events that are more-or-less synchronous over large distances. The upper Pliocene, in contrast, has fewer widespread correlatable events, especially after 2.6 Ma. This probably relates to the onset of less stable climatic conditions and an increase in the poleward thermal gradient.

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Hallazgo de un dinoflagelado en el Océano Indico, ¿vínculo entre los géneros *Amphisolenia* y *Triposolenia*?

Hernández-Becerril, D.U. & Meave del Castillo, M.E. 1998. Hallazgo de un dinoflagelado en el Océano Indico, ¿vínculo entre los géneros *Amphisolenia* y *Triposolenia*? - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 64-65.

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En una muestra de fitoplancton, colectada con red (18-02-1965) del Océano Indico (13° 35.8' N, 70° 50.0' E) en el crucero IOE "Meteor", se encontró un dinoflagelado interesante del Orden Dinophysiales, que fue aislado y estudiado con deatalle en microscopía de luz y electrónico de barrido. El especímen estudiado corresponde a una forma corta (337 µm de largo y 50 µm de ancho) y robusta con características típicas de las especies del género *Amphisolenia*: cabeza comprimida, un cuello corto y posteriormente un cuerpo alargado y ensanchado. Sin embargo, dado que carece del adel-

gazamiento de la hipoteca posterior al cuerpo y que presenta una bifurcación en dos caudas rectas y simétricas, cada una rematada con dos espinas, sus características corresponden también con las del género *Triposolenia*. De esta manera, además de indicar que el ejemplar encontrado pertenece a una nueva especie, se discute su calidad de vínculo entre estos dos géneros de la familia Amphisoleniaceae, Orden Dinophysiales.

Variations in South Atlantic calcareous dinoflagellate associations since the Late Cretaceous

Hildebrand-Habel, T. & Willems, H. 1998. Variations in South Atlantic calcareous dinoflagellate associations since the Late Cretaceous. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 65.

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Calcareous dinoflagellates are prominent contributors to the microfossil content of Mesozoic and Cenozoic marine sediments. Although research activities have been intensified during the last two decades, a general extensive investigation of the evolution of these significant organisms has not been realised as yet. The objective of the present study is to contribute to a better understanding of the factors controlling the temporal and spatial distribution patterns of calcareous dinoflagellates in the South Atlantic Ocean since the Late Cretaceous.

Maastrichtian to Miocene calcareous dinoflagellate associations of several South Atlantic DSDP/ODP sites (Site 356, Site 357, Site 689B) have been examined. The assemblages mainly consist of long-ranging forms, fluctuating qualitatively and quantitatively in distinct stratigraphic patterns. The fluctuations are particularly evident concerning the ultrastructure of the calcareous walls, which are characterized by radially, tangentially, pithonelloid (uniformly inclined), and/or obliquely orientated calcite crystals.

Generally, the Maastrichtian is characterized by stable calcareous dinoflagellate associations, exhibiting high relative abundances of obliquely and radially structured calcareous dinoflagellate cysts. Although no accelerated rates of extinctions are evident at the Cretaceous-Tertiary boundary, the broad spectrum of obliquely and radially structured species is modified by an extreme dominance of the tangentially structured *Operculodinella operculata*, which occurs in high abundances especially in Early Paleocene nannoplankton zones NP1-NP3. The bloom of this species has been reported from numerous localities and apparently had a world-wide distribution. The outstanding dominance of tangentially structured calcareous dinoflagellates as initiated by *O. operculata* persists during the Paleocene and partially the Eocene. Only in the course of the Oligocene and the Miocene, do oblique and radial wall structures become prominent again.

Although the particular factors controlling the stratigraphic differentiation of calcareous dinoflagellate ultrastructures remain ambiguous, changes evidently correspond to variations in the environmental conditions. The changing pattern at the Eocene-Oligocene boundary tentatively suggests a climatic dependence.

Paleocene-Eocene dinoflagellate systs in the Faeroe-Shetland basin

Hjortkjær, B.F. 1998. Paleocene-Eocene dinoflagellate systs in the Faeroe-Shetland basin. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 66.

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The area around the Faeroe Islands experiences an increasing interest from the oil industry due to the large oil discoveries made in the British sector during the past years. This study is a part of a biostratigraphic study incorporating material from UK wells and onshore localities in the North Atlantic area. The purpose is to establish a zonation of Paleocene and Eocene marine and non-marine sediments of the North Atlantic. The zonation is primarily based on dinoflagellate cysts, however spores and pollen are also used when ever possible to correlate between marine and non-marine sediments. Five wells have been studied from the British sector. Sediments from dredge hauls on the Faeroes Shelf are also incorporated.

The main emphasis is put on the Mid-Late Paleocene to Early Eocene interval, which is covered by a sequence stratigraphic work based on seismic and electric logs. The state of preservation of the palynomorphs also limits how far into the Early Paleocene reliable identifications can be made.

The content of dinoflagellate cysts from the Paleocene-Eocene strata of the Faeroe-Shetland Basin exhibits a consistent succesion of events. Combination of the stratigraphic sequences defined by seismic and logs and the results of the a biostratigraphic investigation shows correlation between the sequence boundaries and some of these palynological events. Dramatic changes in the dinoflagellate flora like the large influx of *Apectodinium* spp. in the latest Paleocene and the highest occurrence of an acme of *Deflandrea oebisfeldensis* in Early Eocene seem to be correlative to a sequence boundary while other significant bioevents like the acme of *Areoligera* spp. in the Late Selandien does not corresponds a sequence boundary. The results show that caution should be exercised in interpretation of the palynomorph data purely in terms of sea-level variation. Climatic variations during the Paleocene and Eocene plays a important role on the assemblage of palynomorphs expressed both in the species and abundances of both dinoflagellate cysts and spores and pollen. A number of factors like nutrient levels and interspecific competition may also represent important controls. In general the Faeroe-Shetland Basin dinocyst succession is very similar to that of the North Sea Basin permitting correlation with calcareous nannoplankton zones and hence allowing correlation of Faeroe-Shetland Basin stratigraphy with major regional tectonic and worldwide climatic events.

Using ozone injection technologies in reducing the harms of dinoflagellate blooms

Ho, K.C., Chan, H., Chan, Y.P. & Ho, S.C. 1998. Using ozone injection technologies in reducing the harms of dinoflagellate blooms - NTNU Vitensk.mus. Rappp. bot. Ser. 1998-1: 67.

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In April 1998, a red tide caused by *Gyrodinium aureolum* and *Cochlodinium* spp. posed serious damages to the fish cultivating industry in Hong Kong SAR and Guangdong Province, China. The total fishkill during this red tide incident was more than forty thousand tonnes with the total economic loss greater than 40 million US dollars.

A study was carried out as an immediate rescue effort to the red tide. An ozone injection system, which generated the disinfecting agent by lighting and electrical charges, was tested to elucidate the possible effects of using ozone in killing harmful dinoflagellates. In an experiment, ozone was generated at the rate of not more than 1 g per cubic meter per hour and was diffused into the red tide-contaminated water pumped up from the fish cultivation zone. The ozone-disinfected water was pumped back to a 20 l water tank for fish cultivation. It was discovered that after one minute treatment of the ozone, 70 % of the dinoflagellates in sea water were killed. All (6800 cell/ml) dinoflagellates were effectively killed within 12 minutes of ozone treatment. Besides, the dissolved oxygen content in the contaminated seawater increa-sed from 7.6 mg/l to 17.4 mg/l. The seven fishes cultivated in the experimental water were found unaffected and maintained their healthy conditions after ozone injection.

The ozone injection system was also tested *in situ* a fish cultivation zone. A cage of 2 m (L) x 2 m (W) x 2 m(H) was immersed in the contaminated seawater for cultivation of commercial fishes and ozone treatment. The cage was surrounded by a nylon cloth to enclose the ozone injection boundary and to separate the treated seawater with outside contaminated waters. As recorded, after 15 minutes of ozone treatment all the red tide causative dinoflagellates in the surface layer were killed and the level of dissolved oxygen significantly increased from 0.03 mg/l to 3.5 mg/l. The health conditions of the fishes in the cage were generally unaffected.

The economic aspects of ozone injection were assessed and compared with other technologies in tackling red tide. As shown, the ozone injection technology is shown of practical values in terms of its cost-effectiveness in killing algal cells and abilities in increasing the dissolved oxygen in water. Ozone may also oxidise the algal available ammonium into nitrates thus reducing the risk of red tide outbreak.

Dinoflagellate cysts from Pliocene and Quaternary lacustrine sediments of northern Greece

Hoeve, M.L. van, Kouli, K. & Brinkhuis, H. 1998. Dinoflagellate cysts from Pliocene and Quaternary lacustrine sediments of northern Greece. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 68.

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Within the framework of two paleoclimatic research projects, which both focus on lacustrine sediments from northern Greece but are otherwise unrelated, organic walled dinoflagellate cysts were recovered from a number of horizons. The first project forms part of an archeological investigation and examines the climate and environment of the Late Quarternary in the area around Lake Kastoria. The samples were obtained from two sediments cores from the area around the lake. The second project deals with the climatic and environmental history of the Early Pliocene and its relation to astronomical forcing. Samples were derived from the lignite mines in the area around Ptolemais.

The recorded specimens belong either to the (cyst-)species *Spiniferites cruciformis* or to the cyst-stage of *Gonyaulax apiculata*. Although reported from low-salinity environments, *Spiniferites cruciformis* is not known to occur in fresh water systems. *Gonyaulax apiculata* has so far only been recorded in bottom sediments from Swiss lakes (e.g. Evitt et al. 1985). In this presentation we will illustrate the representative specimens. We will concentrate on the distribution patterns of the species in the analyzed sections and we will discuss possible paleoenvironmental consequences.

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Dinoflagellate cysts across the Cretaceous-Tertiary boundary from the Brazos River section, Texas, USA

Hoof, T.B., van, & Brinkhuis, H. 1998. Dinoflagellate cysts across the K/T boundary from the Brazos-river section, Texas, USA. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 68-69.

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The Cretaceous-Tertiary (K/T) boundary interval at the Brazos river section in Texas consists of thick clastic beds representing chaotic sedimentation. The duration and type of deposition which generated these beds is under strong discussion. Some authors consider these beds to be deposited by Tsunami waves which were generated by a meteorite impact on the Yucatan peninsula of Mexico 65 million years ago (e.g., Smit et al. 1994). Being Tsunami generated, the duration of deposition of these beds is estimated in the order of a couple of days. Others conclude, mainly based on foraminiferal data, that the clastic beds contain one or more hiatuses and thus the duration of deposition is estimated

to be in the order of tens of thousands of years rather then a few days and so these deposits cannot be Tsunami generated (Keller 1989).

Various recent studies have shown that (1) organic-walled cyst-producing dinoflagellates are not pushed to extinction at the K/T horizon, and (2) a variety of qualitative and quantitative events occur within planktonic foraminiferal zone P0, and provide the highest biostratigraphic resolution available for the lowermost Danian (e.g., Habib 1996; Brinkhuis et al. in press).

In this research high resolution dinoflagellate cyst biostratigraphy across the K/T at Brazos River is applied to test available models of its sedimentary history. In this presentation, results will be displayed, and comparison with previous studies and implications discussed.

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Sand-dwelling dinoflagellates of the Wadden Sea (List/Sylt), with special emphasis on *Roscoffia capitata*

Hoppenrath, M. 1998. Sand-dwelling dinoflagellates of the Wadden Sea (List/Sylt), with special emphasis on *Roscoffia capitata*. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 69-70.

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The seasonal distribution of marine sand-dwelling dinoflagellates in the North German Wadden Sea will be presented. During 12 month from March 1997 to February 1998, at two sand flat stations 35 species have been recorded: *Adenoides eludens, Amphidiniopsis hirsutum, Amphidinium bipes, A. britannicum, A.* cf. *carterae, A.* cf. *corpulentum, A. herdmanii, A. incoloratum, A. operculatum, A. poecilochroum, A. psittacus, A. scissum, A. semilunatum, A. testudo, A.* sp., *Bernardinium* spec.. *Glenodinium* sp., *Gymnodinium* cf. *marinum, G.* cf. *variable, G. spec., Gyrodinium* sp. *1, G.* sp. *2, Herdmania litoralis, Katodinium asymmetricum, K. glandulum, Planodinium striatum, Polykrikos lebourae, Prorocentrum* sp. *1, P.* sp. *2, Roscoffia capitata, Sabulodinium inclinatum, S. undulatum, Sinophysis ebriolum, Thecadinium dragescoi, T. swedmarki.*

There has been no reported observation of *Roscoffia capitata* since its discovery by Balech 1956. I was able to examine this

species for the first time by scanning electron microscopy and I also made some additional light microscopical observations.

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Discoasters are recent taxa

Horner, R.A., Carstens, M., Gradinger, R., Ikavalko, J., Spindler, M. & Juhanoja, J. 1998. Discoasters are recent taxa. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 70-71.

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Discoasters are stellate, calcareous marine microfossils thought to be produced by organisms related to present-day coccolithophorids. They were first described by Ehrenberg (1854), but it was Tan Sin Hok (1927) who first used Discoaster as a generic name and provided early species descriptions. Discoaster is now used as a general group name, as the name of the star-shaped structures, and as a generic name for the star-producing organisms.

Discoasters are known from the Upper Paleocene (about 60 Ma) to the end of the Pliocene (about 2 Ma) and were particularly abundant in the Eocene. Their extinction is sometimes used as an indicator of the Pliocene-Pleistocene boundary and they have been used to assign ages to strata because their stratigraphic ranges are fairly short and relatively well-known. Their presence in marine sediments is thought to be indicative of warm water depositional environments. Over time, however, star morphology changed from compact rosettes to a few, narrow rays, calcification became lighter, and the diameter of the stars decreased reflecting general cooling of the physical environment.

The first real evidence that discoasters may be living today was provided by Bursa (1965, 1971), based primarily on sea ice samples from the Canadian Arctic. He described a new genus, new species, and transferred discoasters to a new family in the dinoflagellates. Live discoasters have also been grown in rough cultures started with pieces of sea ice from northern Alaska (R. Horner) and seen in first-year ice samples from the Weddell and Greenland seas (M. Elbrachter, M. Spindler, M. Carstens, R. Gradinger & J. Ikavalko). Scanning electron microscopy and elemental analysis show that the stars are composed of calcium carbonate (J. Juhanoja). Thus, there is evidence that discoasters are still living today in polar sea ice, albeit in relatively small numbers.

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Late Quaternary calcareous and organic-walled dinoflagellate cysts of the tropical Atlantic

Höll, C., Karwath, B., Zonneveld, K.A.F. and Willems, H. 1998. Late Quaternary calcareous and organic-walled dinoflagellate cysts of the tropical Atlantic. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 71.

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To date, environmental information on calcareous dinoflagellates has been extremely limited. In order to enhance this information and to determine their potential use as a tool in (palaeo-) oceanographic reconstruction, the temporal distribution patterns of calcareous dinoflagellates have been compared with those of the ecologically much better known organic-walled dinoflagellate cysts. Two sediment cores have been selected for investigation of calcareous and organic-walled dinoflagellate cyst associations: one from the highly productive eastern equatorial divergence zone and the other from the low productive western tropical Atlantic. Pronounced differences in palaeoproductivity between the two sediment cores are indicated by high and variable organic carbon accumulation rates (TOC) in the east, in contrast to relatively constant and low values in the west. The accumulation rates of organic-walled dinoflagellate cysts exhibit a similar pattern, whereas those of the calcareous dinoflagellates show the opposite: high abundances in the west and lower in the east. At the equatorial divergence zone, temporal variations of organic-walled dinoflagellate cysts and TOC are positively correlated, whereas the calcareous dinoflagellates show, for the most part, an inverse relationship. High calcareous dinoflagellate accumulation rates coincide with low organic-walled dinoflagellate cyst contents and low TOC accumulation rates and vice versa. In the investigated region and time interval, enhanced production of calcareous dinoflagellates and diminished production of organic-walled dinoflagellate cysts can be correlated to periods of reduced palaeoproductivity most probably related to relatively stratified conditions in the upper water column.

Paleocene-Eocene dinoflagellates of Turgay: Biostratigraphical and paleoecological significance

Iakovleva, A. 1998. Paleocene-Eocene dinoflagellates of Turgay: Biostratigraphical and paleoecological significance. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 72.

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A sedimentary sequence of Early Paleocene-Early Eocene age is present in the Sokolovsky Quarry (Turgay region, Southeastern Ural area). It contains two sedimentary parts. The lower unit (Sokolovskaya Unit) mainly consists of carbonated sand. It contains nannoplankton, radiolaria, diatoms and dinoflagellate cysts. The Sokolovskaya Unit corresponds to *Cerodinium speciosum* dinoflagellate zone. The upper unit (Kacharskaya Unit) is founded of silicious clay and argilite which contain dinoflagellate cysts and some diatoms and radiolaria. Most of this unit corresponds to *Apectodinium homomorphum* zone. In the top of this section the Paleocene-Eocene boundary is recognized. The last samples contain the Early Eocene marker *Wetzeliella meckelfeldensis.* Rich dinoflagellate assemblages have been found in the whole section. They contain more chorate gonyaulacoid than peridinoid taxa. The taxa which dominate in Early Paleocene are *Areoligera senonensis, Areologera medusettiformis, Areoligera coronata, Deflandrea denticulata.* The Late Paleocene assemblages include especially *Apectodinium quinquelatum, Areoligera senonensis, Areoligera medusettiformis, Achomosphaera alcicornu.* The Early Eocene assemblage also includes mainly the species of chorate genera *Cordosphaeridium, Achomosphaera, Spiniferites, Homotryblium* and *Areoligera.* And the peridinoid dominants are *Lentinia wetzelii* and *Deflandrea denticulata.*

Dinoflagellate cyst biozonation of the uppermost Callovian and the Lower - Middle Oxfordian in West Siberia

Ilyina , V.I. 1998. Dinoflagellate cyst biozonation of the uppermost Callovian and the Lower-Middle Oxfordian in West Siberia. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 72-73.

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The Callovian and Oxfordian marine sections of Vasyugan Formation penetrated by boreholes on the north of central part in West Siberia have been investigated. Rare Bivalvea, some acritarchs, pollen and spores as well as foraminifera and dinoflagellate cyst assemdlages were occured in these sediments.

The latest Callovian, Early and Middle Oxfordian sequense of dinoflagellate cyst assemblages is established in West Siberia for the first time. A base of the dinoflagellate cyst assemblages consists of *Crussolia deflandrei, Endoscrinium* spp., *Gonyaulacysta jurassica* subsp. *adecta* var. *longicornis, Fromea tornatilis, Liesbergia liesbergensis, Nannoceratopsis pellucida, Rhincho diniop-*

sis cladophora, Rigaudella aemula, Tubotuberella apatela, Wanaea accolaris, Wanaea fimbriata, Wanaea thysanota and other species widespread in West-European Oxfordian dinoflagellate cyst floras. This phenomenon is connected with general warming in the Oxfordian time and also with wide links between the West Siberian and surrounded marine basins of the Sub-Boreal Province. Three biozones are erected in the latest Callovian- Middle Oxfordian dinoflagellate cyst succession in West Siberia based on the first stratigraphical appearance datum (FAD) and /or last stratigraphical appearance datum (LAD) and acme of selected species.

***Wanaea thysanota* Interval Biozone** - Latest Callovian age. It is defined in the interval between the FAD of *Wanaea thysanota* and/or *Trichodinium scarburghensis* to FAD *Wanaea fimbriata* and/or *Crussolia deflandrei.* This Biozone is approximately equivalent to *Trichodinium scarburghensis* Interval Biozone (Lamberti Zone in the Moscow Syncline region and Subordinarium Zone in the Pechora Basin).

***Wanaea fimbriata* Range Biozone** - the Early Oxfordian age. It is defined in the interval between the FAD and LAD of *Wanaea.* The base of this Biozone is also defined by the FAD of *Crussolia deflandrei.* The range tops *Wanaea acollaris* and *Wanaea thysanota* occur within this Biozone. *Wanaea fimbriata* Biozone is coincident with *Wanaea fimbrita* Range Zone of the Russian Platform. It is equivalent to *Crussolia deflandrei-Wanaea fimbriata* Zone of the Barents Sea region and *Wanaea fimbriata* Zone of the East Greenland (Smelror & Below 1992).

Rigaudella aemula Interval Biozone - Middle Oxfordian and the earliest Late Oxfordian. It is he interval between LAD of *Wanaea fimbriata* to LAD of *Rigaudella aemula.* Acme of *Rigaudella aemula* and a last peak of *Nannoceratopsis pelucida* took place in this Biozone. *Rigaudella aemula* Biozone approximately is calibrated with foraminifera Zone *Ammodiscus thomsi, Tolypammina svetlanae* of the Middle Ox-fordian and *Recurvoides disputabilis* Zone of the lowermost Upper Oxfordian of Regional stratigraphical Scale by B. Nikitenko.

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DinoBase - database on dinocysts and other palynomorphs

Iosifova E.K. 1998. DinoBase - database on dinocysts and other palynomorphs. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 73-74.

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"DinoBase" is a relational database, compiled using Paradox 7.0 (copyright 1996) for Windows NT (or 95) and has been developed since 1993. Now this database currently includes nomenclatural, biostratigraphical and geographical information on taxa from 19 groups of palynomorphs (primarily of dinocysts and acritarchs), about 1 500 genera and 15 000 species) and 5 000 publications. It includes world maps at various projections and enables the user to place locations of taxa on the map by coordinates. The maps can be used to show the geographical distribution of data selected be several criteria; for example, various taxa or various ages. It can show the stratigraphical ranges of several

taxa in several sequences, or the stratigraphic ranges of taxa from various localities. At present, age resolution is only down to the stage level. The user can find the nomenclatural information on interesting taxa, lists of papers, where a taxon is cited, its stratigraphical range, its geographical distribution, etc. Taxa can also be listed from a particular publication or sequence.

The compilation of a scientific database from published literature should not include interpretation. The possibility of the interpretation strongly depends on the structure of the database. The structure of DinoBase does not designate interpretation. The data in Dino Base are not interpreted wholly. The user have a possibility to interpret the data by himself. This means, that the user can select criteria and the sequence of criteria so as he want (using query).

Due to that fact, that DinoBase uses Paradox, the user can employ not only the facilities of DinoBase by itself, but also all facilities of interactive Paradox. Thus the user can program the database to resolve any question as long as the data in DinoBase are adequate.

Senoniasphaera fenestroperforata sp. nov. from the Upper Volgian in Kashpir outcrop (central Russia)

Iosifova E.K. 1998. *Senoniasphaera fenestroperforata* sp. nov. from the Upper Volgian in Kashpir outcrop (central Russia). - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 74.

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A new species of Senoniasphaera was found during a routine study of Upper Volgian (nodiger zone) deposits in the Kashpir outcrop. It is characterized by lenticular cyst, slightly pentagonal with low antapical and lateral bulges. Periphragm perforate and becomes fenestrate near the margins of the paraplates. Parasutural arks are also fenestrate. This species is similar to *S. jurassica* (Gitmez & Sarjeant 1972), but differs of it by its per-forated to fenestrated periphragm.

The new species was found in the assemblage with *Gochteodinia villosa,* where it is common.

Optimum growth condition for *Amphidinium carterae* Hulbert from eutrophic waters in Alexandria and its potential toxicity

Ismael, A.A., Halim, Y. & Khalil, A.N. 1998. Optimum growth condition for *Amphidinium carterae* Hulbert from eutrophic waters in Alexandria and its potential toxicity. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 75.

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Although *A. carterae* is a widely distributed species (Steidinger & Tangen 1995, Larsen & Patterson 1990) it has not been recorded before from Egyptian waters. Bioassay experiments (Yasumoto 1987) have shown this species to be toxic to mice and fish. Reported toxic events in Egyptian waters, however, have only been caused by *Alexandrium minutum* Halim (Labib & Halim 1995).

The species was investigated in laboratory unialgal cultures to establish its optimum growth conditions and its potential use for bioassaying industrial and agricultural effluent waters.Its potential towicity was tested using adult and juvenile *Artemia salina*. The *A. carterae* strains used were collected from the Eutrophic Eastern Harbour of Alexandria. After numerous trials with different media at different temperatures and light conditions, the optimum growth was obtained at 25 °C, 2900 lux in GMP medium (Loeblich 1975), but with increased phosphate and nitrate concentrations by 2.5. This higher concentration required by the species may be due to the fact that the strain cultured came from a eutrophic basin. Old cultures (3-4 monthes) showed no toxicity to *Artemia salina*. Tests made with cultures in their exponential growth phase proved to be toxic to both juveniles and adults, leading to total death in two days for juveniles and five days for adults.

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Ultrastructural characterization of food vacuoles within *Alexandrium pseudogonyaulax* and other thecate mixotrophic species

Jacobson, D. 1998. Ultrastructural characterization of food vacuoles within *Alexandrium pseudogonyaulax* and other thecate species. - NTNU Vitensk.mus. Rapp. bot. Ser.1998-1: 76-77.

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A number of naked dinoflagellates (*Gymnodinium, Gyrodinium*), as well as *Ceratium* spp., were found to be feeding on small choreotrich ciliates (Bochstahler & Coats 1993). Similar observations extending the record of mixotrophy to a wide range of thecate phototrophs, (including *Scrippsiella, Gonyaulax* and *Alexandrium*) were made by analyzing food vacuole ultrastructure. Alexandrium ostenfeldii from the Gulf of Maine revealed that this toxic dinoflagellate primarily ingested plastid-containing ciliates and in one case a dinoflagellate (*Dinophysis*) (Jacobson & Anderson, 1996).

Subsequently, the feeding habits of *Alexandrium* and *Ceratium* species from the North Pacific were investigated. Again, using single-cell TEM analysis, the food vacuoles found within *Alexandrium pseudogonyaulax* (collected from Puget Sound, Washington, and Coos Bay, southern Oregon) reveal a variety of food inclusions which varied both temporally and geographically. As much as 20 % of the populations contained food vacuoles, and the majority of food vacuoles were clearly ciliate-derived. While food vacuoles from Puget Sound in early summer 1996 were diverse, containing both plastidic and non-plastidic ciliates (including *Stompidinopsis*), cells from Coos Bay (July 1997) had ingested the red symbiotic ciliate *Mesodinium* sp. (Puget Sound cells often contained a combination of ciliate and dinoflagellate prey; the dinoflagellates were thecate, plastidic and small, only 10 µm in size) A late-summer 1997 Puget Sound sample was also dominated by *Mesodinium* sp. food vacuoles, most retaining their red pigmentation and characteristic yellow auto-fluorescence.

Fortunately, one *Alexandrium* cell was captured in the actual process of ingesting a *Mesodinium* cell through the posterior-sulcal region ; while the epitheca appeared to be intact, the hypotheca looked to have been attenuated, having a less-distinctive appearance than the epitheca. While *Alexandrium* appeared to be selecting *Mesodinium* as food, only a single cell of the co-occurring heterotroph *Oxyphysis oxytoxoides* (which normally contains colorless ciliate food vacuoles: Jacobson & Andersen 1994) contained red food vacuoles, most likely derived from *Mesodinium*.

Ciliate-derived food vacuoles were also found within *Ceratium tripos,* in which up to 50 % of the population had food inclusions.

No food vacuoles were detected in co-occurring *Alexandrium catenatum* cells, nor in a species previously found to contain food, *Gonyaulax (Protoceratium) grindleyi*. Mixotrophy appears to be episodic and variable.

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acuminata, D. norvegica and two heterotrophic dinophysoid dinoflagellates. - Phycologia 33: 97-110.

Calcareous dinoflagellate cysts: Ultrastructure, biomineralization and systematics

Janofske, D. 1998. Calcareous dinoflagellate cysts: Ultrastructure, biomineralization and systematics. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 77.

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Calcareous cyst forming dinoflagellates are a closely related group of small marine phototrophic algae. Almost every theca incubated from calcareous cysts shows the thecal plate pattern described for *Scrippsiella* except from one species of *Pentapharsodinium* and two of *Ensiculifera*. The thecae of these by now numerous species all have *the Scrippsiella* plate pattern with only slight variations in size and shape. Therefore, in this group, a species can hardly be characterized only by thecal features, but can be defined clearly by the morphological features of the corresponding calcareous cyst.

Characters for idenitification of taxa are shape and size of the whole cyst as well as the morphology and crystallographic orientation of the calcite crystals forming the calcareous layer(s). Observations from cultures have shown that in one species the morphology of the crystals may vary due to changes in abiotic environmental conditions but that their crystallographic orientation pattern is always the same.

The analysis of the morphological and the crystallographic ultrastructure in calcareous dinocysts gave evidence that this group of dinoflagellates is capable of influencing crystal growth as proved for other organism groups such as coccolithophorids. To date, the production of mineralized skeletal elements is regarded as a complex process which is induced and controlled by the organism with the help of especially designed organic macromolecules influencing the crystal lattice and therefore crystallographic patterns are regarded as genetically fixed characters.

The characters of the calcareous dinoflagellate cysts with the crystallographic orientation in the first place as well as the extent of the archeopyle and the abiltiy of producing paratabulation patterns can be used for a taxonomic system where features of theca and calcareous cyst of extant and fossil forms are combined.

Dinoflagellate cyst assemblages in surface sediments from the Arabian Sea off Pakistan (Northern Indian Ocean) - preliminary results

Jurkschat, Th. 1998. Dinoflagellate cyst assemblages in surface sediments from the Arabian Sea off Pakistan (Northern Indian Ocean) - preliminary results. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 78-79.

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The Arabian Sea is characterized by a seasonal high pelagic productivity along the shelf edge - upper continental slope caused by an extreme seasonal change of monsoonal activity underlain by a well developed oxygen minimum zone (OMZ) in water depths between 200 and 1000 m (von Stackelberg 1972). The samples for this study were obtained from box- and piston core tops taken during RV Sonne cruise 90 (von Rad et al. 1995) in 1993 between 64°-68° E (Fig. 1).

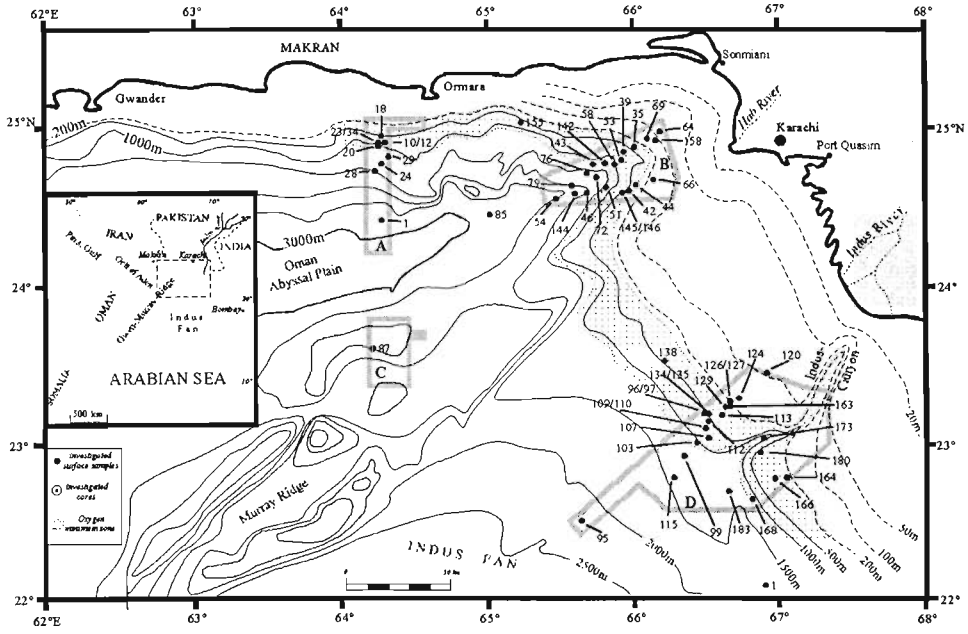

Fig. 1. Map of the N Indian Ocean, location of the studied areas and sampling stations.

The investigation is part of the PAKOMIN Project (Pakistan Oxygen Minimum Zone) to obtain a better understanding of global climatic changes and the processes leading to the formation of organic rich black shales.

For this purpose a detailed quantitative analysis of dinoflagellate cyst assemblages was made. Vegetative dinoflagellate cells were not found. Special attention was given to variation of species abundances inside and outside the OMZ and their causes. The distribution patterns of individual species are compared with oceanographic proxies (e.g. water temperature, salinity, nutrients). Ecological groups are formed and compared to paleoecologic preferences known from literature.

The results are interpreted in terms of influence from different water masses, variations in monsoonal activity, OMZ variability from Recent to Isotope Stage 6 and fluctuations of the fluviatile input (e.g. abun-

dance of freshwater algae *Botryococcus, Pediastrum*).

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Out break of PSP involving the mussel *Perna indica* in India

Karunasagar, I., Joseph, B., Philippose, K.K., Onodera, H., Oshima,Y. & Karunasagar, I. 1998. Out break of PSP involving the mussel *Perna indica* in India. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 79.

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During September 1997 an outbreak of paralytic shellfish poisoning (PSP) occurred in Kerala State, South West Coasat of India. Over seven hundred people from there villages of Vizhinjam, Poovan and Karunkulum were affected and seven persons died. Affected people consumed the mussel *Perna indica*. Mouse bioassay indicated toxin levels ranging from 7000-9000 mouse units/100 g. HPLC analysis indicated that the major components of the toxin were C1/C2, decarbamoyl GTX 2/3, decarbamoyl STX and decarbamoyl GTX 2/3. In eight weeks time, the toxin levels dropped to about 400 mouse units/100 g. Monitoring of the area for residual toxin levels in continuing.

Environmental affinities of *Thoracosphaera heimii* in laboratory and field studies

Karwath, B., Janofske, D. & Willems, H. 1998. Environmental affinities of *Thoracosphaera heimii* in laboratory and field studies. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 79.

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Thoracosphaera heimii is a marine planktonic dinophyte. It is phototrophic and the only dinoflagellate known to have a predominant calcareous coccoid stage in its vegetative life phase. The association of calcareous dinoflagellates in the plankton and in sediment cores is characterised by the overwhelming dominance of *T. heimii*. To gain a better insight into the environmental affinities of this species, *T. heimii* has been cultured under controlled laboratory conditions. The species was tested on its reaction to temperature, light and salinity variations. Additionally to the laboratory studies, the spatial distribution of *T. heimii* was studied in regions of the Atlantic. Samples were collected from the water column, ranging from 10 m to 100 m depth.

Calcareous dinoflagellates planktic distribution patterns

Kerntopf, B., Janofske, D., Karwath, B. & Willems, H. 1998. Calcareous dinoflagellates planktic distribution patterns. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 80.

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During several RV METEOR-cruises surface water plankton samples were collected in the equatorial Atlantic, offshore NW Africa, and around the Canary Isles. Relationships were established between planktic distribution patterns of recorded calcareous dinoflagellate species (i.e. vegetative-coccoid species *Thoracosphaera heimii* and calcareous dinocysts) and oceanographic parameters such as sea surface temperature (SST), sea surface sali-nity (SSS), productivity, biogeography, and the distributing currents of the hydrodynamic system. *T. heimii*-shells are found frequently throughout the studied area. During one cruise they showed maximum abundance at the Canary Isles (12 % of the shelled phyto-plankton organisms), but are absent in the nutrient rich waters offshore NW Africa (off Cape Blanc). The recorded dinocysts assem-blage consists entirely of calcareous species. The calcareous dinocysts can form up to 15 % of the shelled phytoplankton organisms. *"Sphaerodinella" albatrosiana* is the most abundant species in the equatorial East Atlantic; its planktic distribution pattern is linked with the distribution of *" Sphaerodinella" tuberosa* which shows maximum abundance in the equatorial West Atlantic. Both cyst species are restricted to low-latitude waters with SST higher than 24 °C; they may be regarded as thermophytes or as "warm water cysts". *"Sphaerodinella" tuberosa* shows a second restriction to waters with high SSS.

Temporal separation of basin restriction and the latest Palaeocene warm water pulse in the North Sea: High resolution palynofacies data

King, A. 1998. Temporal separation of basin restriction and the latest Palaeocene warm water pulse in the North Sea: High resolution palynofacies data. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 80-81.

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At the end of the Palaeocene in the North Sea Basin, two significant events occurred. Firstly, there is evidence of the Late Palaeocene climatic warming event, and secondly, the Late Palaeocene was a time of maximum basin restriction in the North Sea. The close temporal proximity of these two events has made their separation somewhat problematic until now.

UK Well 22/10a-4 is situated in the Everest Field, on the flanks of the Jaeren High in the UK North Sea. This well yielded over 122 m of continuous, well preserved core, representing a section through the Late Palaeocene Maureen, Lista and Sele Formations of Knox & Holloway (1992).

The intervals of interest in Well 22/10a-4 are the Lista/Sele boundary, marking the onset of

maximum basin restriction in the North Sea, and the Sele Formation, which was found to contain indicators of the well documented Late Palaeocene warming event.

Palynofacies analyses carried out on samples from Well 22/10a-4 indicate the onset of maximum basin restriction of the North Sea extremely well. Dramatic changes occur in the palynofacies assemblage at the level of the Lista/Sele boundary, with the green to grey-green, bioturbated claystones of the Lista Formation yielding a palynofacies dominated by black (oxidised) wood, and very few other components, this formation representing the open marine conditions present prior to the tectonic restriction of the basin. The Sele Formation is characterised by dark grey to black, well laminated mudstones, and has a much more diverse palynofacies assemblage, dominated by brown (unoxidised) wood, and moderate abundances of sporomorphs. Many of the component groups of the palynofacies assemblage show significant changes in abundance at the Lista/Sele boundary.

The tectonic event causing the maximum restriction of the North Sea Basin is clearly separated from the Late Palaeocene climatic warming event, which in Well 22/10a-4 is indicated by an influx of the warm water wetzelielloid dinocyst genus *Apectodinium*. At this locality, this dinocyst genus is present in the Sele Formation from a level 15m above the Lista/Sele boundary.

The preliminary data collected illustrate that the onset of maximum basin restriction in the North Sea, and Late Palaeocene climatic warming event can be clearly temporally differentiated at this locality.

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Dinoflagellate cysts are shown from Lower to Upper Cretaceous strata of the Helvetic and the Rhenodanubian Flysch Zone from South Germany and adjacent areas

Kirsch, K.-H. 1998. Dinoflagellate cysts are shown from Lower to Upper Cretaceous strata of the Helvetic and the Rhenodanubian Flysch Zone from South Germany and adjacent areas. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 81-82.

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In contrast to the Rhenodanubiain Flysch Zone, the Helvetic realm consists of an important, independent sequence of different facies. The Helvetic realm is located between the molasse basin in the north and the flysch deposits to the south. These sediments have been deposited along the southern part of the meso-european shelf, but later sheared from its originally position and involved into the northern alpine system. The sediments consist of sandstones, limestones and abundant sandy marls corresponding to shelf deposits.

The Rhenodanubian Flysch Zone is placed along the most northern margin of the alps and mostly overlaid by the nappes of the Calcareous Alps. In general, the sequence can be defined as a detrial marine sequence

comprised of alternating layers of redeposited turbidites and hemipelagic green and black shales. These flysch formations were deposited over a 75 million year period (Barrêmian - Maastrichtian) in undisturbed deep sea. The various stratigraphic and lithological members are characterised by different dinoflagellate cyst-associations which have been compared with the evolution of the different Helvetic realm and especially the Rhenodanubian Flysch Zone. Within partial stratigraphic sequence of Barrêmian to Albian and Upper Turonian to Maastrichtian sediments, approximately 1000 samples from 30 localities were taken. They have yielded more than 300 different dinoflagellate species.

The highest diversity of dinoflagellate cysts was found within the outer shelf sediments in the Upper Cretaceous where as in comparable flysch sediments diversity was normally very low. In particular, the rhythmically alternating black and green hemipelagic shales of the Lower Cretaceous (Aptian/Albian) are refered to the different content of organic carbon (Corg.) of the sediment. These reflect different associations of palynomorphs and dinoflagellate cysts due to a combined effect of preservation and production. The rhytmic sediments are explained as palaeo-productivity cycles, cyclic variations of oxygen content of the sea water or changes in the atmosphere-ocean system.

Organic matter analysis and dinoflagellate cysts of the Barremian/ Aptian boundary beds in the Hohenegelsen KB 50 borehole in Lower Saxony (NW Germany)

Kirsch, K.-H. & Below, R. 1998. Organic matter analysis and dinoflagellate cysts of the Barremian/Aptian boundary beds in the Hohenegelsen KB 50 borehole in Lower Saxony (NW Germany). - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 82-83.

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In the North West German Basin Corg.-rich black shales occur as fine laminated Blätterton-horizons in alternation with clay-stones in Barremian and Early Aptian times. The black shale development culminated in the "Hauptblätterton" of Barremian age and in the "Fischschiefer" of Early Aptian age. The borehole Hoheneggelsen KB 50 (Niedersachsen/Germany) recovered a unique section of Upper Barremian to Lower Aptian sediments.

The organic matter contains structured palynomorphs like dinoflagellate cysts, prasinophytes, bisaccate pollen and spores as well as amorphous kerogen and phytoclasts.

There are similar distribution patterns of the terrestrial palynomorphs and prasinophytes, which typically show an inverse relationships to the species diversity of dinoflagellate cysts. This reflects the changing influence of the continental system into the marine environment during Late Barremian and Early Aptian times. During deposition of the Corg.-rich Blättertone of the Blätterton/ Tonstein-alternation and the Fischschiefer the terrestrial input was high. Furthermore

the significant freshwater runoff formed a widespread wedge of reduced salinity stratified over normal marine salinity bottom watermasses.

These investigations show a characteristic pollen/prasinophyte/dinoflagellate cyst association in the laminated, Corg.-rich, dark Blättertone, deposited under anoxic conditions of seafloor-water. The minimum input of terrestrial palynomorphs is found within those sediments immediately following the Fischschiefer and indicates a sudden and remarkable change to a normal marine environment with decreased continental influence.

Within this partial stratigraphic sequence of Upper Barremian and Lower Aptian sediments more than 200 different dinoflagellate species have been yielded. Various lithological units are characterised by different dinoflagellate cyst-associations which have been compared with associations of the tethyan sediments from Southern Germany and adjacent areas.

Brackish water dinoflagellate assemblage of Lake Nakaumi, western Japan

Kojima, N. 1998. Brackish water dinoflagellate assemblage of Lake Nakaumi, western Japan. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 83.

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This study shows the assemblage structure of dinoflagellate motile cells and cysts in connection with environments in Lake Nakaumi, western Japan. Many brackish water lakes in Japan have intensely environmental changes in their water condition because of having a rainy season in a warm period and a localized torrential down-pour being caused by typhoon. This investigation and the previous studies have revealed a frequent occurrence of gymnodiniacean species blooms throughout the year and *Prorocentrum minimum* blooms in winter. The cyst assemblage of the lake are mainly composed of heterotrophic species. The result also indicate a general tendency of motile dinoflagellate assemblage type in the brackish water lake. In these unstable condition, r-strategists have an advantage position, but the multiplication rate of autotrophic dinoflagellates are inferior to that of diatoms (Banse 1982). The ratio of heterotrophic and mixotrophic dinoflagellates, then, increases their occupation ratio in the assemblage. The notable species of Lake Nakaumi is *Gyrodinium instriatum*. The cyst of this species has occupied relatively high percen-tages in the cyst assemblage of the lake. This peculiar dinoflagellate is mixotrophic species and it may shift nutritional type or their ratio between autotrophism and heterotrophism in propotion to environmental change.

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Orbitally induced changes in climate and ocean circulation reflected in the palynological record of Late Albian black shales from Central Italy.

Kouwenberg, L.L.R., Leereveld, H. & Galeotti, S. 1998. Orbitally induced changes in climate and ocean circulation reflected in the palynological record of Late Albian black shales from Central Italy. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 84.

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The Late Albian Amadeus segment from Central Italy consists of bundles of limestones, marls and black shale layers. Several authors have reported a response to orbital parameters (especially precession and eccentricity) of the carbonate content (Herbert & Fisher 1986), trace fossil distribution (Erba & Premoli Silva 1994) and planktic (Premoli Silva et al. 1989) and benthic (Coccioni & Galeotti 1993) foraminifera. The present study concentrates on the palynology of the two meter thick Amadeus segment in the Fiume Bosso section. Fluctuations in the palynological record matching the precession and short eccentricity cycle could be observed. In this study, productivity proxies might respond to eccentricity cycles rather than precession cycles. This indicates that black shale/marl bundles could represent periods of lower productivity compared to the more calcareous parts of the segment as a result of lower circulation rates and/or reduced vertical mixing. The individual black shale layers in these bundles contain relatively much higher amounts of pollen and spores than the marly layers, indicating enhanced run-off (more humid climatic conditions). The black shale layers are also characterized by a relatively high abundance of *Litosphaeridium conispinum* (within the genus) as opposed to the dominance of *Litosphaeridium arundum* in the marly layers. Increased fresh water input during periods of lower circulation intensity could have resulted in stratification of the water column, creating dysoxic conditions favourable for the preservation of organic matter.

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Holocene dinoflagellate cysts and chlorococcalean algae: Reconstruction of surface water masses in the Laptev Sea (Arctic Ocean)

Kunz-Pirrung, M. 1998. Holocene dinoflagellate cysts and chlorococcalean algae: Reconstruction of surface water masses in the Laptev Sea (Arctic Ocean). - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 85.

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Aquatic palynomorphs, in particular dinolagellate cysts were analysed by means of multivariate statistical analysis in order to define ecological preferences and to reconstruct the Holocene history and surface water masses in the eastern Laptev Sea. This shelf sea is located in the eastern Arctic Ocean and is characterized by a strong seasonality in sea-surface temperature and salinity, nine to ten month sea-ice cover per year, and an enormous freshwater influx from the large Siberian rivers in summer.

The distribution of dinoflagellate cysts in recent sediments is clearly related to the hydrographic conditions of the polar surface waters. The assemblages of the Laptev Sea shelf is dominated by *Brigantedinium* spp. (mainly *B. simplex*), *Algidasphaeridium? minutum* and related morphotypes. *Impagidinium? pallidum, Nematosphaeropsis labyrinthus* and *Operculodinium centrocarpum* characterize the asemblages on the continental slope. *N. labyrinthus* and O. *centrocarpum* indicate the influence of warmer Atlantic waters. To reconstruct the specific environmental conditions of the Laptev Sea in detail, it is necessary to use both marine dinoflagellate cysts and chlorococcalean algae which reflect the freshwater discharge into the Laptev Sea.

The development of the surface water masses during the last 7400 years is characterized by the influence of different water masses and a strong variability in the freshwater input. Between 7400 and 7000 B.P. the influence of higher saline water masses was very low due to the freshwater input. Around 6400 B.P. the freshwater discharge into the Laptev Sea was probably twice ass high as today. Since 2500 B.P. the fluvial input is similar to the present situation. The sea-ice margin has migrated landwards between 2500 and 1050 B.P. The productivity in surface water masses increased near the ice margin. At that time period some dinoflagellate cyst species documented, that Pacific surface water masses entered the eastern Laptev Sea sporadically. Since 1050 B.P. the average sea-ice margin in summer moved northwards and reached the present position (77°N) since 550 B.P. During the last 550 years a decrease of warm adapted dinoflagellate cyst species indicates a development of present day polar conditions.

Stratigraphic changes of Oligocene. Early Miocene dinoflagellate cyst assemblages from the boreal Northwest Pacific

Kurita, H., Obuse, A. & Matsuoka, K. 1998. Stratigraphic changes of Oligocene. Early Miocene dinoflagellate cyst assemblages from the boreal Northwest Pacific. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 86-87.

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This paper aims to describe Oligocene to Early Miocene dinoflagellate cyst assemblages from several outcrop localities in northern Japan and Sakhalin of Russian Far East, and to discuss their biostratigraphic and paleoenvironmental implications. Material from Sakhalin was collected by a Japan-Russia joint scientific project lead by Prof. Ogasawara, University of Tsukuba, Japan.

Standard Biostratigraphy in Hokkaido, northern Japan

Observation of dinoflagellate cysts from a composite outcrop section in Hokkaido, which has good age calibration by diatoms, planktonic foraminifera and radiometric dating, has lead to establish a biostratigraphic zonation for the Oligocene and Lower Miocene. Proposed are totally eight assemblage-zones; two in the Lower Oligocene, four in the Upper Oligocene and two in the Lower Miocene. This scheme has been tested its workability in outcrop and subsurface sections in Hokkaido, where occurrence of calcareous microfossils are not very significant.

General Stratigraphic Trends

Dominance by peridinioid taxa marks the early to middle Oligocene assemblages. The Early Oligocene assemblages are notable for persistent dominance by few species including *Trinovantedinium boreale* as well as for few stratigraphic changes through the interval. In the early Late Oligocene assemblages, number of species is also low, although the dominant species are replaced by *Williamsidinium* sp. A and *Spinidinium*? sp. C. These characteristics decline distinctively in the late Late Oligocene assemblages in which many non-peridinioid taxa including *Operculodinium*, *Spiniferites* and *Tuberculodinium* have their first significant appearance in the studied areas.

Oligocene Assemblages in Sakhalin

Early Late Oligocene assemblages which contain *Williamsidinium* sp. A have been found in the Makarov area in the southern part of Sakhalin Island and in Schmidt Peninsula in the north. This confirms extension in Sakhalin of the lower Upper Oligocene biozones defined in Hokkaido and suggests a probable coastal marine paleoenvironment relatively uniform from Hokkaido (present latitude 43° N) to northernmost Sakhalin (present latitude 54° N).

Discussion

When considering the overall stratigraphic trend in Cenozoic dinoflagellate cyst assemblages from northern Japan in a wider scope of geologic time (Kurita & Matsuoka 1995), the decline of the low diverse, peridi-nioid-rich flora in the Late Oligocene repre-sents one of the significant turnovers through the latest Paleocene - Middle Miocene record. This change may be interpreted in several ways; it can be a result of large-scale paleoceanographic changes in coastal waters such as latitudinal migration of cold water front, or a result of regional tectonic control on proximity and connectivity of the basin to the oceanic environment, or a mixture of those possibilities.

Further study on dinoflagellate cysts in the Northwestern Pacific - Kamchatka - Bering Sea region will be crucial for marine paleoenvironmental reconstruction in the boreal Pacific because of their potential biostratigraphic application as well as paleoenvironmental information from themselves.

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High-resolution dinoflagellate zonation and distribution in the Lower Paleogene, block 25/11, North Sea. Preliminary results

Kvernes, S. & Mangerud, G. 1998. High-resolution dinoflagellate zonation and distribution in the Lower Paleogene, block 25/11, North Sea. Preliminary results. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 87-88.

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The aim of this Cand.scient. thesis is to establish a high-resolution biostratigraphy of the Balder, Lista, Sele and Våle Formations, ranging in age from Early Paleocene to Early Eocene. The investigated succession is from the Grane-field (formerly Hermod), well 25/11-20, on the eastern flank of the southern Viking Graben, southern North Sea. The investigated succession shows a transition from Cretaceous carbonate deposition to Tertiary marine claystones. The Tertiary parts of the succession are often characterised by regionally mappable condensed sections, often associated with high gamma peaks. An example is the boundary between the clay-dominated Sele and the tuffaeous Balder Formations, which is picked on a distinctive high gamma spike (Mudge & Bujak 1996, Mudge & Copestake 1992). The most important regional biotic events are recognised by other North Sea stratigraphers. Important in the Upper Palaeocene Lista Formation, are the recognition of first downhole occurrence (FDO) of *Alisocysta margarita* and the various abundance events of *Areoligera gippingensis*. Also the FDO of *Palaeocystodinium bulliforme* and an abundance of *Palaeoperidinium pyrophorum* are important markers. There is also observed an additional abundant event of *Deflandrea denticulata*.

There is a sharp transition, with a marked drop in cyst diversity and a greater abundance of terrestrial derived material, from the Lista and up into the Sele Formation, with the lower Sele Formation characterised by the *Apectodinium* acme. The Lower Eocene Balder palynomorph assemblage is also dominated by pollen and spores, e.g. *Inaperturo pollenites*. Important dino-cyst markers are *Deflandea oebisfeldensis* and *Ceratopsis wardenensis*, which is basically found in the upper part of the formation. The lower part of the Hordaland Group shows an increased cyst diversity compared to Balder Formation, and an important marker is *Eatonicysta ursulae*.

The work includes identification of dinoflagellate cysts, construction of a range chart to outline their stratigraphic distribution, and the use of quantitative analysis to define important stratigraphic markers, local acme- and abundance events. One aim is also to establish the fossil content across defined condensed sections and compare them with

other high gamma log peaks that is not under this definition. The results presented, are preliminary, as this work is ongoing and much work still remains.

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Some applications of flow cytometry in studies of environmental agents in dinoflagellates

Lage, O.M., Sansonetty, F. & O'Connor, J.E. 1998. Some applications of flow cytometry in studies of environmental agents in dinoflagellates. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 88-89.

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Flow cytometry (FCM) is being increasingly used in diverse studies of phytoplankton and its relevance has been summarised by Phinney & Cucci (1989). FCM has unique advantages, namely: a) it makes possible the performance of fast real time multiparametric analyses, on significant samples, of more or less heterogeneous cellular populations; b) it is highly sensitive and reproducible; c) it is an efficient alternative for cell purification (cell sorting). We have been exploring FCM as an adequate approach to study the effect of environmental agents in cell populations of the unicellular marine dinoflagellate *Amphidinium carterae*, by monitoring alterations of: a) two intrinsic structural cell parameters, relative cell size (forward scatter) and complexity (side scatter) b) one intrinsic (amount of chlorophyll) and two extrinsic (esterase activity and oxidative burst) functional parameters. After cell loading with FDA, we obtained both decreases and increases of fluorescein labelling (Lage 1996, Lage et al. 1996). Lower fluorescein labelling was interpreted as decreases in esterase activity and/or affected membrane permeability induced by sub-lethal levels of copper. Higher fluorescein labelling was interpreted as an intracellular pH increase due to extreme copper toxicity, stress conditions in aged cultures and effect of some zwitterionic buffers. The first two conditions are associated with cyst formation. Kinetic measurements gave evidence of an immeadiate effect of copper on *A. carterae* by a raise of intracellular pH, which seems to involve an oxidative action on the Na^+/H^+ antiporter at the plasma membrane. Oxidative stress induced by copper was analysed by the detection of the production of superoxid anion and hydrogen peroxide after labelling with FCLA and DCFH-DA. An increase of both oxidants was observed under sublethal toxic levels (Lage 1996). The analysis of the red autofluorescence showed that chlorophylls were not affected by any of the agents studied. Our results show that FCM is a promising way to study cell physiological processes with relevance to environmental biology.

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Dinoflagellate assemblages from the Lebanese seawater (Eastern Mediterranean)

Lakkis, S. 1998. Dinoflagellate assemblages from the Lebanese seawater (Eastern Mediterranean). - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 89.

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Among 385 phytoplankton species found in the neritic Lebanese waters during the last 25 years of survey; 227 are dinoflagellates belonging to 33 genera while 151 species of diatoms are included in 46 genera (Lakkis et al. 1996). The majority of the species are of warm temperate type, with certain tropical affinities inhabiting the Mediterranean Sea. If the Dinophyceaea represents 60 % of total occurring phytoplankton species, they only contribute to 25 % of the entire standing crop. The ecological cycle of the dinoflagellates is characterized by regular spatio-temporal distributions in composition and in abundance. Qualitative and quantitative assemblages of populations are affected by the prevailing hydrographic conditions, namely temperature and salinity, much more than trophical factors and nutrient enrichment (Lakkis 1991). The density of populations and the species diversity are more important at offshore water than in coastal zone, and the concentration is higher in subsurface layers more than at sea surface. The peak in the abundance of the the majority of species is recorded usually during the second half of the year, between May and December, corresponding to the increase of temperature and salinity.

The genus *Ceratium* with 54 species and varieties comes first in number and in abundance, followed by *Protoperidinium* 32 species, *Dinophysis* 28, *Prorocentrum* 11, *Gonyaulax* 9 *Oxytoxum* 9 species, *Ornithocercus* 7, and *Amphisolenia* 6 species. Spatio-temporal assemblages carried out by clustering analysis provided two main species groups; a spring group and summer-fall group; while the principal component analysis leade to the ordination of the species on a the two factorial axis plan according to their variances.

Two Lessepsian migrant species present in the Lebanese waters are of Eritrean and Indo-Pacific origin and are confined only to the Levantine Basin; those are: *Ceratium breve*, with two varieties v. *schmidtii* and v. *parallelum*, and *C. egyptiacum*. Eleven potentially toxic dinoflagellates are present in this area but in few number, they belong mainly to the the four orders Dinophysales, Gymndiniales, Peridiniales et Prorocentrales.

The palaeoenvironmental distribution of the Upper Cenomanian-Lower Turonian dinocyst assemblages of Potiguar basin, North-eastern Brazil

Lana, C.C. 1998. The palaeoenvironmental distribution of the Upper Cenomanian-Lower Turonian dinocyst assemblages of Potiguar basin, North-eastern Brazil. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 90.

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The dinocyst contents of the upper Cenomanian-early Turonian section were investigated in seven boreholes from onshore and offshore sites of the eastern Potiguar Basin (NE Brazil). This section comprises a number of depositional environments, from continental (non-marine) to open marine siliciclastic deposits of the Açu and Quebradas Formations to the carbonate and mixed marine strata from the basal part of the Jandaíra Formation (Araripe & Feijó 1994).

The qualitative and quantitative analyses of dinocyst allowed for the recognition of distinct assemblages, whose distribution is closely related to the paleobathymetric variations, established by microfossiliferous and sedimentological data. The observed changes in the assemblages may be attributed to environmental changes, mainly related to the bathymetry, salinity, temperature and nutrients availability.

In the upper Cenomanian siliciclastic section the following assemblages were recognized, according to a onshore-offshore profile: paralic assemblages, strongly dominated by *Subtilisphaera* spp., whith high frequency of *Kallosphaeridium* sp. 1; shallow neritic, represented by *Spiniferites* spp. - *Florentinia* spp. *Odontochtina costata* - *Subtilisphaera* spp.; middle neritic, characterized by *Cribroperidinium cooksoniae* - *Exiguisphaera?* sp. 1, with a high species diversity expressed by several indeterminate gonyau-lacoid cysts; deep neritic assemblage, with the highest diversity, made up by *Spiniferites* spp. - *Exiguisphaera?* sp. 1 - *Odontochtina* spp. - *Florentinia* spp. - *Subtilisphaera* spp. - *C. cooksoniae* - *Trichodinium* spp. assemblage. The upper bathial environment, sampled only at the most distal site of the studied area, was distinguished by the low diversity Cyclonephelium spp. - *Spiniferites* spp. as-semblage.

The lower Turonian mixed and carbonate facies also presented different assemblages, whose distribution is probably related to the nutrient/terrigenous influx, higher in the proximal sites.

The analysis of the horizontal and vertical distribution of dinocyst assemblages confirm their potencial as paleoecological/paleobathymetrical indicators, besides allowing for paleoecological inferences to be drawn on some taxa.

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Microfossils and paleoenvironment of the Lower Cretaceous section of Subarctic Ural (North-Western Siberia)

Lebedeva, N.K. & Nikitenko, B.L. 1998. Microfossils and paleoenvironment of the Lower Cretaceous section of Subarctic Ural (North-Western Siberia). - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 91.

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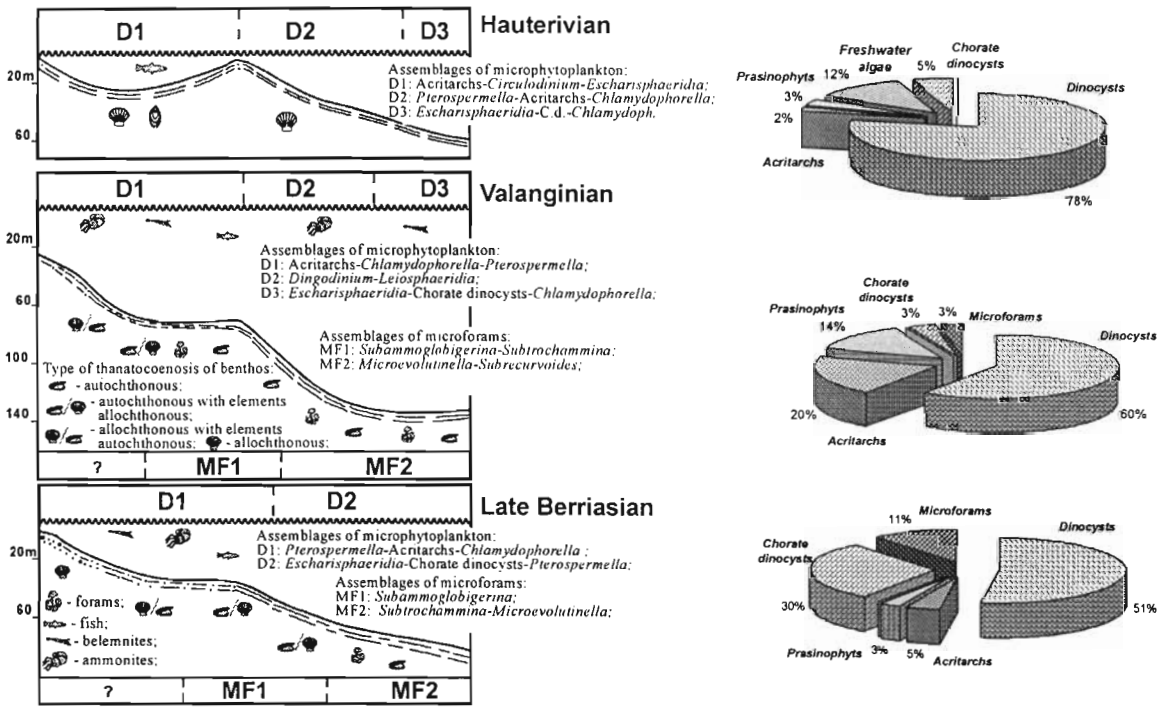
The most complete section of the marine Neocomian is exposed in the Subarctic Ural (Yatria River). There is a continuous sequence from Volgian to Lower Hauterivian deposits properly characterized by diverse associations of ammonites, belemnites, and bivalves. Paleoalgological study of this section has revealed a variety of microphytoplankton and microforaminifera assemblages. This section has a number of advantages for biofacial studies. It was deposited under a variety of marine environments ranging from rather deep-water to lagoonal. There are detailed litological, taphonomical, paleontological observation (Golbert et al. 1972). Moreover, micropaleontological and paleoalgological researches are carried out by the authors. Distribution of microphytoplankton and microforaminifera depending on fluctuation of a coastal line and depth are revealed. Consecutive changes of microphytoplankton and microforaminifera associations in the Cretaceous sea of Subarctic Ural reflecting environmental changes are established (Fig.). The boundaries of bionomical zones on microbenthos and microphytoplankton do not coincide, that is connected to a sharply differing image of life and to distinction of the factors of environment which control their distribution. This research was support by grant RFBR 96-05-66080.



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Cyst-theca relationships in the *Spiniferites* complex

Lewis, J. & Rochon, A. 1998. Cyst-theca relationships in the *Spiniferites* complex. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 92.

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Current understanding of the *Spiniferites* complex (including *Nematosphaeropsis, Impagidinium, Bitectatodinium, Tectatodinium,* and *Ataxiodinium*) suggests multiple "cyst species" giving rise to a single "motile species" (*Gonyaulax spinifera*). Much of the original work establishing cyst-theca relationships was done prior to improvements in the understanding of motile cell taxonomy based on detailed plate analysis. Therefore we have recently started work revisiting this complex using single cyst hatching experiments to establish taxonomic relationships within the group. We will report our preliminary findings on the excystment and re-encystment of *Spiniferites elongatus, S. membranaceus* and *S. ramosus*. Using cultures derived from single cysts we find there are subtle differences in the morphology of the motile stages arising from each of these species. We have re-encysted these cultures and the resultant cyst morphology can be variable findings analogous to those of previous studies on *Lingulodinium*.

Quaternary Western Mediterranean paleovegetation, paleoclimate and paleohydrology from the ODP Leg 161 Site 976 (Alboran Sea)

Londeix, L., Combourieu-Nebout, N. & Turon, J.-L. 1998. Quaternary Western Mediterranean paleovegetation, paleoclimate and paleohydrology from the ODP Leg 161 Site 976 (Alboran Sea). - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 92-93.

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Palynological analyses (dinocysts and pollen), investigated as regular sampling from the composite core at ODP Leg 161 Site 976 (Alboran Sea), allow to reconstruct a continuous record of marine and continentalpalaeoenvironmental changes in the West mediterranean for the almost complete Pleistocene and the Holocene.

Variations in dinoflagellate cyst assemblages correspond to the variations of marine superficial environments along the sequence. Interpretations interms of climatic and hydrological changes are correlated to continentalpaleoenvironmental changes during the same period as recorded by the pollen assemblages of the same samples.

Use of a dinocystal sea surface temperature proxyleads to distinguish numerous climatic oscillations, which are correlated to alternation between extensions of semi desert and

forest on theneighbouring continents. Such oscillations are related to the Pleistocene Glacial/interglacial cyclicity. An abrupt change in the dinocyst flora occurs around 700 ka and is interpreted as a sharp hydrological change in the sea surface waters.

Focused on the last 30 ka, the palynological records exhibits the classic climatic steps from the Last Glacial Maximum to the Holocene (Last Glacial Maximum, Oldest Dryas, Bölling/Alleröd, Younger Dryas) and Holocene. Three coolings of the Sea surface waters are marked by the development of the dinocysts *Nematosphaeropsis labyrinthea* and/or *Bitectatodinium tepikiense* and correlated with three aridity phases on the Alboran Seaborderlands. Two of them are related to periods of enhanced productivity and pointed out around 15.5 ka and during the Younger Dryas.

A new "microwave technique" for the recovery of organic walled dinocysts from sediment: Efficiency and reproducibility tests

Loucheur, V. & de Vernal, A. 1998. A new "microwave technique" for the recovery of organic walled dinocysts from sediment: Efficiency and reproducibility tests. - NTNU Vitensk.mus. bot. Ser. 1998-1: 93-94.

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An automated system for chemical treatments using a microwave oven (Microdigest apparatus designed by Prolabo) was adapted for the palynological preparation of marine sediment in order: (i) to foster the dissolution of silicate particles and the elimination of inorganic material from the sediment and, thus, to improve the quality of slides to be analyzed, (ii) to decrease the time required for samples preparation, and (iii) to improve the safety during sample preparation, by reducing the number of manipulations.

The efficiency of the chemical treatments using microwaves depends upon the power and the time of exposure, which were determined after experiments performed on samples characterized by abundant silicate and/or organic matter. Treatments with a microwave power ranging 10 to 30 % during 5 to 20 minutes were adequate, depending upon the nature of the sample.

Reproducibility tests were performed in order to compare the palynological assemblages after different techniques of preparation, with and without microwaves. The analyzed samples (N ~ 100) are representative of different types of sedimentary facies: pelagic, hemipelagic or terrigenous, some of them being characterized by abundant detrital or biogenic silica, or terrestrial organic matter.

Systematic observations and counts were done under transmitted light microscope, with special attention paid to dinocysts. On the whole, the results indicate that none of the currently observed dinocyst taxa are selectively affected by microwave treatments following the procedure described above. The cysts of *Protoperidium* spp., which are particularly fragile and often affected by oxidation treatments, remain well preserved after microwave digestion. The technique we have developed does not alter the composition of dinocyst assemblages. However, the microwave cooking affects the chromatic signature of most taxa, both in transmitted light and in fluorescence. As a consequence,

many cyst taxa (e.g., *Spiniferites* spp., *Impagidinium* spp., *Peridinium faeroense, Nematosphaeropsis labyrinthus,* and *Trinovantedinium capitatum*) that are normally semi-transparent yield a yellowish to brownish color, and lose their fluorescence.

Prorocentrum from Chinese coastal waters and the Baltic and North Sea

Lu, D. & Göbel, J. 1998. *Prorocentrum* from Chinese coastal waters and the Baltic and North Sea. - NTNU Vitensk.mus. Rapp. bot. Ser.1998-1: 94.

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Eight *Prorocentrum* species (Dinophyceae), namely *P. balticum, P. donghai, P. gracile, P. minimum, P. micans, P. rostratum, P. sigmoides, P. triestinum,* were examined and identified by light and scanning electron microscope. The species identification is based on shape, size, valve surface micromorphology, ornamentation of thecal plates and the architecture of the periflagellar area and intercalary bands. Most of them have been recorded as blooming-form species. Some aggregates of *Prorocentrum* are observed at the end of blooms. An event of strong discoloration caused by *P. donghai* could be detected by satellite sensor in the East China Sea in the late spring of 1995.

Ynezidinium, a new gonyaulacoid genus from the Paleocene of California

Lucas-Clark, J. & Helenes, J. 1998. Dino - *Ynezidinium*, a new gonyaulacoid genus from the Paleocene of California. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 94-95.

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Studies of a Paleocene (Bulitian) florule from the Santa Ynez Mountains of Southern California yeilded well preserved specimens of a gonyaulacoid dinoflagellate species which is similar in some repects to some previously described species which have been difficult to classify.

"Ynezidinium malloyi" shows paratabulation details which indicate that it belongs to the Family Gonyaulacaceae, subfamily Leptodiniodeae, but which, in combination, distinguish it from previously described genera. The paratabulation details include: 1) pentagonal sixth precingular (1i) in contact with both fourth and first apicals (A and 1u); 2) elongate and subparallel fourth and first apicals; 3) sigmoidal sulcal region; 4) lack of

small intercalary (K) paraplates; 5) Q/B preapical arrangement.

The paratabulation details of *Ynezidinium* are probably identical to those of the genus *Spiniferella*, but that genus, like *Spiniferites*, is distinguished by furcate gonal spines. In general, the similarity in detail of the paratabulation of species of gonyaulacoid genera with and without furcate gonal spines, raises a question as to whether these species should be placed in separate genera, or whether the same species might occur with and without gonal spines in differing environments. Clarification from living species of gonyaulacoids which produce cysts would be welcome, but could have a severe impact on generic classification of fossil species.

Other species which show *"Ynezidinium"* paratabulation features, insofar as they are expressed include: *Impagidinium brevisulcatum* Michoux 1985, *I. pentahedrias* Damassa 1979 *I. waipawaense* Wilson 1988, and *Leptodinium latolineatum* Yun 1981. These species will be newly combined with *Ynezidinium* in a forthcoming publication by the authors.

Dinoflagellate cyst biostratigraphy in the Miocene of NW Germany and neighbouring areas

Lund, J.J. 1998. Dinoflagellate cyst biostratigraphy in the Miocene of NW Germany and neighbouring areas. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998 - 1: 95-96.

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Based on investigation of dinoflagellate cysts from the research wells Nieder Ochtenhausen (Strauß et al. in print) and Groß Pampau as well as on unpublished exploration wells, possibilities of stratigraphic subdivision of the NW European Miocene are discussed. *Impagidinium "densiverrucosum"* occurs in microfaunal dated Pliocene-Miocene transition of the Ems Area and is tentatively used to mark the top of the Miocene in the southern North Sea. *Cannosphaeropsis passio* is an important marker in the higher Middle Miocene dated by other means in the Groß Pampau well (Spiegler & Gürs 1996). In the deeper Middle Miocene FAD and acme of *Nematosphaeropsis aquaductum* yield a prime correlation horizon, which can be traced to the Mediterranean. The Lower Miocene displays a series of stratigraphically useful LAD's with *Cribroperidinium tenuitabulatum* and *Cordosphaeridium cantharellum* marking the top of the Lower Miocene.

Contrary to earlier opinions (e.g. Daniels et al. 1990), the genus *Palaeocystodinium* range into the deeper Upper Miocene, but differentiation of species helps to distinguish Upper, Middle, and Lower Miocene. The occurrences of *H. obscura* and *S. armageddonensis* overlap in the higher Upper Miocene of Nieder Ochtenhausen indicating a stratigraphically more complete sedimentary succession than the one investigated by de Verteuil & Norris (1996) from eastern North America.

There are considerable differences in dinoflagellate cyst communities between localities near the basin margin and such in more central areas. The latter are often extremely rich in dinoflagellate cysts, but abundance of *Polysphaeridium zoharyi* is only observed in the more marginal areas.

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Evolution of *Dinopterygium* and other goniodomaceans: Problems and progress

MacRae, R.A. 1998. Evolution of *Dinopterygium* and other goniodomaceans: Problems and progress. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 96-97.

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Numerous, superbly-preserved specimens of *Dinopterygium* from the Late Albian (latest Early Cretaceous) Kiowa Formation, Kansas, USA have been subjected to detailed light and SEM microscopy, and are tentatively assigned to the type species, *Dinopterygium cladoides*. The complete paratabulation and partial overlap pattern have been determined. As previously recorded in the literature, the tabulation corresponds to the formula 1pr, 4', 6'', Xc, 6''', 1p, 1'''', 1ps, the hypocystal tabulation is quinqueform with ps in the sulcus, and the epicystal tabulation is insert. New observations include a recognition that the archeopyle is not always epicystal, but can involve only some of the apical series, the entire apical series plus some precingulars, or the entire epicyst. In this way, the archeopyle is very similar to that described for the modern, chorate cyst *Polysphaeridium zoharyi*, produced by the thecate stage *Pyrodinium bahamense*, and for the fossil cyst *Homotryblium*, all regarded as goniodomaceans of the subfamily Pyrodiniaceae. These archeopyle observations call into question the generic distinction between *Dinopterygium* and *Xiphophoridium*, and with the type of *Glossodinium*, *Glossodinium dimor-phum*, which has been considered a junior synonym of *Dinopterygium* by some authors.

Additional surface details of *Dinopterygium* bear remarkable resemblance to the theca of modern *Pyrodinium*. For example, plate growth is reflected in the cyst, and pores in the cyst correspond to the distribution of trichocyst pores in the theca of *Pyrodinium*. The development of septal crests on *Dinopterygium* closely parallels the theca of *Pyrodinium* in that the septa are not precisely on the parasutures, but are usually displaced to one side, with the displacement related to the direction of plate overlap. The development of antapical horns as elongations of the septa, and the occurrence of a large pore in the preapical plate also correspond to similar features in *Pyrodinium*. The main anatomical difference between these specimens of *Dinopterygium* and modern *Pyrodinium*, other than their being a cyst, is their insert epicystal tabulation - *Pyrodinium* is meta-

sert - and the development of spines along the septa, which is highly variable in these specimens, and in other species of *Dinopterygium*. With such a close analogue as far back as the Cretaceous, it is natural to wonder why all modern goniodomaceans, and, indeed, most Cenozoic goniodomaceans, produced chorate cysts. Perhaps this is only a relatively recent development.

The fossil record of *Dinopterygium* suggests a first appearance in the Late Jurassic, if the reassignment of *Glossodinium dimorphum* is accepted, otherwise the earliest record of *Dinopterygium* is in the Early Cretaceous. The upper limit to its distribution is harder to determine, but is at least as young as Maastrichtian. They have been recorded from the Cenozoic, but at least some of these may be the related goniodomacean *Heteraulacacysta*, to which it bears superficial resemblance. Further research is needed to determine whether true *Dinopterygium* are found in the Cenozoic.

Fossil dinoflagellates: The past as a key to the present

MacRae, R.A., Fensome, R.A. & Williams, G.L. 1998. Fossil dinoflagellates: The past as a key to the present. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 97-98.

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It is estimated that only about 15 percent of living dinoflagellates produce fossilizable cysts. This percentage implies that the dinoflagellate fossil record is woefully incomplete. In the past, this observation has led to the pessimistic view that the fossil record can say little about dinoflagellate evolution. However, we maintain that, if viewed from certain perspectives and with due caution, the dinoflagellate fossil record not only has much to say about evolution, but can point to areas of potentially fruitful investigation of living dinoflagellates.

Most obviously, the fossil record provides evidence of entire groups about which we would otherwise know nothing. Perhaps the most spectacular example is the order Nannoceratopsiales, whose single genus, *Nannoceratopsis,* is restricted to the Jurassic. *Nannoceratopsis* is a kind of dinoflagellate centaur, half peridiphycidean, half dinophycidean - a classic evolutionary link. In another example, the gonyaulacalean suborder Cladopyxiineae is today represented by one family and five genera, in contrast to five families and over thirty genera in the fossil record. Intriguingly, the tabulation of fossil cladopyxiineans is in many ways intermediate between that of the Gonyaulacales and Peridiniales. An examination of the broad pattern of the fossil record is also revealing. The pre-Mesozoic record is largely devoid of forms that can be reasonably linked with the dinoflagellate lineage - only the Silurian *Arpylorus antiquus* is a respectable candidate. This is despite evidence from cell ultrastructure, molecular phylogenetic and biogeochemical studies, which together indicate that the dinoflagellate lineage had diverged by Cambrian times, possibly earlier. The early record is thus in sharp contrast to the situation for the Mesozoic and Cenozoic. The dinoflagellate record of the Mid Triassic to Mid Jurassic shows evidence of a major radiation event. Within a relatively short period of geological time, all the main tabulation types appear, along with many other types that were eventually "winnowed out" by extinction - dinoflagellates appeared to be "experimenting" with tabulation. Is it possible that there were at least two radiation

events in dinoflagellate history: one in the early Mesozoic that was responsible for producing the modern dinoflagellate flora, and one when dinoflagellates originally diverged, which left a cryptic record at best.

Molecular phylogenetic analysis should be able to test some of these evolutionary hypotheses. For example, if some modern, non-fossilizable forms (e.g. syndinialeans and noctilucaleans) are relicts of a pre-Mesozoic divergence, this should be apparent from such analyses. In another case, molecular analysis of *Cladopyxis* could be critical in confirming or denying the hypothesis that peridinialeans derived from the gonyaulacalean cladopyxiineans. The way ahead is clearly a collaboration between paleontologists and neontologists; any complete evolutionary analysis of dinoflagellates must take account of fossil evidence, as well as information from, for example, molecular phylogenetics and living cell ultrastructure.

Late Mesozoic non-marine dinoflagellates - when did they invade land-water from the ocean

Mao, S., Wan, C., Qiao, X. & Zhao, C. 1998. Late Mesozoic non-marine dinoflagellates - when did they invade land-water from the ocean. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 98-99.

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The fossil records of dinoflagellaates provide complementary evidence in revealing the evolution of the extent dinoflagellates that live in both ocean and land-water today. The traditional idea drew based on the available fossil records that dinoflagellates did not migrate to land-water until the Early Tertiary, and the occurrences of pre-Tertiary dinoflagellates indicate marine transgresion has prevailed before the late 1980', no matter that records of Cretaceous non-marine dinoflagellates were firstly reported from China in 1981. For the last 10 years non-marine dinocysts have been recovered from a number of basins including the large songliao basin in northeastern China. Geological and gechemical evidence indicte that these basins are in-craton lacustrine basins far away from paleoceanic coast. There are no Cretaceous marine fauna and flora found in these basins, on the contrast, the paleobiota including more than 20 groups (such as Ostracoda, Conchostraca, Bivalves, Gastropoda, fish, Charophyta, Cyanophyta, stromatolites, Chlorophyta, dinoflagellates, Euglenophyta, acritarchs, macrobotanical fossils of Pteridophyta, gymnosperms, and angiosperms, turtles, lizards, dinosaurs, and insects) yielded from these basins support their terrigenous origin, and they consist of species of mostly endemics.

The early dinoflagellate flora in northeastern China is composed of mainly ceratioid and gonyaulacoid cysts. The former are more diverse including 25 species of 9 genera as *Balmula, Cruciceratium, Cyclonephelium, Lacustridinium, Nyktericysta, Pseudoceratium, Quasiperidinium, Tetrangulodinium,* and *Versperopsis*. Among gonyaulacoid cysts there are 19 species belonging to 8 genera as *Batiacasphaera, Cleistosphaeridium, Chlamydophorella, Dinogymniopsis, Kiokansium, Operculodinium, Sentusidinium* and *Tetrachacysta*.

All peridinioid cycts produced in these basins posses combination archeo-pyle the formation of which involved at least intercalary and apical plates, they *are Bohaidina, Bosedinia, Palaeoperidinium, Paraperidinium,* and *Zhongyuandinium.* Two types of dinoflagellate associations basically related to water salinity were recognized, the one developed in frush water to slightly brackish water (with NaCl 0-<0.50 ‰) environment is dominated by ceratioid cysts while another developed in slightly brackish to brackish water (with NaCl 0.23-0.58 ‰) is mainly composed of gonyaulacoid cysts. Geochemical testing of sediments, for instence, value of Sr/Br being < 0.8 (0.32-0.58) (>0.8 in marine sediments) indicate both associations are terrigenous non-marine.

These evidences may suggest that marine dinoflagellates invaded land-water much earlier than Early Tertiary and non-marine dinoflagellates may have a evolution pattern parallel to their marine counterpart during Late Mesozoic time.

Subsurface bloom of the *Prorocentrum arcuatum* schiller in the saline coastal lake Rogoznica (Adriatic sea)

Marasović, I. & Ninčević, Ž. 1998. Subsurface bloom of the *Prorocentrum arcuatum* Schiller in the saline coastal lake Rogoznica (Adriatic sea). - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 99.

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Prorocentrum arcuatum is an autotrophic thecate dinoflagellate which seasonaly forms subsurface blooms in the saline coastal lake Rogoznica. *P. arcuatum* is not present in the surrounding sea with which the lake communicates via many small cavities (karst area).

The *P. arcuatum* bloom is linked to specific conditions in the lake. which contain a large amount of nutrients and H_2S, are hypoxic or anoxic.

During most of the year the lake is extremely stratified - thermocline and halocline are present at depths between two and eight meters depending on the season. The bloom is generaly found in the layer with the highest temperature.

Pole to pole dinoflagellate cyst distribution in surface sediments: Ecological and oceanographical significance

Marret F., de Vernal A., Harland, R., Matthiessen, J., Rochon, A., Turon, J-L., Zonneveld, K., Hoeck, R. & Willems, H. 1998. Pole to pole dinoflagellate cyst distribution in surface sediments: Ecological and oceanographical significance. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 100-101.

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Dinoflagellate cyst analysis in recent sediments of the North Atlantic and adjacent basins (Rochon 1997), the equatorial Atlantic and the Southern Oceans have provided data bases documenting the distribution of cyst assemblages and their relationships with environmental conditions. Herein we present the cyst assemblages recovered from north to south, and compare their taxonomic composition and the biogeographical significance. On the whole, the different data bases reveal the latitudinal trend, temperature, salinity, and sea-ice cover influence, and the coastal to oceanic water mass trend in the cyst distribution. From a diversity point of view, in high latitudes of both hemispheres, sediment samples record a high number of taxa (ca. 50) while the number decreases with latitude (towards ca. 40 in the equatorial domain). However, from high to low latitudes, 8 to 14 taxa constitute ca. 90 % of assemblages. Although differences in the taxonomic composition are observed, polar assemblages in the north and south high latitudes are mainly dominated by the Peridiniaceae species (*Algidasphaeridium? minutum* and *Brigantedinium* spp. in the north, and *Selenopemphix antarctica*, recognised as an endemic species, and *Brigantedinium* spp. in the south) accompanied with the Gonyaulacaceae species *Impagidinium? pallidum.* Cold environments are characterised by the occurrence of the Gonyaulacaceae species *Operculodinium centrocarpum* and *Nematosphaeropsis labyrinthus* in both high latitude regions. Low latitude cyst distribution is related to a combination of hydrological factors (coastal upwellings, river discharge and thermal domes). For instance, *Brigantedinium* spp. is largely abundant in low salinity environments, whereas *Spiniferites delicatus, Polykrikos*

kofoidii and *Nematosphaeropsis labyrinthus* are abundant in samples located in the seasonal coastal upwelling. The documentation of the dinoflagellate cyst distribution in various environments illustrates the ecological affinities as well as the biogeographical boundaries, and offers a means to interpret fossil assemblages in terms of past sea-surface conditions.

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Paleogeographic implications of Oligocene dinocysts from the phosphorites deposits of Baja California Sur: Opening of the Gulf of California

Martínez-Hernández, E. & Ramírez-Arriaga, E. 1998. Paleogeographic implications of Oligocene dinocysts from the phosphorites deposits of Baja California Sur: Opening of the Gulf of California. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 101-102.

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In this particular survey, several localities from "El Cien" and "San Gregorio" formations had been studied. At the "Aguajito" and "San Juan de la Costa" regions, the lower part of the San Juan member was sampled. At the Purisima region, several outcrops belonging to the San Gregorio Fm. previosly dated by Kim & Barron (1986) as Late Oligocene based in the presence of diatoms *Rocella vigilans* (sub-zone B), but later, several boreholes were drilled by "El Consejo de Recursos Mine-rales", which were carefully sampled and studied.

The recuperation of palynomorphs vary from region to region, the best results were obtained from the boreholes from "La Purisima" (La Bocana Proyect), where the preservation and quantity of palynomorphs is excellent with the preservation and quantity of palynomorphs is excellent with presence of sixty five taxa of dinocysts throughout the column, which allow a good biostratigraphic control by the occurrence of *Chiropteridium lobospinosum, Hystrichokolpoma rigaudiae, Cribroperidinium tenuitabulatum* and *Melitasphaeridium choanophorum.* Other dinocysts have paleoecologycal significance as *Lingulodinium machaerophorum* and *Operculodinium centrocarpum* the former indicator of cold to temperate water and high productivity and the second taxon is only abundant in high latitudes decreasing toward tropical cater masses. All the above mentioned taxa with high percentages at the Purisima, also occur to the South at the San Juan member of the "El Cien" Formation and in the Aguajito and San Juan de la Costa areas- Nevertheless, if the assemblages from San Gregoria Fm. (Purisima region) are compared with the assemblages from the southern localities (Cien Formation), it is noticeable a drastic decrease in the number of taxa as well as in the absolute number of palynomorphs per gram of sediment. Also the planktonic green algae *Tythodiscus* sp. and *Pterospermella* sp. follow the same ecological trend, diminishing their value at

"San Juan de la Costa" and Aguajito localities. On the other hand, there are some taxa as *Thalassiphora* cf. *pelagica* which distributions is the opposite, being more abundant toward southern localities. The differences in the assemblages in these litostratigraphic units can be interpreted as the result of distinct environmental setting: at the region "La Purisima" (San Gregorio Fm.) correspond to an open neritic platform with high productivity which allow the accumulation of phosphorites as well as diatomites. In contrast, at the Aguajito and San Jua de la Costa (El Cien Fm.) the assemblages indicated a stressful environment that can be related to the opening of the Gulf of California. The palynological data suggest a cool ocean current on the continent with a semiarid landscape.

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Dinoflagellates and stratigraphic interpretation of the Early Eocene (Sparnacian) transgression in the Northeastern part of the Paris

Masure, E., Hochuli, P.A. & Lecomte, G. 1998. Dino - Dinoflagellates and stratigraphic interpretation of the Early Eocene (Sparnacian) transgression in the Northeastern part of the Paris. - NTNU Vitensk.mus Rapp. bot. Ser. 1998-1: 102-103.

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The Sparnacian, a regional stage defined in the northern part of the Paris Basin (Dollfus, 1880) corresponds to the first Eocene transgression over the Late Cretaceous Chalk. For a long time the corresponding lithological units (Argile plastique & Lignites) were regarded as isochronous. Based on palynological evidences, Gruas (in Laurain et al. 1983) considered the Sparnacian of the type area near Epernay younger than the same marginal marine facies in the area of Soissons. The type section in the Epernay area contains dinoflagellate assemblages which can be assigned to the regional zones W3-W5 of the Paris basin (Châteauneuf & Gruas 1978) whereas the assemblages of the Soissons area defined zone W1 of Châteauneuf & Gruas (1978).

New results obtained from three sections of the Soissons area indicate also a younger age ranging from zone W3 to W5 or in terms of the British and the Northwest European zonations from the upper part of the *D. simile* zone to the *Kisselovia coleothrypta* zone (Powell 1992) and from the D 7a to D 8 (Costa & Manum 1988) respectively. These zones correspond to the interval between the upper part of calcareous nannoplankton zone NP11 and the lower part of

NP12. According to these results the authors suggest that the Sparnacian and the Cuisien stages might be at least partially equivalent. The regional dinoflagellate zones W1-W5 (Châteauneuf & Gruas 1978) have to be compared with better known sections from Belgium and England and their significance reconsidered.

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Dinoflagellate cyst evidence for sea-surface conditions in the southeastern Norwegian Sea during the last glacial/interglacial cycle

Matthiessen, J., Turon, J.-L., Eynaud, F. & Labracherie, M. 1998. Dinoflagellate cyst evidence for sea-surface conditions in the southeastern Norwegian Sea during the last glacial/interglacial cycle. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 103-104.

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Dinoflagellate cysts analysis of high-resolution sediment core MD 952009 which was recovered east of Faeroe Island revealed a high amplitude variability of the assemblages during the last glacial/interglacial cycle. The strong fluctuations in assemblage composition reflect changes between periods with an enhanced inflow of warmer surface waters from the North Atlantic and with a predominance of colder polar conditions. The continuous presence of species adapted to warmer conditions suggest that the southeastern Norwegian Sea did not have a perennial sea-ice cover during tha last glacial. The seasonal extent of sea-ice cover varied considerably and relatively open water conditions prevailed at the core location in summer even during colder periods. The strong variability of surface water conditions is a recurrent feature during the entire oxygen isotope stages 2 to 4 including

Terminaation Ia and the Last Glacial Maximum (LGM).

The comparison with a dinoflagellate cyst recort from the East Greenland continental margin shows that the glacial surface water conditions in the Norwegian-Greenland Sea were probably characterized by strong Zonal gradients. The modern oceanographic conditions were established stepwise during Termination I. The interglacial circulation system existed from ca. 13 000 years BP, and a reorganisation of the hydrography resulted in surface water conditions with three major water masses from the end of Termination I.

Dinoflagellate cyst from the last deglaciation of the Laptev Sea continental margin (Eastern Arctic Ocean)

Matthiessen, J., Boucsein, B., Fahl, K. & Stein, R. 1998. Dinoflagellate cyst from the last deglaciation of the Laptev Sea continental margin (Eastern Arctic Ocean). - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 104.

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Relatively few information are available about paleoenvironmental development along the Sibirian continental margin during the last deglaciation. This is mainly due to the extreme environmental and sedimentary conditions in the Arctic Ocean resulting in the absence or low abundances of calcareous and siliceous microfossils in sediments. Variable fresh water discharge from the large Siberian rigers associated with a high suspension load in the river plumes cause additional ecological stress and further limits the ability of marine planktic species to cope with such harsh conditions.

In the framework of sedimentological and geochemical investigations on the paleoenvironmental evolution during the last 13,000 years, a comprehensive study on palynomorphs, in particular dinoflagellate cysts, has been conducted in a welldated sediment core form the continental slope off the Laptev Sea (PS2458) to elucidate paleoceanographic changes during the last deglaciation. Previous stable isotope, and geochemical studies suggest that distinct changes in deposition of organic carbon occurred during Termination I. In particular, the content of marine organic carbon increased first after Termination Ib. The palynomorph record will be compared with bulk geochemical parameters, maceral analysis and certain biomarkers (sterols, alkanes, fatty acids) to evaluate the potential of dinoflagellate cysts and oter palynomorphs to reflect these changes in organic carbon accumulation, to describe qualitatively and quantitatively organic matter fluxes, and to reconstruct the source and age of organic matter.

Dinoflagellate cysts and harmful algal blooms

Matsuoka, K. 1998. Dinoflagellate cysts and harmful algal blooms. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 105.

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As some harmful dinoflagellates can produce resting planozygotes preservable in sediments, we can recognize past harmful events through various analytical methods. The subjects carried out by such methods are followings so far;

1 Biogeographical distribution of harmful species.
2 Recognition for seed beds of harmful species.
3 Population dynamics of harmful species recorded in sediments.
4 Toxicological study on living cysts accumulated in surface sediments.
5 Artificial migration of harmful species through ballast water tanks.
6 Expansion timing of harmful species.
7 Cyst formation index.
8 Living cysts as "seed bank".

Among them, it is one of interesting and important subjects for both paleontologists and biologists to know how many cysts can be produced from vegetative cells. For taking basic information relationship among numbers of vegetative cells, planozygotes, and hypnozygotes (resting cysts) of harmful dinoflagellates, an annual field observation for *Alexandrium catenella* (Whedon et Kofoid) Balech was carried out from June of 1983 to June of 1984 in Tanabe Bay, central Japan. The cell number of normal vegetative cells and planozygotes produced in that year were calculated based on the cell numbers taken at three levels of the water column (1 cm^2 x 1 350 cm) by using water sampler. The cysts were collected by using a sediment trap settled at the same station for observation of motile cells.

The results from this investigation are as follows;

The number of normal vegetative cells in the water column was 1.15 x 106 in max. to 6.6 x 105 in min. cells/cm^2/1350 cm/year. The number of planozygotes in the water column was 2.8-3.5 x 104 cells/cm^2/ 1350cm/year. The total 5.7 x 103 cysts/cm^2 was produced within the same year. Based on these date, the index of cyst formation [C/I = 2Nc/ (N+ 2 Nc)*100 (%)] is 1.2 to 2.1 %.

Most of the vegetative cells and planozygotes were reproduced during the big bloom during May 19 to 25 in 1984, and in other seasons these cells were very low in cell number. The time-distribution of the cysts also showed as the pattern of the vegetative cells.

Preliminary results from a survey of dinoflagellate cysts in recent marine sediments around the coasts of the British Isles

McCall, H., Lewis, J.M. & Reid, P.C. 1998. Preliminary results from a survey of dinoflagellate cysts in recent marine sediments around the coasts of the British Isles. - NTNU Vitensk.mus. Rapp. bot. Ser.1998-1: 106.

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A survey of dinoflagellate cysts was conducted in intertidal sediments at selected sites all around the coasts of the British Isles. Sites were chosen to approximate to sites sampled in a survey conducted by P.C. Reid in 1968 (Reid 1972). Non-destructive methods of extraction of cysts by sonication were used to provide the first survey around the British Isles to include the calcareous cysts. The sonication method was compared with HF acid extraction. Sites where subtidal sinks occur in association with high levels of rain-water runoff, such as the Western Scottish sea lochs, had very few cysts in the intertidal sediments. Small isolated accumulations of mud amongst mobile sandy sediments were found to act as traps concentrating cysts. G:P ratios were found to be very much lower than those found in 1968, and this is believed to be due to the destructive HF acid extraction methods used by Reid. Geographic zonation of cyst assemblages was similar to that found by Reid (1975), with the zones bounded by frontal systems. This is shown by the sharp delineation of ranges provided by the Flamborough Front in the North Sea, the clear separation between the Celtic and Irish Seas, and the assemblages characteristic of the Moray Firth. The significant reduction in numbers of *Lingulodinium polyedrum* found in the estuary of the River Dee (Wales) will be discussed and may be due to an increase in turbulence since 1968.

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Palynomorphs as ideal biostratigraphic and paleoenvironmental tools for sequence stratigraphic studies - an example from the New Jersey margin

McCarthy, F.M.G., Gostlin, K.E. & the ODP Leg 174A Scientific Party 1998. Palynomorphs as ideal biostratigraphic and paleoenvironmental tools for sequence stratigraphic studies - an example from the New Jersey margin. - NTNU Vitensk.mus. Rapp. bot. Ser. 1988-1: 107.

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A major objective of ODP Leg 174A (New Jersey shelf and slope) was to test the concept that sequence boundaries result from glacioeustatic sea-level fluctuations (Shipboard Scientific Party in press). This requires dating sequences to test the assumption of global synchroneity as well as evaluating the importance of more local influences, e.g. tectonic processes, subsidence, and sediment supply in determining continental margin architecture. A broader aim was to investigate how sea level change affects sedimentation on continental margins. Continental shelf and slope sediments contain few calcareous and siliceous planktonic microfossils, so biostratigraphic and paleoenvironmental interpretations in these settings rely strongly on palynomorphs.

Palynomorphs record a marked difference in the pattern of terrigenous vs. marine influx in Upper Miocene and Pleistocene sequences. Most Pleistocene sequence boundaries (erosional unconformities) are overlain by sediments containing very high pollen: dinocyst (P:D) ratios which decline upcore within the sequence, recording deposition during rapid sea level rise following low stands. During the Miocene, in contrast, P:D ratios are unexpectedly low in muddy glauconitic sands above unconformities and increase within sequences, peaking in silty and sandy sediments just below the unconformities that bound the top of the sequences. This pattern suggests that the shoreline rapidly prograded during the regressive phase of sedimentation, recording high sediment supply. The dinocyst zones erected by de Verteuil & Norris (1996) also allowed recognition of a condensed sequence just above upper Miocene erosional surface m1.

A change in sedimentation noted in palynological analysis of the mid to late Pleistocene sequence from Site 1073 parallels changes in the seismic record. Erosional unconformities in the lower part of the Pleistocene sequence are associated with large peaks in P:D and are characterised by reflections that clearly differ from surrounding sediments. The upper part of the Pleistocene sequence is characterised by more evenly spaced reflections that appear to drape the topography- no large peaks in P:D are noted in these sediments although the ratio of gonyaulacoid:protoperidiniod dinocysts (G:P) peaks near an erosional unconformity, possibly reflecting taphono-mic alteration of the dinocyst assemblage.

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Toxic *Alexandrium tamarense* isolates (Dinophyceae) from the Orkneys are descended from North American stocks

Medlin, L.K., Lange, M., Wellbrock, U., Donner, G., Elbrächter, M., Hummert, C., Luckas, B. 1998. Toxic *Alexandrium tamarense* isolates (Dinophyceae) from the Orkneys are descended from North American stocks. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 108.

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Isolates of the *Alexandrium tamarense* (Lebour) Balech species-complex taken from a bloom in the Orkney Islands, north of Scotland in May 1997 have been examined morphologically. A subset of these isolates has been genetically analysed using both sequence data from the D1/D2 region of the LSU rRNA gene and a RFLP assay for D1/D2 region of the LSU and the entire SSU rRNA gene. All isolates have been tested for toxicity using HPLC analysis. The isolates fall into the morpho-species of *A. tamarense* rather than *A. fundyense*. Toxicity studies show that these *A. tamarense* isolates are as toxic as the most toxic *A. fundyense* isolates from North America. All geneticanalyses indicate that these *A. tamarense* populations are descended from North American genetic stocks. More than 10 base substitutions in the D1/D2 region of the LSU rRNA gene suggests that introduction into the Orkneys by human mechanisms (i.e., in ballastwater or in shellfish stocks) is unlikely. A more likely scenario is that these *A. tamarense* popula-tions in Northern European waters have been seeded in recent evolutionary time from stocks in North America via dispersal mechanisms, such as currents. In contrast, other populations from Western European waters previously shown to be non-toxic belong to a different gene pool.

Recent breakthroughs in applications of dinoflagellates biohorizons in India

Mehrotra, N.C. 1998. Recent breakthroughs in applications of dinoflagellates biohorizons in India. - NTNU Vitensk.mus. Rapp. bot. Ser. 1988-1: 108-109.

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With the acceleration of exploration activities by ONGC, India's National Oil Company, in the variuos prospective basins, a lot of subsurface data has been generated; the application of fossil dinoflagellates has emerged as an important tool for high resolution biostratigraphic studies, particularly in the Western Offshore and Krishna - Godavari basins. In the past few years, several global dinocysts events/biohorizons have been identified in the Cretaceous and Tertiary of Krishna - Godavari Basin and Tertiary of Western Offshore.

The dinocyst bioevents identified in Western Offshore Basin are based on LADs of species - *Conneximura fimbriata* (Danian : Late Paleocene - Early Eocene Boundary, 60.2 Ma); *Alisocysta margarita* (Thanetian : Early Eocene to Late Paleocene Boundary 54 Ma); *Deflandrea oebisfeldensis* (Ypresian, 53 Ma): *Glaphyrocysta ordinata* (Ypresian, 51 Ma); *Areoligera senonensis* and *Hystrichosphaeridium tubiferum* (Ypresian : Middle Eocene - Early Eocene Boundary, 49 Ma); *Glaphyrocysta exuberans* (Priabonian, 38 Ma); *Diphyes colligerum* Priabonian : Rupelian - Priabonian Boundary, 36 Ma); *Achilleodinium biformoides* (Rupelian, 31 Ma), *Corodosphaeridium gracile* (Rupelian : Chattian - Rupelian Boundary, 30 Ma); *Polysphaeridium congragatum* (Chattian, 28 Ma); *Thalassiphora pelagica* (Chattian, 27 Ma); *Cribroperidinium tenuitabulatum* (Serravallian, 13 Ma); and *Spiniferites splendidus* (Pliocene, 4 Ma).

The bioevents in the Krishna - Godavari Basin marked by LAD's of marker dinoflagellate species are - *Cassiculosphaerodia magna* (Barremian, 115 Ma); *Muderongia tetracantha* (Late Aptian, 109 Ma); *Cribroperidinium edwardsii* (Turonian-Cenomanian Boundary, 92 Ma); *Odontochitina porifera* (Santonian, 87 Ma); *Coronifera oceanica* (Early Maastrichtian - Late Campanian Boundary, 74 Ma); *Odontochitina operculata* (Early Maastrichtian, 73 Ma); *Isabelidinium pellucidum* (Early Maastrichtian, 72 Ma); *Dinogymnium acuminatum* and *Triblastula utinensis* (Late Maastrichtian; Early Paleocene - Maastrichtian boundary 66.5 Ma); *Dana californica* (Danian, 62 Ma), *Deflandrea oebisfeldensis* (Ypresian, 53 Ma); *Areoligera senonensis* (Middle - Early Eocene Boundary, Ypresian, 49 Ma); *Eocladopyxis paniculata* (Lutetian, 41 Ma); *Adnatosphaeridium multispinosum* and *Heteraulacacysta porosa* (Late Eocene - Middle Eocene Boundary, Bartonian, 39.4 Ma); *Areosphaeridium diktyoplokus* and *Diphyes colligerum* (Priabonian : Early Oligocene - Late Eocene Boundary, 36 Ma); *Cribroperidinium tenuitabulatum* (Serravallian, 13 Ma); *Batiacasphaera micropapillata* and *Systematophora placeantha* (Serravallian : Late Miocene - Middle Miocene Boundary, 10.2 Ma); *Sumatradinium hispidium* (Messinian, 6.3 Ma); *Spiniferites ellipsoideus* (Pliocene, 4 Ma); and *Tuberculodinium vancampoae* (Pliocene - Holocene).

The interpretation of global bioevents and their absolute ages are based on Haq et al. (1987), Helby et al. (1987) from Australia. Williams et al. (1993) from Northern Hemisphere and the available micropaleontological data from the Indian subcontinent.

Dinoflagellate bioevents/biohorizons have been used in building high resolution biostrati-graphic and biochronostratigraphic framework; identification of K/T Boundary in Krishna - Godavari Basin; identification of several hiatuses and determining their time span in Western Offshore and Krishna - Godavari basins; and paleoenvironmental interpretation as well as paleogeographic reconstructions based on integrated dinocyst and spores-pollen data. This data has been utilised for basin analysis and geological modelling for planning future exploration and explotation of targets.

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New dinoflagellate cysts from the Eocene of the North Sea basin

Michoux, D. 1998. New dinoflagellate cysts from the Eocene of the North Sea basin. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 110.

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Ten new dinoflagellate cyst taxa (six species and one subspecies) from North Sea Eocene sediments are presented here. Seven are referred to known genera:

Areoligera (two species)
Areosphaeridium (one subspecies)
Eatonicysta (two species)
Hystrichokolpoma
Membranophoridium
Palynodinium

Two taxa are considered to represent new genera.

Eocene dinoflagellate palynostratigraphy of the North Sea (UK Continental Shelf)

Michoux, D. 1998. Eocene dinoflagellate palynostratigraphy of the North Sea (UK Continental Shelf). - NTNU Vitensk..us. Rapp. bot. Ser. 1998-1: 110.

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The abundance, diversity and rapid evolution through time of dinoflagellate cysts in North Sea Paleogene deposits led to their wide use for sequence calibration, regional correlation and reservoir layering.

Early published schemes for the Eocene (e. g. Heritier et al. 1979) focused on the prospective Early Eocene interval. The first fully documented zonation scheme for the whole Eocene is that of Bujak & Mudge (1994).

The zonation scheme proposed here allows the subdivision of the Eocene interval into 34 zones or subzones. These are based on dinoflagellate cyst last stratigraphic occurrences (tops) and quantitative events. In addition to index species, emphasis is placed on accessory taxa, some of them undescribed, that provide improved resolution of the general scheme, especially in the Ypresian and Lutetian intervals.

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Taxonomy of naked dinoflagellates, using mainly a combination of flagellar apparatus reconstruction, toxicity, pigment analysis and 28S rRNA sequencing

Moestrup, Ø., Calado, A., Daugbjerg, N., Hansen, G., Larsen, J. & Rees, T. 1998. Taxonomy of naked dinoflagellates, using mainly a combination of flagellar apparatus reconstruction, toxicity, pigment analysis and 28S rRNA sequencing. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 111.

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Naked dinoflagellates are important and common constituents of many freshwater and marine ecosystems. Several species are known to form plankton blooms whose effects on the environment can be devastating. Due to the lack of a welldefined amphiesma of thick plates, species are often fragile and readily change shape during observation or when preserved, preventing identification to species level. However, identification to generic level is equally problematic, as the circumscriptions of the genera go back to the last century and are based on often very incomplete descriptions of the type species. This has resulted in considerable taxonomic confusion. The taxonomic problems have been apparent for a long time and we have for some years tried to reach a more satisfactory circumsciption of the genera, using a combination of several different approaches. The present contribution will discuss the present state of the art.

Integration of biological, biochemical and geological research on dinoflagelates

Moncheva, S. & Doncheva, V. 1998. Dinoflagellates blooms and succession - an indicator of the environmental changes in the Black Sea ecosystem (Western part). - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 111-112.

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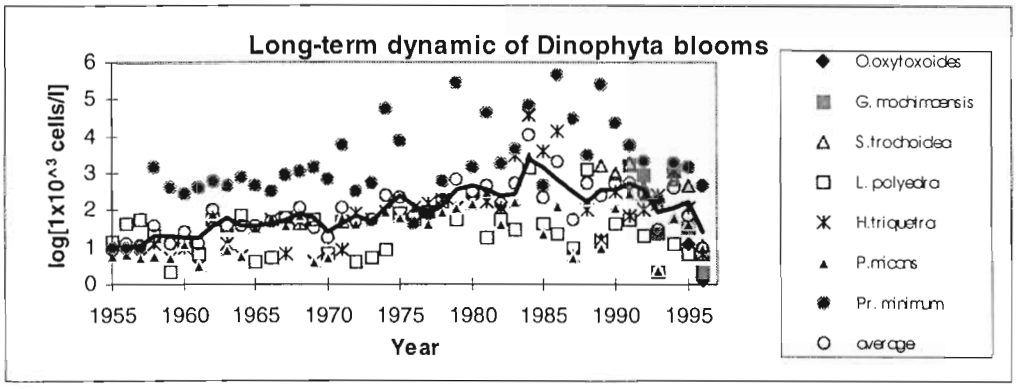
The present paper focus on an overview of Dinophyta blooms along the Bulgarian Black Sea coast (Western part) as they represent the main concern for the ecosystem especially during the summer period (Moncheva et al. 1995). The goal is to evaluate the main trends in their taxonomic composition and abundance, frequency and succession in relation to the variability of the environmental parameters (temperature, solar activity, nutrients and their ratios, zooplankton dynamic) with special attention given to the eutrophication stress as the key ecological factor in this part of the basin. As in order to assess the effect of anthropogenic influence a knowledge on the natural variability of the ecosystem is essential (GESAMP 1995) it is perceived that the long-term data set discussed in the present paper (1955-1996) can provide a valuable clue. The Dinophyta blooms dynamic is interpreted in relation to the pattern of total phytoplankton blooms and Bacillariophyta blooms variability. A special statistical package is used (PRIMER

1994) aimed to distinguish between natural and man-induced alterations.

The general trend in the dynamic of the most common dinoflagellates blooms is presented on the figure bellow.

The comparative analysis of the period up to 1970 (considered a relatively prestine) with that between 1971-1990 (a period of intensive eutrophication) in terms of average bloom density, the number of species invol-ved, and their frequency provide evidence that the alterations after 1991 could be considered more a sign of recovery of the ecosystem than interannual variability. The results suggest that among the environmental factors the shift in N:Si and P:Si ratios is the key factor in the dramatic perturbations in the phytoplankton communities and the shifts in Bacillariophyta : Dinophyta dominance.



Detailed morphology and stratigraphy of the *Spiniferites* complex in the Danian of Mid-Norway

Monteil, E. & Williams, R. W. 1998. Detailed morphology and stratigraphy of the *Spiniferites* complex in the Danian of Mid-Norway. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 112-113.

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In the course of a comprehensive morpho-stratigraphic analysis of Danian localities from the North Sea (Ekofisk field), four cored sections penetrating 20 metres of the Lower Ekofisk Formation were investigated with a dense sample coverage (1 sample/ meter).

Palynological residues yielded rich and diversified assemblages of *Spiniferites* spp. Detailed morphological analyses carried out on this complex allowed the recognition of about fifteen different morphotypes.

The results of this project demonstrate that refined morphological analyses of taxa which are often overlooked stratigraphically, may reveal their true correlative value. Because of their complexity and number, most morphotypes of *Spiniferites* are commonly registered only at the generic level in routine industrial

biostratigraphy. By applying a morphostratigraphic approach, recording changes in sometimes only one morphologic character, biostratigraphers can exploit these "unusable" cysts groups in order to maximise the number of stratigraphic events.

Acknowledgments: the authors would like to express their gratitude to Norsk Hydro, Saga Petroleum and Statoil who kindly supported this project.

Seasonal patterns of dinoflagellate cyst production in the Gulf of Naples (Mediterranean Sea)

Montresor, M., Zingone, A. & Sarno, D. 1998. Seasonal patterns of dinoflagellate cyst production in the Gulf of Naples (Mediterranean Sea). - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 113.

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To assess the diversity and seasonality of dinoflagellate cyst production, sediment trap samples were collected bimonthly over two annual cycles at a station one mile offshore in the Gulf of Naples. A long-term monitoring project, including phytoplankton sampling, is being conducted at this site since 1984.

Cyst flux was markedly different between the two years (1.26 and 0.55 x 10^8 cysts m^{-2} y^{-1}, respectively), mainly due to high production peaks at the beginning of spring and autumn of the first year. In both years, the assemblage was dominated by calcareous cysts belonging to several different species (Montresor et al. 1994), with maximal production rates (up to 1.6 x 10^6 cysts m^{-2} d^{-1}) recorded from spring to late autumn. Other abundant morphotypes included smooth and hairy gymnodiniod cysts, *Protoceratium reticulatum* and *Alexandrium andersoni*. Different production patterns were detected: some species formed cysts almost continuously over several months, others encysted in different periods of the year.

Cyst-forming species constituted a relatively small percentage of the total number of dinoflagellate species recorded in the area, and did not include some of the most abundant and regularly recurrent taxa. For some of the cyst-forming species, including small gymnodinioids and *Scrippsiella*-like cells, a relationship was traced between cyst production and the presence of corresponding vegetative stages in surface waters. In other cases, motile stages were extremely rare or not at all recorded.

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Latest Eocene to Early Oligocene organic walled dinoflagellate cysts of the MASSICORE, Central Italy

Mourik, C.A. van & Brinkhuis, H. 1998. Latest Eocene to Early Oligocene organic walled dinoflagellate cysts of the MASSICORE, Central Italy. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 114-115.

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The (pelagic) Massignano section in central Italy has been ratified as the GSSP for the Eocene/Oligocene (E/O) boundary at meter 19 of the total 22.9 m. Thus, unfortunately only some 4 m of lowermost Oligocene is exposed at the GSSP site. To extend the lower Oligocene record at Massignano, the MASSICORE was drilled about 110 m south of the stratotype section (Lanci et al. 1996). The correlation of the core with the Massignano quarry (GSSP) section indicates that the E/O boundary in the MASSICORE occurs at a depth of 19.2 m (dated at 33.7 ± 0.5 Ma; Lanci et al. 1996), and that hence, an additional 15 m of lower Oligocene strata was recovered.

Detailed dinoflagellate cyst zonation of the E/O transition interval in the Mediterranean area indicates that the E/O boundary GSSP correlates to the middle part of the classic (marginal marine) Priabonian type section in northeast Italy (Brinkhuis & Biffi 1993; Brinkhuis 1994), thus placing the classic Priabonian/Rupelian boundary (and E/O boundary) now in the lowermost Oligocene. These, and other results from the Priabonian type area prompted Brinkhuis & Visscher (1995) to suggest that the E/O GSSP was unsuitably placed, and proposed alternative horizons, for example the TA4.3/4.4 third order sequence boundary of Haq et al. (1988), close to the extinction of the dinoflagellate cyst *Areosphaeridium diktyoplokus*.

To further elucidate the Early Oligocene history in central Italy, we analyzed 58 samples taken between 20.50 to 1.15 m of the MASSICORE palynologically, emphasizing dinoflagellate cysts. Our data indicate cooler conditions and lowstand across the E/O boundary GSSP, followed by transgression and a brief warmer interval during the earliest Oligocene. Subsequently, our record indicates that a more pronounced cooler and lowstand period occurred. The corresponding sequence boundary may well be correlated to the TA4.3/4.4 boundary, occurring just below the last occurrence of *Areosphaeridium diktyoplokus*. These results are well correlatable to those from the Priabonian type area, and once again stress that this "cooling/sequence stratigraphic" concept of the E/O boundary enables and facilitates world-wide recognition, and that hence, the position of the E/O GSSP should be reconsidered.

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Geochemical evidence for changes in dinoflagellate production during sapropel formation in the Aegean Sea

Mudie, P.J., Aksu, A.E. & Abrajano, T. 1998. Geochemical evidence for changes in dinoflagellate production during sapropel formation in the Aegean Sea. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 115.

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Dinoflagellate cysts, pollen and other acid-resistant particulate organic matter (POM) were studied in four cores on a north-south transect of the Aegean Sea to test various models for the origin of the early Holocene sapropel S1. Mediterranean sapropels contain 2-6 % organic carbon (TOC) and previous studies postulate that this reflects increased net primary production (NPP) and/or better preservation of TOC during conditions of high freshwater inflow, strong stratification and bottom anoxia. The Aegean cores, however, show that maximum dinocyst production was in the late glacial (14-9.5 ky BP) when low diversity assemblages were dominated by the euryhaline gonyaulacoids *Operculodinium centrocarpum* and *Nematosphaeropsis labyrinthus*. Organic geochemistry studies of the n-alkanes also show a dominance of low molecular weight (lmw) compounds ($C_{15,17,19}$), indicating high marine NPP during this time.

In contrast, sapropel deposition (9.5-6.4 ky BP) is marked by large increases in terrigenous sporomorphs and refractive humic compounds, with relatively small increases in dinocyst production, mainly the protoperidinioid *Brigantedinium simplex* and stenohaline gonyaulacoids *Bitectatodinium tepikiense* and *Tectatodinium psilatum*. The palynological data provide strong evidence for increased freshwater inflow and high influx of terrigenous POM, but only minor increase in NPP. This interpretation is verified by geochemistry data showing that the start of sapropel formation is marked by increased high molecular weight (hmw) n-alkanes ($C_{29,31,33}$), indicating terrigenous POM. Geochemical profiles of Ba, Fe and Mn show that post-depositional oxidation does not account for the changes in dinocyst abundance or assemblage composition. Within the sapropel, however, an upward decline in hmw n-alkanes and increase of lmw n-alkanes, indicate a recovery of NPP after ~7 kyBP, when sapropel deposition was interrupted in other parts of the Mediterranean. This geochemical change corresponds to a switch from dominant protoperidinioids (and presumed heterotrophic metabolism) to dominant gonyaulacoids with autotrophic metabolism. Post-sapropel and modern dinoflagellate assemblages are also mainly gonyaulacoid autotrophs, including the stenothermal and -haline species *Impagidinium aculeatum, O. israelianum*, and *Polysphaeridium zoharyi* but productivity is low in these hypersaline waters.

Late Quaternary dinocysts from the Black, Marmara and Aegean Seas: Variations in assemblages, morphology and paleosalinity

Mudie, P.J. Aksu, A.E. & Duman, M. 1998. Late Quaternary dinocysts from the Black, Marmara and Aegean Seas: Variations in assemblages, morphology and paleosalinity. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 116.

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Previous studies (e.g. Wall et al. 1973, Dale 1996) have suggested there is a link between low salinity and cyst morphology, e.g. reduction of process length and cruciform body shape. Dinocysts have now been studied in new cores of turbidite-free Upper Quaternary sediments from the S.E. Black Sea, Marmarma and N.E. Aegean seas, where oxygen isotope ($d^{18}O$) profiles and planktonic foraminiferal data show that sea surface salinities (SSS_w) range from 7-18 ‰, 15-22 ‰ and 36-39 ‰, respectively.

In the Black Sea cores B7 and B13, late glacial lutites contain low diversity (S = 2) "cruciform" assemblages of *Spiniferites cruciformis* and *Tectatodinium psilatum*, with most of the *S. cruciformis* cysts having large expanded, perforate septal membranes (form 1: circular outline; form 2: irregular). This assemblage is restricted to the interval with $d^{18}O$ values of <-4 ‰ (SSS<7 ‰). The overlying sapropel, with $d^{18}O$ = -2 ‰, contains a *Lingulodinium machaerophorum-Spiniferites-Cymatiosphaera* assemblage, with *L. machaerophorum* having clavate processes and *S. cruciformis* mostly with reduced septa (forms 3 & 4). The late Holocene coccolith-rich sediments ($d^{18}O$ = 0-2 ‰; SSS~18 ‰) have diverse (S=15) assem-blages of *Brigantedinium* and *Spiniferites* spp., *L. machaerophorum* (normal form), *Peridinium ponticum* and some short-spine forms of *O. centrocarpum* (f. *truncatum*).

In the N.E. Aegean core 3 (Aksu et al. 1995), the Black Sea species/morphotypes are rare and occur mostly as low percentages of *S. cruciformis* f. 3 & 4, and *O.c.* f. *truncatum* in the mid-Holocene sapropel, deposited when salinity was lowered by 1.5 ‰ during a period of increased runoff and Black Sea water input.

The Marmara Sea core M9 records salinities ranging from 14-18 ‰ during late glacial sapropel deposition and 20-22 ‰ for the overlying marine sediments. Here both the sapropel and unit B are dominated by *S. cruciformis* f. 1 & 2 (80 %), *T. psilatum* and *P. ponticum* (20 %). Unit B also contains common *L. machaerophorum* (clavate and normal forms), which becomes co-dominant with *O. centrocarpum* (normal and truncate forms), *Brigantedinium* and *Spiniferites* spp. in the surface Unit A. Downcore graphs of percentages of *S. cruciformis* (four morphotypes), *T. psilatum* and *L. machaerophorum* (two forms) plotted against $d^{18}O$ or SST_w, however, show no simple correlation, indicating that the morphotype variation is related to paleosalinity in a complex way.

Red tides and El Niños: Ultra-high resolution studies of seasonal and decadal changes in a Holocene record of annual varves from Saanich Inlet, western Canada

Mudie, P.J. 1998. Red tides and El Niños: Ultra-high resolution studies of seasonal and decadal changes in a Holocene record of annual varves from Saanich Inlet, western Canada. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 117.

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Ultra-high resolution studies (seasonal to decadal scale) are being made of dinoflagellates in Saanich Inlet, S.W. British Columbia, where high productivity and anoxic bottom waters form annual varves up to 1 cm thick. Drilling on ODP Leg 169A recovered a 105m-long section of these diatomaceous varved marine sediments, for which 17 radiocarbon dates show an almost unbroken record of Holocene deposition starting from ~2,000 y B.P.

To calibrate the drillhole data to modern dinocyst production, studies were first made on frozen-finger core samples of 1-cm thick annual varves recording seasonal changes from 1993 back to 1835 AD, including the time of historical records for red tides and sea surface temperature measurements. These studies showed that cyst preservation in the Saanich varves is exceptionally good, particularly for thin-walled protoperidinioids (e.g. *Votadinium calvum, Dubridinium caperatum*) and *Polykrikos* spp. Some varves even contain intact thecate-stage cells of *Gonyaulax polyedra, Alexandrium* and *Gymnodinium*. The annual light-dark layers were subsampled at 2mm-thick intervals to compare cyst deposition at bimonthly intervals with monthly records of dinocysts in sediment trap samples. The bimonthly samples show there are normally two peaks in annual cyst production: a late spring (April-June) bloom of cysts from non-toxic, diatom-eating heterotrophs, dominated by *Brigantedinium, Lejeunecysta* and *Polykrikos* spp., and a late summer (August-September) peak of cysts of autotrophs, mainly *Spiniferites* and *Operculodinium* spp., and sometimes, cysts of the toxic species *L. machaerophorum, A. tamarense* and *A. acatenella*. The 165-yr record shows increases of cysts from toxic dinoflagellates over the past 50 years, with peaks at times of moderate to strong El Niño events. There is also an upcore increase in diversity of toxic cyst species which parallels plankton-tow records of harmful algal blooms (HABs).

Work on ODP Leg 169B, Hole 1034B has begun with study of dinocysts in varves representing 25-yr intervals from ~1880 to 11 000 y B.P. Dinocyst preservation remains excellent to the base of the continuously varved sediments at ca. 8 000 y B.P. and thecate-stage specimens of *A. tamarense* and *G. sanguineum* were found down to about 65m (~10 000 y B.P.). At this decadal level of resolution, the major change seen is a large increase of gonyaulacoid cysts in early Holocene samples (~8 590 - 10 185 y B.P.), perhaps reflecting the longer, warmer summers during this time. However, the abundance of cysts of toxic species is lower than in the late Holocene and youngest (post-1940) sediments.

Paleoecological implications for the distribution of *Dinogymnium*, *Isabelidinium*, and *Heterosphaeridium* from the Interior Seaway and Sverdrup Basin (Canada) during the Upper Cretaceous

Núñez-Betelu, K., Collom, C.J. & Hills, L.V. 1998. Paleoecological implications for the distribution of *Dinogymnium*, *Isabelidinium*, and *Heterosphaeridium* from the Interior Seaway and Sverdrup Basin (Canada) during the Upper Cretaceous. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 118-119.

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Palynological study of an Upper Cretaceous section of west-central Alberta shows striking distribution patterns for the marine dinoflagellates *Heterosphaeridium difficile* and several species of *Dinogymnium* and *Isabelidinium*. This study was part of a multidisciplinary project using sedimentology, micropaleontology (palynomorphs and foraminifers) and molluscan macropaleontology to establish a sequence stratigraphic framework for the Upper Cretaceous of the Western Canada Sedimentary basin (WCSB). The palynological study was conducted on a section located on the Smoky River, Alberta – including the Kaskapau, Muskiki, Bad Heart, and Puskwaskau formations (in ascending order). The section studied is uppermost Turonian to upper Santonian in age based on ammonite and inoceramid bivalve biostratigraphy; the base being marked by the *Scaphites corvensis* Zone and the top by the *Scaphites novimexicanus* Zone.

In excess of 16,000 palynomorph specimens were counted and identified from 26 samples collected at regular intervals from the 90 m thick Smoky River section, and averaged more than 600 specimens per sample. Among the palynomorphs there were 130 species of dinoflagellate cysts and acritarchs, and 55 species of pollen and spores. Throughout the entire section, marine palynomorphs were consistently more abundant and diverse than terrestrial forms, and represented between 55 and 94 % of the assemblages. Some dinoflagellate cysts dominate the assemblages. These include, in terms of abundance: *Isabelidinium* spp. (*acuminatum*, ? *amphiatum*, and *cooksoniae*) *Heterosphaeridium difficile*, *Dinogymnium* spp. (*acuminatum*, *sibiricum* and *westralium*), *Trythirodinium suspectum*, *Laciniadinium* spp. (*arcticum*, *biconiculum*, and *williamsii*), and *Areoligera* spp. (*guembelii* and *senonensis*). For example, *Isabelidinium* accounts for > 70 % of the total assemblages in sample, whereas in other samples *H. difficile* represents 35 %, *Trythirodinium* 26 %, *Laciniadinium* 23 %, and *Dinogymnium* 22 %.

The most interesting aspect of these distributions, however, involves the relative abundances of *H. difficile*, *Dinogymnium* spp. and *Isabelidinium* spp. The first two species do not occur together in any sample (seemingly "avoiding" each other), despite their overall abundance. Furthermore, in the upper four samples, *H. difficile* is absent, *Dinogymnium* spp. becomes very scarce, and there is a sudden bloom in *Isabelidinium* (~70 % of the total palynomorph assemblage), continuing to the uppermost sample. These distributions surely represent significant changes in the paleoenvironment during the Upper Cretaceous in the WCSB. Similar assemblages have been identified in the Sverdrup Basin of the Canadian Arctic.

Despite thorough searches, *Dinogymnium* appears to be absent from the northwestern part of the basin and only occurs in adjacent areas, indicating paleoecological constraints on its distribution. As no known geographical barriers were present between the Interior Seaway and the Sverdrup Basin during most of the Upper Cretaceous, we conclude that paleoceanographic changes during the Coniacian and Santonian were responsible for the observed lateral and vertical distributions of dinoflagellates and associated palynofloras.

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The stratigraphic and environmental importance of *Trithyrodinium fragile* Davey, 1969, and *Trithyrodinium evittii* Drugg 1967; (two species or) one species artificial separated by processing technique

Nøhr-Hansen, H. & Dam, G. 1998. The stratigraphic and environmental importance of *Trithyrodinium fragile* Davey, 1969, *Trithyrodinium evittii* Drugg, 1967; (two species or) one species artificial separated by processing technique. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 119.

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Trithyrodinium evittii is regarded as a "warm water" Late Cretaceous Tethyan species that migrate to Boreal areas due to global warming in earliest Paleocene time (Smith & Brinkhuis 1996). Palaeogeographical plots of recorded *Trithyrodinium evittii* and *T. fragile* illustrate a distribution from approximately 30° to 50° N and approximately from 30° to 45° S in the latest Cretaceous. This picture changes remarkably in the earliest Paleocene where the palaeogeographical distribution of the two species range from approximately 30° to 70° N and from approximately 30° to 70° S.

Stratigraphically *Trithyrodinium evittii* and *T. fragile* have been reported from Campanian to Paleocene. *Trithyrodinium evittii* are reported abundant just above the K/T boundary in California, USA (Drugg 1967), New Zealand (Strong et al. 1995) and Denmark (Smith & Brinkhuis 1996). *Trithyrodinium fragile* has recently been recorded in high numbers just above the K/T boundary from West Greenland (Nøhr-Hansen & Dam 1997) and from Stevns Klint, Denmark.

Davey (1969) described the species *Trithyrodinium fragile* as a cyst with subspherical shell, consisting of a two layered smooth brown inner body, surrounded closely by a thin hyaline membrane that protrudes into a small apical and two small antapical horns. The inner layer of the inner body is thin and colourless, the outer layer thick, brown and commonly possessing crescentic cracks.

The present study of one sample from Nussuuaq, West Greenland and one sample from Stevns Klint, Denmark illustrate that specimens of the species not treated with KOH after oxidation have a prominent brown pigmented layer with crescentic cracks, whereas the brown pigmented layer is

washed out of specimens from the same samples when they were treated with KOH. This implies that the morphology of *Trithyrodinium fragile* specimens treated with KOH lose their brown pigmented layer and become identical with the species *Trithyrodinium evittii*.

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Species range types of recent marine dinoflagellates

Okolodkov, Y.B. 1998. Species range types of recent marine dinoflagellates. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 120-121.

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Species ranges are the basis of biogeographical division of any geographical region. Namely the maps of species ranges and lists of species constitute the subject of biogeography (Beklemishev & Semina 1986). About 270 dinoflagellate species have been recorded from the Arctic (Okolodkov 1996). Out of them, the ranges of some 220 species were mapped. The dinoflagellate flora of the Arctic Ocean consists of Arctic-boreal, tropical-boreal, Antarctic-tropical-boreal, cosmopolitan and bipolar species. The species range types are consistent with those distinguished by Semina (1974) based mainly on planktonic diatoms. The circumpolarity in distribution of Arctic-boreal species along with the longitudinal extension of their ranges bear witness to the unity of Arctic-boreal biogeographical zone. The percentage of endemics in this zone among dinoflagellates is 2 %, no purely Arctic species having been found (Okolodkov 1996). As a rule, Arctic-boreal species do not occur in the area south of the socalled Ortmann Line in the Northern Hemisphere (Ortmann 1896). The fact of existence of bipolar species is still in doubt, although four species can be conventionally called bipolar. Not less than 40 tropical-boreal and 17 provisionally Antarctic-tropical-boreal dinoflagellates have been recorded from the Arctic (Okolodkov & Dodge 1996). They tend to penetrate into the Arctic with the warmer Atlantic and Pacific waters along the eastern parts of the oceans. Comparison in their geographical distribution shows that the former seem to be more tolerant to the lower temperature than the latter. No reliable records of tropical dinoflagellates in the Arctic have been known hitherto. The term "cos-

mopolitan" still remains confusing. Some planktonic algae known from the literature as cosmopolitan cannot be considered as such until they have been found in the Arctic regions not influenced by the warmer currents, therefore to refer to subcosmopolitan distribution is preferable. Circulation and temperature are most likely the main physical factors which determine the large-scale distribution of dinoflagellates in the ocean.

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Dinoflagellate cysts from the Cretaceous-Tertiary boundary section at Woodside Creek, New Zealand

Oosting, A.M. & Brinkhuis, H. 1998. Dinoflagellate cysts from the Cretaceous-Tertiary boundary section at Woodside Creek, New Zealand. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 121.

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A quantitative palynological assemblage study of the Cretaceous-Tertiary (K/T) boundary section at Woodside Creek, Marlborough, New Zealand, has been carried out. Samples from immediately above the K/T boundary, as previously defined by Strong (1977) and Alvarez et al. (1980), show a dinoflagellate cyst assemblage dominated by *Manumiella druggii*. Furthermore, a previously undescribed dinoflagellate cyst was observed above the K/T boundary. This poster will display this new dinoflagellate cyst along with the palynological assemblage results obtained from this section. These results are compared with Northern Hemisphere K/T boundary records (Brinkhuis et al. in press). In addition, biostratigraphal and palaeoenvironmental interpretation of the Woodside Creek section will be discussed.

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Maastrichtian dinoflagellate cysts from North Bulgaria: Biostratigraphical and palaeoenvironmental interpretations

Pavlishina, P. 1998. Maastrichtian dinoflagellate cysts from North Bulgaria: Biostratigraphical and palaeoenvironmental interpretations. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 122.

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Maastrichtian dinoflagellate cyst assemblages are documented for the first time from four sections in North Bulgaria. Twenty species belonging to 16 genera are fully described. The new combination *Trithyrodinium trendallii* (Cookson & Eisenack) is proposed. The obtained dinocyst assemblages are palynologically distinctive and easily corre-lated with the biostratigraphycally well controlled dinocyst framework established for Western Europe and the type Maastrich-tian area. They indicated *Triblastula utinensis* Zone in the investigated sections. The age of the zone is from the middle part of the Early Maastrichtian to the early part of the Late Maastrichtian. The changes in the composition of the dinocyst assemblages in the section at Dermantsi are related to depositional environments. The Kunino For-mation is considered to represent a quite energy depositional environment, realized in a partially enclosed inshore basin. This for-mation contain rich but uniform dinocyst assemblages, represented only by two species. The Mezdra Formation which repre-sents a more open marine depositional en-vironment contains rich, diverse and well preserved dinocyst assemblages.

Modern distribution of dinoflagellate cysts in coastal lagoons of Rhode Island, USA

Pospelova, V. & Chmura, G. 1998. Modern distribution of dinoflagellate cysts in coastal lagoons of Rhode Island, USA. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 122-123.

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In this study we examine the abundance and diversity of dinoflagellate cysts in back-barrier lagoons of Rhode Island, along the coast of Block Island Sound. These lagoons are shallow and, generally, unstratified estuarine systems. In each lagoon we have sampled at multiple stations in locations characterized by deposition of fine-grained and organic-rich sediments. At a sample depth of 2 cm, we assume that our assemblages represent less than 10 years deposition in these generally, rapidly accreting systems. Water chemistry of all sample stations has been monitored over a period of years. Salinities range from nearly fresh water to 34 ppt (dependent upon precipitation and inlet management) with average salinities of 24 ppt. Water temperatures range in winter from 2 to 5 °C and in summer from 25 to 30 °C. Nutrient loading to these systems is variable with some systems designated as eutrophic. Measurements of dissolved nitrates have been as high as 107 mM/l and phosphates as high as 3 mM/l.

Dinoflagellate cyst assemblages are variable

within a single lagoon. Concentrations are on the order of 10 thousand cysts per gram dry weight of sediment. The most important taxa are *Spiniferites, Operculodinium,* and *Protoperidinium types*. The dominance of *Spiniferites* in the lagoonss is an interesting contrast to that found in deeper waters (and assumed more stratified) by Wall et al. (1977) who noted its lower relative abundance in samples they collected from the same region.

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Neogene dinoflagellate cyst palaeoclimatology and palaeoenvironment of the southern Jylland, Denmark and the Danish North Sea area

Poulsen, N.E. 1998. Neogene dinoflagellate cyst palaeoclimatology and palaeoenvironment of the southern Jylland, Denmark and the Danish North Sea area. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 123-124.

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During the earliest Cenozoic the North Sea Basin became part of a large north-eastern European sedimentary basin. In the Paleogene (post-Danian) sedimentation was marine and clastic-dominated. During the Paleogene-Neogene, regional subsidence took place gradually, resulting in a large depositional basin focused on the central part of the present North Sea. More than 3000 metres of sediments accumulated during the Paleogene-Neogene and up to 600 meters in the Quaternary. The base of the Upper Miocene is locally developed as a low angle unconformity and marks the shift from predominating mud sedimentation during the Paleogene to deposition of sands, silt intercalations in the Neogene. The Neogene sedimentary sequences show progradation from the East. The Neogene is overlain by glacial deposits of the Quaternary.

On the basis of a study of dinoflagellate cysts from the Miocene beds of the Lille Tønde borehole, southern Jylland (Denmark) and of the Karl-1 borehole, Danish North Sea sector, palaeoecological interpretations showed that:

- The lowermost Miocene formation of the Lille Tønde borehole was found to have been deposit in an inner neritic environment, possibly with reduced salinity. The sea temperatures were subtropical, the winter surface temperatures were found to be above 10 °C.
- The overlying Lower to Middle Miocene formation was deposit under middle-outer neritic palaeoenvironmental conditions and with fairly similar palaeotemperatures.
- The Upper Miocene beds were deposit under outer neritic palaeoenvironment conditions, but possibly under falling sea temperatures. The sea level rose apparently, until it reached a maximum near the Tortonian-Messinian boundary.
- The Miocene beds of the Karl-1 borehole were found to have been deposited in an outer neritic-oceanic palaeoenvironment;

the sea level apparently rose to a maximum near the Tortonian-Messinian boundary. The sea temperatures in the Early-Middle Miocene were subtropical, whereas the Late Miocene shows falling sea temperatures.

The study demonstrates similar palaeoecological interpretations as older suggestions of the depositional palaeoenvironment, with the Arnum Formation in an inner neritic shelf or estuarine environment, the Hodde and Gram Formations in an outer shelf environment. The sea level maximum is probably near the Tortonian-Messinian boundary. Palaeotemperatures were as in the present day Atlantic near Portugal to southern France.

Bajocian to Volgian (Jurassic) palynology of the Polish Jurassic

Poulsen, N.E. 1998. Bajocian to Volgian (Jurassic) palynology of the Polish Jurassic. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 124.

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A palynological investigation of the Bajocian-Bathonian (Middle Jurassic) organic-rich claystones succession, the Callovian sandy to clay deposits and gaize (dispersed biogenic silica), Oxfordian (Late Jurassic) carbonates and marlstones of the central and northern Poland has provided a detailed correlation between the Polish Submediterranean Province (northern Tethyan Realm) and the Subboreal Province of the North Sea area (chronostratigraphy and dinoflagellate zonation).

The dinoflagellate cyst assemblages of the Upper Bajocian-Bathonian clays and the Lower Callovian sand and gaize show a similar evolution in the assemblages as to coeval north-western European assemblages (for example England in Riding & Thomas 1992). The assemblages are dominated by *Atopodinium, Ctenidodinium, Dichadogonyaulax,* and *Wanaea* spp. The British or the Subboreal zonation (Riding & Thomas 1992, Poulsen & Riding in press) is demonstrated useful for the Polish sections. Some marker species have, however, minor differences in their first or last appearances in Poland compared to those reported from England.

Middle Callovian - Upper Oxfordian samples from Poland are often barren of dinoflagellate cysts. Some samples with common-abundant dinoflagellate cysts occur from this interval and demonstrate, that the reason for barren samples is poor preservation. Investigation of the Oxfordian (Late Jurassic) dinoflagellate cysts of the Barcin area, demonstrate good correlation to the British-Danish dinoflagellate cyst zonation.

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Oxygen deficiency in the Oligocene of Southwest Germany: Evidence from dinoflagellate cysts

Pross, J. 1998. Oxygen deficiency in the Oligocene of Southwest Germany: Evidence from dinoflagellate cysts. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 125.

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Dinoflagellate cysts from the mid-Rupelian (Oligocene) bituminous "Fish Shales" of the Mainz Basin, a small epicontinental basin at the northern end of the Rhine Graben (Southwest Germany), were studied from boreholes drilled in different depositional environments within the basin.

In the sample material, the relative abundance of the dinoflagellate cyst *Thalassiphora pelagica* correlates inversely not only with the oxygen content of the bottom water, as has been derived from foraminifers, but also with dinoflagellate cyst diversities. At the same time, the occurrence of A, B and C forms sensu Benedek & Gocht (1981) (i.e. potentially ontogenetically young specimens of *T. pelagica*) is restricted to samples with maximum percentages of this taxon.

Based on these observations, a model for the reaction of the dinoflagellate flora to changes in the oxygen content of the bottom water is proposed: during periods of decreased oxygen supply, the excystment process of all dinoflagellate taxa except *T. pelagica* was interrupted due to unfavourable environmental conditions. This led to a pronounced drop in their population, as is documented by decreases of dinoflagellate cyst diversities in the sediment. In contrast, *T. pelagica*, which was less sensitive to oxygen depletion, invaded the resulting ecological niche, thus leading to an increased proportion of this species in the dinoflagellate cyst spectrum. With further deterioration in the oxygen supply, however, the environmental conditions became critical even for *T. pelagica*. As a result, some of the *T. pelagica* cysts perished at an early ontogenetic stage. This is evident in samples with maximum *T. pelagica* percentages which contain ontogenetically young specimens of this taxon.

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Siliceous dinoflagellates of the neogene of Andaman and Nicobar islands, India

Rai, J. 1998. Siliceous dinoflagellates of the Neogene of Andaman and Nicobar islands, India. - NTNU Vitensk. mus. Rapp. bot. Ser. 1998-1: 125-126.

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The Andaman and Nicobar islands are located in the Bay of Bengal, forming a chain of about three hundred islands extending from north to south for about 850 km between 6°45' N and 13°45' N latitudes. The origin of these islands is volcanic and are extremely important for micropalaeontological view point. That indicates blocks of

oceanic rise extending from Burma to Sumatra & Java islands. The uplifted Neogene sediments of Andaman and Nicobar islands are dated on the basis of planktonic foraminifers, calcareous nannofossils, diatoms, radiolaria and and silicoflagellate assemblages. The present assemblage of endoskeletal dinoflagellates is represented by the solitary genus *Actiniscus* viz., *Actiniscus pentasterias* Ehrenberg, *Actiniscus elongatus* Durniteica and several new species. These are considered to be organisms of exceptional beauty bearing symmetrical depressions, which successfully transgressed Plio-Pleistocene crisis and are belived to thrive in present polar regions and tropical realms. The relative shift of CCD and convectional current pattern arising from geothermal vents along mid oceanic ridges are possibly responsible for planktonic blooming which might have brought datable calcareous and siliceous microfossils toget-her.

The admixture of angular glass shards in the assemblage testifies the active volcanic phases in the region during this particular time slice. Their existence might also be linked with the volcanic and quiescent phases of opening and closing of Andaman Sea.

The present recovery of well preserved and diversified andoskeletal dinoflagellate cysts is made from Sawai Bay Formation (Late Miocene) of Nell Island, Ritchie's Archipelago (Long. 93°2' E, Lat. 11°50' N) off the east of Andaman ridge lying approximately 32 km east of Port Blair in the Andeman Sea. The Eastern and Northeastern part of the island are elevated forming appreciable hich cliffs of glaucoritiv mudstones of Sawai bay Formation which are discontinuously over... by fossiliferous and hard Neill West Coast Formation. The nannofloral assembling rescovered from Sawai Bay Formation have been assigned to NN11 *Discoaster quingueramus* Zone of Martini 1971 correlated with CN 9 *Discoaster quingueramus* Zone of Okada and Bukry 1980 and lying within CN9A *Discoaster bergenii* Subzone of Okada and Bukry 1980. Their palaeoecological importance over its biostratigraphical relevance is well known but its ancestry and lineage studies with respect to recover new species seems promising.

The Continuous Plankton Recorder Survey: *Ceratium* species in the North Atlantic and North Sea (1931-1995)

Reid, P.C. & Hunt, H.G. 1998. The Continuous Plankton Recorder Survey: *Ceratium* species in the North Atlantic and North Sea (1931-1995). - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 126-127.

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For more than sixty five years Continuous Plankton Recorders (CPRs) have been used in a systematic, monthly survey of the near surface (~10m) plankton of the North Atlantic and North Sea. Currently ~3500 samples are analysed per annum and more than 180 000 samples have been analysed since the survey began. Because of their large size ceratia are well sampled by the CPR and have been identified (45 species) and counted since the survey first started in 1931. Distribution maps for 36 species, based on the period 1958-1968, were given in the CPR Atlas (Edinburgh Oceanographic Laboratory 1973). Here we evaluate seasonal, interannual and spatial variability for the seven

most abundant species in the north east Atlantic and North Sea: *C. fusus, C. furca, C. horridum, C. lineatum, C. longipes, C. macroceros* and *C. tripos* over a sixty five year period (1931-1939, 1946-1995). The results will be discussed in relation to known ecology and interpreted on the basis of ususual events such as that described by Dickson et al. (1992) and recent major changes in plankton (Reid et al. in press) that appear to be linked to decadal changes in climate.

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Upper Neogene dinoflagellate cyst assemblages from Oued Arjart, Bou Regreg Basin (Morocco)

Rivas-Carballo, M.R., Civis, J., Alonso-Gavilán, G. & González-Delgado, J.A. 1998. Upper Neogene dinoflagellate cyst assemblages from Oued Arjart, Bou Regreg Basin (Morocco). - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 127.

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Variations in the dinoflagellate cysts assemblages during the Upper Neogene (*Globorotalia margaritae* and *G. margaritae/G. puncticulata* data) of Oued Arjart section (Bou Regreg Basin, NW Morocco) reflect several sea level fluctuations. Dinocyst assemblages at the base of the section are dominated by *O. israelianum* and show littoral, probably confined, conditions. At the middle part of the stratigraphic column dinoflagellate cyst assemblages are composed by outer-neritic species suggesting the stablishment of more open marine conditions. Subsequently, these are replaced again by the littoral assemblage. At the top a new change in the composition of the dinoflagellate cyst assemblage is noted: *L. machaerophorum* becomes dominant and a slight increase of a new neritic assemblage is noted while the most of the species from the previous samples including *O. israelianum* dissapear. These facts imply a change in the environmental conditions and they may indicate the stablishment of a coastal shelf. These results are agree with the data obteined from the macro and microfauna in the same section (Alonso-Gavilán et al. 1997, González-Delgado et al. 1997).

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González-Delgado, J.A., Civis, J. & Andrés, I. 1997. The benthic communities (mollusks and foraminifers) in the lower Pliocene of the Oued Arjart section (Bou Regreg basin, NW of Morocco). - pp. 65-66 in: Abstracts of the 2nd Congress R.C.A.N.S.

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Dinoflagellate cyst evidence for a two step Younger Dryas cooling event in the North Sea

Rochon, A., de Vernal, A., Sejrup, H.P. & Haflidason, H. Dinoflagellate cyst evidence for a two step Younger Dryas cooling event in the North Sea. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 128.

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Norwegian Channel core Troll 89-03 spanning the last 15 ka has been analysed for its palynomorph content with special attention paid to the Bølling-Allerød (BA; 13 to 11 ka) and the Younger Dryas (YD; 11 to 10 ka) intervals. The palynological analyses include counts of dinoflagellate cysts to reconstruct sea surface conditions (summer and winter temperatures and duration of sea-ice cover), in addition to counts of pollen and spores to establish correlation with the vegetation history of northwest Europe. During the BA, a rise in sea-surface temperature both in February (up to 3 °C) and August (up to 15 °C) led to the establishment of ice free conditions in the northern North Sea, while pollen data reveal an increase of the vegetation cover. The beginning of the YD is marked by an increase in non-arboreal pollen input indicative of the opening of the vegetation cover, concomitant with a cooling in surface water during winter and development of sea-ice cover. However, sea-surface conditions remained relatively warm in summer until about 10 300 yr B.P., when extremely cold conditions and extensive sea-ice cover developed. Improving conditions are recorded in surface water by ~10 100 yr B.P., a few hundred years before the development of forested cover onshore as shown by the pollen record. Such a discrepancy between marine and terrestrial indicators at the end of Younger Dryas suggests a delayed response of the vegetation to regional climate warming.

A dinoflagellate approach to correlation of Piripauan-Haumurian (Upper Cretaceous) sections from the South Island of New Zealand

Roncaglia L., Field, B.D., Raine, J.I., Schiøler, P. and Wilson, G.J. 1998. A dinoflagellate approach to correlation of Piripauan-Haumurian (Upper Cretaceous) sections from the South Island of New Zealand. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 29-130.

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In New Zealand, continuous and fossiliferous Mesozoic and Cenozoic sections provide a complete low-latitude southern hemisphere sequence of biozones and stages of high international relevance. However, the endemic character of most New Zealand fossil faunas impedes precise correlation with the international chronostratigraphic units. The New Zealand Time Scale Project, currently being undertaken by the Institute of Geological and Nuclear Sciences (IGNS), New Zealand, aims to improve New Zealand chronostratigraphy and calibrate the local stages with the international timescale by means of bio-, magneto- and isotopestratigraphy in key sections.

The present work focuses on two sections in southern Marlborough and three sections in northern Canterbury, of Piripauan-Haumurian age (Late Cretaceous). In these sections, siliciclastic sediments rest unconformably on basement rocks (Torlesse Supergroup) of Late Jurassic to Early Cretaceous age (Warren 1995). A qualitative analysis of the dinoflagellate assemblages and correlation with sections studied by Schiøler & Wilson (in press), show that in the type section for the Piripauan and Haumurian stages (Haumuri Bluff, southern Marlborough) the Piripauan Okarahia Sandstone is of Late Coniacian to Early Santonian age, and the Haumurian Tarapuhi Grit is of Early to mid Campanian age. Hence, the Type Piripauan and the base of the Type Haumurian are separated by an unconformity encompassing at least the mid to upper Santonian interval. In southern Marlborough, the Haumurian Conway Siltstone and Claverley Sandstone together span the Campanian interval. In northern Canterbury, the Haumurian Broken River Formation is of mid to Late Campanian age; the base of the overlying Conway Siltstone is here of Late Campanian to Early Maastrichtian age; the top of the Conway Siltstone, and the base of the overlying Haumurian Loburn Mudstone are of latest Early to Late Maastrichtian age. The interval from the lower Campanian to upper Maast-richtian can be subdivided into five dinoflagellate zones: *Satyrodinium haumuriense* Interval Zone (Early to mid Campanian), *Isabelidinium korojonense* Interval Zone (new) (mid-Late Campanian), *I. pellucidum* Interval Zone (new) (mid-Late Campanian), *Alterbidinium acutulum* Interval Zone (Late Campanian-Early Maast-richtian) and *Manumiella druggii* Zone (latest Early to Late Maastrichtian). The *S. haumuriense* Interval Zone is subdivided into three new subzones: *Trithyrodinium suspectum* Interval Subzone, *Vozzhennikovia spinulosa* Interval Subzone and *Canninginopsis bretonica* Interval Subzone. The *A. acutulum* Interval Zone is subdivided into two new subzones: *Cerodinium diebelii* Interval Subzone and *Palaeocystodinium granulatum* Interval Subzone. These results have enabled significant revisions to the correlation of the New Zealand timescale with international Upper Cretaceous stages, and greatly improved resolution within the New Zealand local stages. Based on quantitative palynological analysis, a palaeoenvironmental interpreta-

tion is provided for each studied section where the siliciclastic sediments represent a range of depositional settings from coastal swamp to mid shelf. The onlap of Upper Cretaceous sediments onto the Torlesse Supergroup marked the start of a long term transgression probably caused by subsidence associated with south-west pacific Gondwana break-up.

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Distribution and biomass of oceanic dinoflagellates in the polluted coastal waters of Tuticorin, India

Santhanam, R. & Srinivasan, A. 1998. Distribution and biomass of oceanic dinoflagellates in the polluted coastal waters of Tuticorin, India. - NTNU Vitensk. mus. Rapp. bot. Ser. 1998-1: 130-131.

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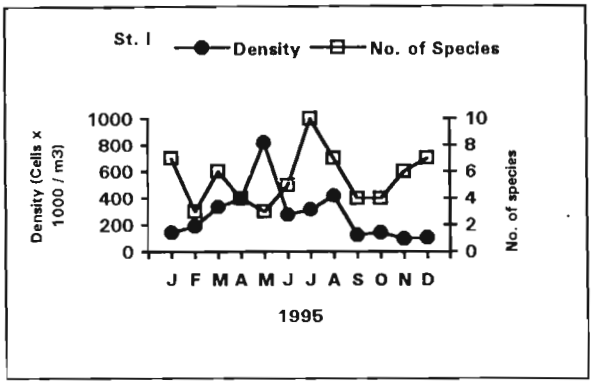
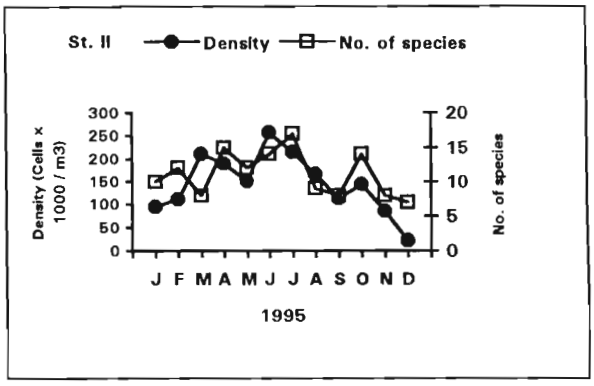
An annual investigation on the distribution and biomass of oceanic dinoflagellates was made during January - December 1995 in sewage polluted coastal waters (St. I) and non-polluted nearshore waters (St. II) of Tuticorin, a segment on the Gulf of Mannar in the Southern India. Though a total of 38 dinoflagellates have been found to occur in this coast, only 10 and 17 species of oceanic dinoflagellates have been recorded from St. I and St. II respectively. Interestingly St. I owing to its rich nutrient content showed maximum density (821 000 cells/m^3) of oceanic dinoflagellates especially during summer (March-May). The distribution and biomass of individual oceanic dinoflagellate species in relation to pollution and other hydrographical parameters are discussed.





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Dinoflagellates, fossil and modern: Certain unresolved problems

Sarjeant, W.A.S. & Taylor, F.J.R. 1998. Dinoflagellates, fossil and modern: Certain unresolved problems. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 131.

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Since the 1950's, when the relationship of the so-called "Hystrichospheres" was first recognized through the percipient studies of W.R. Evitt, our knowledge of their stratigraphical and geographical ranges has increased vastly. There has been a developing understanding of their morphology, though some concepts remain extremely controversial and though our understanding of the literature is made more difficult by varying terminologies. Even so, through the joint work of Fensome et al. (1993), it has proved possible at last, to formulate a classification that embraces both living and fossil forms. Moreover, we have begun to understand their life histories and there is considerable documentation concerning their distribution, not only in the present day plankton but also in the sediments forming in certain contemporary environments. In contrast, relatively little has been learned ascertained with regard to their ecology and palaeoecology. Additional problems have resulted from the proliferation of published names for taxa and inadequacies in description and illustration of many of these taxa.

In this paper, we identify certain areas which we believe require urgent study, if future work on dinoflagellates (modern or fossil) is to be soundly based. These include questions relating to environments, encystment, morphology, taxonomy and origins. We trust that our ideas may stimulate thinking about these organisms and may perhaps suggest paths for future research.

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Delving among dead dinos. An informal history of the study of fossil dinoflagellates, from the stone age to DINO 6

Sarjeant, W.A.S. 1998. Delving among dead dinos. An informal history of the study of fossil dinoflagellates, from the stone age to DINO 6. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 132.

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An informal history of the study of marine organic walled microfossils - variously called xanthidia, palinospheres, tasminitids, hystrichospheres, acritarchs and (ugliest of all) dinocysts - is presented. It be profusely illustrated by slides (some of them perhaps potentially libelous!) and rendered lively by anecdotes of varying credibility and opinions of questionable wisdom. In consequence, tape recording of the address will be prohibited and all cameras confiscated by the attendants before the presentation begins!

Dinoflagellate chloroplasts and phylogeny

Schnepf, E. & Elbrächter, M. 1998. Dinoflagellate chloroplasts and phylogeny. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 132-133.

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Only about 50 % of the recent dinoflagellate species are photosynthetic. Most taxa above genus level comprise species with or without chloroplasts and this applies also for many genera. The dinophytes have obviously acquired the chloroplasts early in their evolution and later lost them multiply. The genuine chloroplast is enveloped by three membranes with tylakoids in stacks of three. Pyrenoids are generally present. Stigmata, if present, are usually parts of the chloroplast or are modified genuine plastids. The characteristic dinophyte pigments are chlorophyll *a* and c_2 and the carotenoid peridinin. Unique for eukaryotes is that the rubisco belongs to the form II type which is elsewhere found only in some anaerobic bacteria. It is disputed whether the genuine dinophyte chloroplasts are derived from a primary endosymbiosis with a prokaryote or a secondary endosymbiosis with an eukaryote. Various dinoflagellates contain aberrant chloroplasts. Some, e.g., *Kryptoperidinium foliaceum* and *Peridinium balticum*, have a single, nearly complete endosymbiont, achieved from a pennate diatom. *Podolampas bipes* houses several symbiont cells. Highly reduced are the "symbionts" of *Lepidodinium viride* and *Gymnodinium chlorophorum*, derived from a prasinophyte. Even the presence of a symbiont nucleus is not yet proven definitevely. Aberrant with respect to the pigments (fucoxanthin derivatives, no peridinin) and/or the fine structure are, e.g., the chloroplasts of *Gymnodinium breve*, *G. galatheanum*, *G. micrum* and the *Gyrodinium aureolum* species complex. The dinoflagellate host do not seem to contain parts of the former endosymbiont except the chloroplasts. These organisms indicate a possible evolution which has to imply lateral gene transfer. Photosynthetic *Dinophysis* species have chloro-

plasts with only two envelope membranes and cryptophycean-like thylakoids, the pigments are typical for cryptophytes, including phycobilins, peridinin is missing (in contrast to former evidence). It is discussed whether they are derived from a cyanobacterium or from a cryptophyte. Symbiotic cyanobacteria are found in other members of the Dinophysiales, e.g., *Amphisolenia*, *Citharistes*, *Histioneis*, *Ornithocercus*. Various dinophytes, e.g. *Amphidinium poecilicroum*, *Gymnodinium aeruginosum*, use kleptochloroplasts from ingested cryptophytes transiently for photosynthesis. Genuine as well as secondarily acquired chloroplasts can be used for phylogenetic considerations only in exceptionally cases: it seems unlikely that the Prorocentrales have developed from the Dinophysiales as all Prorocentrales posses genuine dinoflagellate chloroplasts, no aplastidial member of the Prorocentrales has been reported whereas there is no member of the Dinophysiales known to have typically dinoflagellate chloroplasts.

Dinoflagellate blooms: Some patterns, causes and trophic consequences

Smayda, T.J. 1998. Dinoflagellate blooms: Some patterns, causes and trophic consequences. - NTNU Vitensk. mus. Rapp. bot. Ser. 1998-1: 133.

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A global expansion in the frequency and occurrence of dinoflagellate blooms, accompanied by extensions in the geographical ranges of major bloom-species, is in progress. This altered behavior appears to be part of a general phytoplankton response, in which altered dinoflagellate dynamics are pre-eminent, since other phylogenetic groups are also showing similar events (possibly exclusive of diatoms). This suggests that significant changes in the phytoplankton niches and community equilibrium are taking place in global coastal waters. My presentation will focus on dinoflagellates, with treatment rooted in bloom-species' autecology. This will reveal the considerable diversity that characterizes dinoflagellate bloom-species in terms of their habitat preferences, requirements, and in key features of their survival and bloom strategies. This autecological diversity contradicts the generally held view that dinoflagellates have a high degree of autecological similarity masking the factors regulating their species' selections and blooms, and giving the erroneous impression that these features are primarily stochastic events. The potential mechanisms altering dinoflagellate niches are evaluated, and the various patterns, trends and regulation of dinoflagellate blooms, both as natural occurrences and in response to habitat perturbation, discussed. Other aspects of dinoflagellate bloom ecology considered are: geographical range extensions, dispersal mechanisms, monospe-cific blooms, the role of microbial loop dynamics vs. metazoan zooplankton grazing in bloom control, and the linked issues of niche disruption, dinoflagellate blooms and phytoplankton community stability. The trophic consequences of dinoflagellate blooms are also demonstrated, as is the need to distinguish ecological consequences from human health and aquacultural impacts in discussions of harmful dinoflagellate bloom dynamics.

High resolution palynological analysis of the Vlieter; a record of the last 60 years from the Dutch Waddensea

Sprangers, M., Boessenkool, K.P., Brinkhuis, H. & Oost, A.P. 1998. High resolution palynological analysis of the Vlieter; a record of the last 60 years from the Dutch Waddensea. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 134.

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The Vlieter, located between the coasts of the dutch provinces of North Holland and Friesland was one of the major tidal channels of the former "Suydersea-embayment". After construction of the "Afsluitdijk" in 1932, separating the "IJsselmeer" from the Waddensea, the channel was abandoned. In the Vlieter channel, located to the north of the Afsluitdijk, current velocities decreased and the channel started to silt-up. Since 1932 an almost continuous 4.5 meter thick sedimentary record formed due to the quiet hydrodynamic conditions in combination with a low bioturbation intensity. Hence, cores from this abandoned channel allow high-resolution investigation of its sedimentary history over the past 60 years in an unprecedented way.

As part of a larger-scaled project investigating the Vlieter's sedimentology, geochemistry and biostratigraphy, we quantitatively analyzed its palynological content, emphasizing dinoflagellate cysts. An ultimate aim of the project is to correlate all findings to historical data records, and to investigate the nature of occurring cyclicities (e.g., seasonal and decadal).

In this poster, we present preliminary results and discuss their implications in relation to the other available results from the Vlieter project.

Heterotrophic dinoflagellates and their significance in the phytocenose dynamics of the Black Sea

Sukhanova, I.N. 1998. Heterotrophic dinoflagellates and their significance in the phytocenose dynamics of the Black Sea. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 134-135.

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In certain periods of the seasonal succession heterotrophic phytoplankton makes a significant share in total phytoplankton numbers and biomass in the Black Sea. The highest numbers of heterotrophic species in the open areas of the sea were observed in spring in the end of phytoplankton bloom culmination and in the following period when degradation in blooms of abundant diatoms *Nitzshia delicatissima* and *Rhizosolenia calaravis* has just begun. At the period heterotrophic phytoplankton share in total phytoplankton biomass makes from 18 % to 39 %. In Burgass Bay in summer of 1981 the group accounts for 1 % to 7 % of total phytoplankton biomass.

List of heterotrophes of the Black Sea phytoplankton includes 46 species. All the species exept *Ebria tripartita* belongs to Dinophyceae class. The largest contribution to total phytoplankton biomass in spring time was made by widely distributed species *Protoperidinium pellucidum*. Maximum values of the species biomass in open areas of the sea were as high as 280 mg/m^3 on a background of total phytoplankton biomass of heterotrophic phytoplankton. Maximum values of *P. pellucidum* biomass over the shelf was 45 mg/m^3 (with total phytoplankton biomass 1680 mg per cubic metre) which makes 87 % of total biomass of phytoheterotrophs. In fall maximum contribution to heterotrophic phytoplankton biomass varied from 1 to 8 mg/m^3.

Significant contribution to the Black Sea heterotrophic phytoplankton is made by mixotrophic species. Four of the species were revealed: *Exuviaella cordata, E. compessa, Hillea fusiformis, Ceratium fusus*. The species widely spread in the Black Sea and in certain periods are found in high numbers. *E. cordata* blooming often cause red tides in coastal areas. Heterotrophic forms of *E. cordata* appear in the end of the species bloom period and make 10 % to 40 % of total phytoplankton numbers. Numbers and biomass of *E. cordata* heterotrophic form in the western Black Sea were found to be as high as 2-3 x 10^{6}cells/l and 3.4-5.1 g/m^3. Transition of part of the population to heterotrophs was identified according to changes in amino acids and glucose consumption rates as well as changes in chloroplasts fluorescence. In fall the most abundant species was *C. fusus*. The species share in total phytoplankton biomass made from 5 % to 37 %. In areas influenced by upwelling in the eastern and western parts of the sea heteroptophic component of *C. fusus* population forms less than 2 % of total phytoplankton biomass. In central areas of the sea heterotrophic cells of the species make up to 15-22 % of total biomass. Maximum values of *C. fusus* biomass were as high as 50 mg/m^3. The highest numbers of *Hillea fusiformis* heterotrophic cells were observed in the central and western areas of the sea as well as over the north-western shelf in the area of the Zernov Phyllophora Meadows in a time of spring diatom bloom decline. The numbers of heterotrophic cells was 2.7 x 10^7 cells/l which makes 50 % of the total species numbers.

Results of analyses of heterotrophic and mixotrophic components of the Black Sea phytoplankton are evidence of their significant role in the plankton community which is comparable with zooflagellates and infusoria taken together.

Dinoflagellate cysts as possible indicators of industrial pollution in a Norwegian fjord.

Sætre, M.M.L, Dale, B., Abdullah, M.I. & Sætre, G.-P. 1998 Dinoflagellate cysts as possible indicators of industrial pollution in a Norwegian fjord. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 135-136.

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Variation in dinoflagellate cyst assemblages through the last approximately 300 years was studied in two sediment cores, one from the heavily polluted Frierfjord, and one from the adjoining, relatively unpolluted Brevikfjord, in order to document possible dinoflagellate responses to pollution. Changes in the cyst-flora were compared with historical information on the development of industry and also with geochemistry of the sediments,

reflecting aspects of pollution. In the Frierfjord core, increasing pollution was accompanied by a decrease in cyst concentration, possibly reflecting reduced production, at least of dinoflagellates, and a shift toward more heterotrophic species, possibly reflecting reduced light penetration in the euphotic zone, or increased production of prey for the heterotrophs. These trends seem to have reversed as pollution decreased after about 1975, suggesting that cyst assemblages contain signals that may prove useful for tracing the development of pollution. Cyst assemblages in the Brevikfjord core only showed minor changes.

Biogeochemistry and the early evolution of dinoflagellates

Talyzina, N.M. & Moldowan, J. M. 1998. Biogeochemistry and the early evolution of dinoflagellates. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 136.

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The natural product chemistry of modern organisms shows that dinosterols are specific and abundant molecules in dinoflagellates. Dinosteranes and triaromatic dinosteroid hydrocarbons are the molecular fossils (or biomarkers) of dinosterols. These hydrocarbons are extremely stable during a long period of time in the absence of high temperature, pressure or oxidation.

Biomarker analysis of selected fractions of Early Cambrian acritarchs which have some morphological similarities with dinoflagellate cysts, demonstrated that they have dinoflagellate affinity on the molecular level. Quantitative dominance of *Globosphaeridium, Skiagia, Comasphaeridium* and *Lophosphaeridium* was observed in the kerogen samples containing dinosteranes and structuraly related 4-methylstigmastanes from different localities. This indicates that the dinosterane and 4-methylstigmastane producers are most likely among these genera.

The affinity of particular Early Cambrian acritarchs with dinoflagellates pushes back recognition of dinoflagellate ancestry at least 300 million years from the first generally accepted Middle Triassic dinoflagellate cysts (Goodman 1987, Helby et al. 1987). The biomarker investigation of the isolated acritarch cell walls supports chemical data previously reported from numerous oil and rock samples in which the dinosterane record has been established continuously from Precambrian to Cenozoic (Moldowan et al. in press).

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A high-resolution dinoflagellate cyst study across oxygen isotope stage 100 in the Mediterranean

Tap, M., Brinkhuis, H., Dekker, M., Lourens, L.J. & van der Laan, E. 1998. A high-resolution dinoflagellate cyst study across oxygen isotope stage 100 in the Mediterranean. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 137.

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As part of a multidisciplinary investigation dinoflagellate cysts have been studied in detail from sediments spanning oxygen isotope stages 99 to 101 at Monte San Nicola, Sicily, Italy. Oxygen isotope stage 100 is considered to represent one of the first Late Cenozoic Northern Hemisphere glaciations at about 2.5 Ma (Late Pliocene,Tertiary). In order to investigate high-frequency climate oscillations within this interval, 120 samples were taken from 6.1 m, corresponding to a sample resolution of approximately 400 yr.

We present preliminary results, and the comparison with those obtained from magnetic susceptibility analysis, various geochemical analyses and distribution patterns of planktonic foraminifers. Paleoenvironmental as well as climatic implications are discussed.

A palynological approach to study the onset and ending of sapropel S1 in the Easten Mediterranean

Targarona, J., Zonneveld, K., Boessenkool, K. & Brinkhuis, H. 1998. A palynological approach to study the onset and ending of sapropel S1 in the Easten Mediterranean. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 137-138.

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Neogene marine sediments from the Mediterranean contain distinct sapropels, organic-rich sediments. Most studies on the fromation of sapropels agree that these sediments were deposited with intervals with a warm and humid climate, leading to the stagnation of the water masses and/or to weak circulation. however, the relationship between the timing of the oceanographic and climatic changes which foster and end sapropel formation and the role of productivity resulting in anoxia are still a matter of debate. The palynological record (dinoflagellate cysts and pollen) in cores from the Alboran and Adriatic Sea, providing a basinwide perspective of environmental changes is used to time

and link the response of the oceanic circulation to climate forcing in relation to the formation of the most recent sapropel S1. Deposited in the Adriatic Sea between 8.3 and 6.3 ky BP(unc). Results show that increased runoff at 10 ky BP(unc) in the Adriatic Sea may have triggered the onset of sapropel formation in the Northern Aegean sea, dated at 9.8 ky BP. Between 10 and 7 ky BP(unc), a combination of increased runoff and rising sea surface temperatures in the Adriatic Sea (the main site of deep water formation and thus oxygen advection to the bottom) and also in the Alboran Sea, promote the formation of S1. After 7 ky BP(unc) runoff and productivity are low, thus between 7 and 6 ky BP(unc) the influence of high sea surface temperatures becomes dominant.

Dinoflagellate cyst record in upwelling systems: Past and present

Targarona, J., Jung, S., Zonneveld, K., Brinkhuis, H. & Willems, H. 1998. Dinoflagellate cyst record in upwelling systems: Past and present. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 138.

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Upwelling in the ocean is a unique process by which nutrient-rich water is brought up to the surface. As a result, phytoplankton growth is enhanced. This in turn may lead to rich fisheries. The mechanisms by which upwelling occurs are several and its details complex. However, in many instances the occurrence of upwelling is related to the atmospheric circulation and is extremely sensitive to its changes. This connection makes such areas interesting for studying mechanisms of Global Change. Finally, high productivity makes these areas a major sink of carbon in the ocean. Hence, areas of paleo-upwelling are also potentially interesting for oil exploration. Therefore, one of the main areas of ongoing research at the Laboratory of Paleaobotany and Palynology (Utrecht University) and Bremen University is the dinoflagellate cyst assemblages of major upwelling regions around the world (Portugal-NW Africa, Arabian Sea, Equatorial Atlantic, Benguela, Peru). The record of cysts in sediment traps, surface and core sediments for these regions is presented. From this research links to past ocean and atmosferic circulation are made. The aim of this Netherlands School of Sedimentary Geology sponsored poster session is to bring together the expertise gained in this field by both institutes. In this session, a basis for comparison among the different regions studied is provided, and recent progress is summarized.

(Joint LPP Utrecht University - Bremen university cooperation, NSG sponsored)

The evolution of dinoflagellates revisited

Taylor, F.J.R. & Saldarriana, J.F. 1998. The evolution of dinoflagellates revisited. - NTNU Vitensk.mus. Rapp.bot. Ser. 1998-1: 139.

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The senior author has reviewed this subject several times previously but not recently and this contribution reviews previous hypotheses, given the most recent data, including published molecular sequence comparisons. In particular the similarity between the phylogenetic patterns within the group, derived from comparative morphology (primarily tabulation), some biochemical features (primarily histones), the fossil record and ribosomal DNA sequences, is examined.

The position of dinoflagellates within the "eukaryotic tree" is examined first There is good agreement with the allocation of the dinoflagellates to the "Alveolates", a well-defined lineage divergent from the Chromists that also includes sporozoans (Apicocomplexans) and ciliates. Some "predinoflagellates", including *Oxyrrhis*, are identified.

A surpising degree of relational robustness can be observed, supporting the hypothesis of progressive loss of histones within the group. In this model the lowest branches are parasites, the Syndinians and Blastodinians, together with the non-parasitic Noctilucoids (none of these have a fossil record). The details of this model have been recently developed by Fensome, Taylor et al. Gymnodinoids are considered to be polyphyletic but generally forerunners to the strongly thecate groups, including the tabulationally closely related gonyualacoids and peridinioids. The most derived dinoflagellates are now thought to be the dinophysoids and prorocentroids, together forming a lineage, and possibly some highly derived gymnodinoids. Most of this is supported by molecular sequencing and, where available, the fossil record. However, the most widely used molecular phylogenetic methodology, small subunit cytoplasmic ribosomal DNA sequences, have so far failed to resolve the relative relationships of gymnodinioids, peridinioids and prorocentroids (the so-called GPP complex). Morphological data does not agree with such a grouping. This anomally, probably a flaw in the methodology, is discussed.

Establishing a hydrostratigraphic framework using dinoflagellate stratigraphy: An example from the Savannah River Site, South Carolina

Van Pelt, R.S., Engelhardt, D.W. & Christopher, R. 1998. Establishing a hydrostratigraphic framework using dinoflagellate stratigraphy: An example from the Savannah River Site, South Carolina. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 140.

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At the Savannah River Site in South Carolina, characterizing the nature, extent, and stratigraphic relationships of subsurface units is an integral part of ongoing environmental restoration efforts. Palyonology is used to assist in interpretation of hydrostratigraphic and depositional environments of subsurface sediments. Palynologically based biostratigraphy (specifically dinoflagellate stratigraphy) and paleoenvironmental interpretations provide refined hydrostratigraphic correlatin. Dinoflagellate species diversity and palynofacies are used to characterize various lithofacies and document the transgression and regression of depositional environments in response to changes in sea level. Depositional features, in turn, can serve as preferential pathways for groundwater movement.

The result of an analysis of Upper Cretaceous through Eocene sediments in selected wells demonstrate the effectiveness of using dinoflagellate stratigraphy and palynofacies in the interpretation of the complex hydrostratigraphy of the South Carolina Coastal Plain.

The *Prorocentrum cordatum/Prorocentrum minimum* problem in the evolution of the Black Sea ecosystem

Velikova, V. & Larsen, J. 1998. The *Prorocentrum cordatum/Prorocentrum minimum* problem in the evolution of the Black Sea ecosystem. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 140-141.

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Historically, the occurrence of red tides along the western coast of the Black Sea has been regular since 1974. Until 1986 there was no doubt that the majority of reported dinoflagellate blooms has been associated with massive development of a most traditional and easily identifiable species - *Prorocentrum cordatum* (Ostenfeld) Dodge (=*Exuviaella cordata* Ostenfeld, 1901, Caspian Sea samples), which densities ranged between

5.0 and 808.0 x 10^6 cells.l^{-1} during the last 25 years. In June-July 1997 the *P. cordatum* density was more than 200.0 x 10^6 cells.l^{-1} and the red tide's duration was more than 40 days.

For a long time it was considered that *P. cordatum* is an endemic species in the Black, Azov, Aral and Caspian Seas. In fact in other regions it was identified as *E. pyriformis, E. pacifica, E. peisonis* etc. (Dodge. 1975). The species has an optimum temperature of 20-24 °C and an optimum salinity of 10.2-15.0 ‰, thus being in the phytoplankton through the year *P. cordatum* "prefers" summer period (June-July) and brackish waters for its exponential phase of growth, just like another very similar to it species - *Prorocentrum minimum* (Pavillard) Schiller. Marasovic (1990) appears to have been the first author suggesting that the causitive organism in the Black Sea red tides history was not *P. cordatum* but *P. minimum.* Besides the authors who have studied phytoplankton in the above mentioned seas have never pointed in their lists of species *P. minimum.* Just only Kisselev (1938) described for the Caspian sea a species similar to *E. cordata* but with a small "proboscis" (apical spine) and identified it as *Exuviaella* sp., supposing that it is a varietal status of *E. cordata* or the same species. Later all taxonomists admit that the only characteristics that gives reason to consider the discussed organisms as specific is namely the presence of apical spine in *P. minimum* which unfortunately is not always well visible under LM. Under SEM examination of Black Sea samples (June, 1986) a spine was easily identifiable in the cells of *P. cordatum* (Marasovic et al. 1990) and it was concluded that early the authors simply have not paid attention to this detail following Morozova-Vodjanickaja (1954) who included *E. cordata* in the list of Black Sea phytoplankton species. Another interesting fact is that actually *P. minimum* red tides have been reported in France, Norway, Netherlands, Denmark, Japan etc. simultaneously with the Black Sea *P. cordatum* ones - the tendency of these organisms in longterm aspect to form spectacular blooms proved to develop absolutely identically. The question is do the taxonomic notes, life history, ecological spectrum and biogeographical distribution give enough foundations to consider *P. cordatum* and *P. minimum* as different species. If the answer is positive, then which is the blooming species in the Black Sea - so common and so unknown?

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Dinoflagellate biomarkers and their geological record: A general overview.

Versteegh, G. 1998. Dinoflagellate biomarkers and their geological record: A general overview. - NTNU Vitenstk.mus. Rapp. bot. Ser.1998-1: 142.

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Many living dinoflagellates are capable of producing unique organic molecules, amongst which specific toxins, steroids, pigments have been reported. Several species are also capable of producing cysts which may differ in their resistance to strong bases, acids and oxidising agents. This suggests that dinoflagellates are also able to produce different kinds of macromolecules for cyst wall formation.

In the fossil record only a very limited set of dinoflagellate specific molecules has been reported. Amongst other reasons, alteration and degradation of the original biomolecules and a lack of knowledge on the chemical composition of sediments play a role.

A better known dinoflagellate derived lipid is dinosterol (4,23,24-Trimethyl 5a-cholest-22-en-3b-ol). High quantities of dinosterol or its derivatives are sometimes present in sediments where dinoflagellate cysts are completely absent and vice versa.

In the present paper an overview is presented of the overlap between chemical information from living dinoflagellates, dinoflagellate cysts and sediment extracts. Subsequently, it tries to address possibilities of how these insights may contribute to future studies on dinoflagellate derived compounds.

Recent organic- and calcareous-walled dinoflagellate cyst distributions in the western Equatorial Atlantic, and their ecological significance

Vink, A., Zonneveld, K.A.F. & Willems, H. 1998. Recent organic- and calcareous-walled dinoflagellate cyst distributions in the western Equatorial Atlantic, and their ecological significance. - NTNU Vitensk. mus. Rapp. bot. Ser. 1998-1: 142-143.

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In the last decades, Quaternary dinoflagellate researchers have focused mainly on the studies of organic-walled dinoflagellate cysts, and the ecological information obtained from them has proved to be useful in reconstructing palaeoenvironment, palaeoclimatology, palaeoecology and palaeoceanography. Even though the calcareous-walled dinoflagellate cysts overwhelmingly dominate the total cyst flux into the sediment (concentrations of several millions of cysts per gram of sediment are not uncommon) and probably form a significant contribution to the total oceanic carbonate flux, the ecological information concerning these dinoflagellates is extremely limited and their use as palaeoenvironmental indicators has only just started to develop. Recent studies suggest that enhanced abundances of calcareous dinoflagellates occur when the productivity is low, i.e.

in oligotrophic water conditions (Höll et al. in press). However, other factors could simultaneously play a role in their distribution and a more detailed knowledge of the ecological preferences of each dinoflagellate species must be obtained.

For these purposes, surface sediment samples from the western Equatorial Atlantic, with emphasis on the Amazon Fan area, have been quantitatively analysed for their organic- and calcareous-walled dinoflagellate cyst content, as well as for the calcareous vegetative coccoid *Thoracosphaera heimii*. In order to obtain information on the (palaeo-)ecological significance of individual cyst species, a comparison between the distributions of organic- and calcareous-walled cysts and *Th. heimii* in the investigated sediments and several environmental characteristics of the overlying water column (i.e. temperature, salinity, nutrient content and stratification over different times of the year) is made, using the statistical techniques Detrended Correspondence Analysis and Canonical Correspondence Analysis. Furthermore, special attention is paid to the processes of cyst transportation, dilution (due to spatially varying sedimentation rates) and preservation (i.e. organic-walled cysts may be oxidised through the exposure of sediments to oxygen, and calcite may partially or totally dissolve at depths below the lysocline or Calcium Compensation Depth respectively). Studies as these are important as they provide a basic skeleton of ecological information suitable for the analysis of Quarternary sequences.

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Oceanic productivity and *Gymnodiniun catenatum* at the North West African Margin

Warnaar, J., Targarona, J. & Boessenkool, K.P. 1998. Oceanic productivity and *Gymnodiniun catenatum* at the North West African Margin. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 143-144.

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To investigate the present oceanic primary productivity near the coastline of Morocco and the Canary Islands (Agadir Canyon), organic walled dinoflagellate cyst assemblages of surface sediment samples are analyzed. Two transects from near the coastline to outer neritic are made to determine the location of maximum primary productivity, invoked by coastal upwelling. The area is generally characterized by an abundance of the species *Lingulodinium machaerophorum* and *Gymnodinium catenatum*, with highest concentrations below the upwelling zone. (*L. mach.* $1,0 \times 10^4$> cysts/g and *G. cat.* > $2,0 \times 10^3$ cysts/g). *G. catenatum* can cause paralytic shellfish poisoning (PSP). Recent research showed that this species is (re-) populating the North European German (Nehring 1995) and Danish waters (Ellegaard 1994).

In addition, the organic walled dinoflagellate cyst and pollen assemblages of a sediment core (from ±20 ky BP - subrecent) taken below the area of maximum productivity have been analyzed, to portray changes in

productivity (caused by upwelling) and climate. Preliminary results show that *L. machaerophorum* and *G. catenatum* have been continuously abundant for at least the last several thousand years. This suggests that these waters have possibly acted as a refuge for *G. catenatum* (Wyatt 1992) since its temporal disapearance from North European waters.

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Application of calcareous dinoflagellate cysts in high resolution analysis of Cenomanian chalk-marl Milankovitch cycles

Wendler J., Gräfe, K.-U., Mai, H. & Willems, H. 1998. Application of calcareous dinoflagellate cysts in high resolution analysis of Cenomanian chalk-marl Milankovitch cycles. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 144-145.

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A high resolution study focusing on the distribution and absolute abundances of calcareous dinoflagellate cysts was carried out to improve our understanding of Late Cretaceous orbital forcing (22 ka precession period) of chalk-marl sedimentary cycles. The results of this study were compared to the distribution of coccoliths and planktonic and benthonic foraminifera.

The studied sub-cycle forms part of a Middle Cenomanian section of the London-Paris Basin and is composed of rhythmically alternating grey chalk with chalky marl and claystone. The section (Escalles, S of Calais, NW France) is situated in a central, outer shelf position of this epicontinental basin. The complete Cenomanian/Turonian profile was interpreted in terms of biostratigraphy and sequence stratigraphy by Robaszynski & Amedro 1993.

The aim of the present study is to investigate high frequency cycles with respect to the calcareous dinoflagellate cyst content. The species spectra and the absolute abundances of specimens were analysed in detail. The investigated sedimentary cycle is, excluding one exception, dominated by Pithonelloids (>90 % of the assemblage). Pithonelloids are very rare in the basal marl of the cycle and reach highest abundances in the chalks. In addition, the ratio *Pithonella sphaerical Pithonella ovalis* was plotted, showing distinct fluctuations during the cycle. Low ratios are recorded in the basal marl and positive peaks occur in the chalks. There is a relation to the changes occuring within the oblique calcareous dinoflagellate cysts which are mainly represented by *Obliquipithonella pachystrata* zügel 1994 and the paratabulated forms *Cubodinellum renei* Keupp 1987 and *Pentadinellum vimineum* Keupp 1987. The two paratabulated forms show an inverse distribution. The abundances of *O. pachystrata* zügel 1994 show a distinct peak in the climax of the chalk development. An unknown bulge shaped structure of some specimens of *Obliquipithonella pachystrata* cysts was documented to occur in this peak.

The observed patterns probably represent short term productivity variations which can be interpreted to reflect climatic changes.

A distinct recrystallisation behavior due to diagenetic overprint was observed in the Pithonelloids whilst other calcareous dinoflagellate cysts show no signs of comparable effects. Thus high abundances of Pithonelloids positively correlate with increased diagenetic compaction of the chalks observed in disintegration experiments.

The data were compared to the lithological data of the cycle derived from plotting the percentages of certain grain size fractions of the sediment. This plot clearly shows a gradual development of the cycle without abrupt changes in lithofacies. It provides a more detailed distinction between marls and chalks than the field observation provides. In addition, the data set was compared to the distribution of foraminifera and coccoliths. The distribution patterns of these three groups, their relationship to one another and the various environmental factors that are likely to have controlled these distribution patterns will be discussed.

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Calcareous dinoflagellates - State of the Art

Willems, H. 1998. Calcareous Dinoflagellates - State of the Art. - NTNU Vitensk,mus. Rapp. bot. Ser. 1998-1: 145-146.

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Calcareous dinoflagellates - mostly 20 - 80 µm in size - have hitherto only received little attention, although their occurrence throughout earth's history sometimes reaches rock-forming quantities, as can be seen in the Upper Cretaceous chalk facies. Today they are the focus of extensive research activities at Bremen University. The studies of my research team cover their stratigraphic range from Upper Triassic to Recent, questions concerning their systematics and biodiversity, their palaeoecologic requirements, and actualistic culturing experiments. This lecture will inform of the actual projects and their national and international integration, and will point out special contributions on this subject within the frame of the DINO 6 Conference.

The first steps in the investigation of these dinoflagellates belonging to the Peridiniaceae more or less were a matter of chance - and the outcome of various preparation methods. The history of the study of taxonomic elements is described, which are used for the grouping of the calcareous tests summarized in the subfamily Calciodinelloideae. For a better understanding of the morphologic variability as well as of the wall structures as observed in fossil material, culturing experiments are being carried out on dinoflagellates living today and producing calcareous cysts.

Case studies from Cretaceous and Tertiary - especially of the Boreal realm - allow insights into the biostratigraphic value and the palaeoecologic potential of these organisms. Even though there are no rapid or grave changes at the K/T boundary, we can

observe successive changes in the composition of populations or in the wall structure of their calcite tests. An example from the Middle Cretaceous shows the applicability in palaeobiogeography. In combination with organic-walled dinoflagellate cysts, calcareous dinoflagellates are very useful proxy-indicators for certain palaeoceanographic parameters.

Our culturing experiments on calcareous dinoflagellates initiate new research methods. An innovative culturing equipment has been developed for this field of "experimental palaeontology" which allows the simulation of various environments under actuo-palaeontologic aspects (variable temperature, salinity, light intensity, nutrition).

Selected Tertiary dinoflagellates: The hole story is greater than the sum of the parts

Williams, G.L., Damassa, S.P., Fensome, R.A. & Guerstein, G.R. 1998. Selected Tertiary dinoflagellates: The hole story is greater than the sum of the parts. - NTNV Vitensk.mus. Rapp. bot. Ser. 1998-1: 146-147.

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Detailed morphological studies of certain Paleogene dinoflagellates from offshore eastern Canada are helping us refine the existing biostratigraphic resolution. In this poster, we highlight a number of cases, some of the most intriguing of which involve members of the subfamily Wetzelielloideae. This subfamily first appears in the late Paleocene and in its early development in the Ypresian shows significant "experimentation", especially in the archeopyle. After the Ypresian the archeopyle and related morphologic features become increasingly stable. Failure to recognize this evolutionary pattern has led to use of arbitrary differences such as relative lengths of horn, degree of periphragm ornamentation, and process structure distally to separate genera and species. A typical example is *Wetzeliella articulata*, which is characterized by having a well developed apical horn and two unequal antapical horns. With such an all encompassing morphology it is not surprising that some authors consider the stratigraphic range of this species to be Ypresian to Chattian. Such a range, of about 18 million years, would be surprisingly long for the species. To understand *Wetzeliella articulata*, it is necessary to read in full Eisenack's original description and to appreciate the nature of the archeopyle. The type is from the Oligocene and the archeopyle is soleiform. None of the specimens from the Ypresian and Lutetian recorded as *Wetzliella articulata* have a soleiform archeopyle. Rather they have different archeopyle types, referred to here as hyperepeliform, epeliform, latiepeliform or hypersoleiform archeopyles. Thus, *Wetzeliella articulata*, as currently conceived, can be subdivided into several species.

By extending this philosophy to other species of the genera *Wetzeliella*, *Rhombodinium*, *Dracodinium* and *Charlesdowniea* it is possible to emend the genera, based primarily on differences in archeopyle style and secon-

darily on ornamentation. The proposed subdivision of the Wetzelielloideae appears to make it a much more useful subfamily for stratigraphic subdivision.

Other complexes where a re-evaluation is proving worthwhile are the *Adnatosphaeridium-Emmetrocysta* complex, the *Systematophora-Cleistosphaeridium* complex and the *Glaphyrocysta-Enneadocysta* complex. We present examples of our findings on all the above groups in our poster.

Dinium-Alpha: A chronostratigraphy, morphology and photomicrography database builder for dinoflagellate cyst taxa

Williams, R.W. 1998. Dinium-Alpha: A chronostratigraphy, morphology and photomicrography database builder for dinoflagellate cyst taxa. - NTNU Vitensk.mus. Rapp bot. Ser. 1998-1: 147-148.

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Dinium-Alpha is a database application that runs under Microsoft Windows™ 95 and Windows NT4.x operating systems. Dinium-Alpha's primary objective is to provide the user with an intuitive, graphical interface for storage and retrieval of morphologic criteria, chronostratigraphic ranges and digital images of cyst taxa. The application functions as a platform for organising cyst taxa and images based on morphology and chronostratigraphy, thereby providing a consistent, interactive database for a single biostratigrapher or a large group.

Morphologic criteria are depicted on the interface by descriptive icons subdivided into four main categories: cyst shape, archeopyle type and cyst wall. Chronostratigraphic ranges are stored and queried through a scrollable time scale accommodating several search strategies related to appearances and acme events. Dinium-Alpha allows the user to search for cyst taxa using any combination of morphologic criteria and range parameters. Range and abundance events may also be differentiated according to geographic occurrence or individual studies and selectively queried.

Dinium-Alpha interfaces with portions of DinoSys-Svithjod, a comprehensive taxonomy and image database application developed by LPP, Laboratory of Palaeobotany and Palynology, University of Utrecht. This enables the user to retrieve original and supplementary descriptions and over 8000 images from the DinoSys-Svithjod database.

For applications in modern cysts, future upgrades will include a GIS interface for storing and retrieving geographic distribution. For correlation based on phenotypic variation, a morphostratigraphy function is under development that will allow logging and range chart plotting of morphologic characters vs. sample depth or geographic distribution.

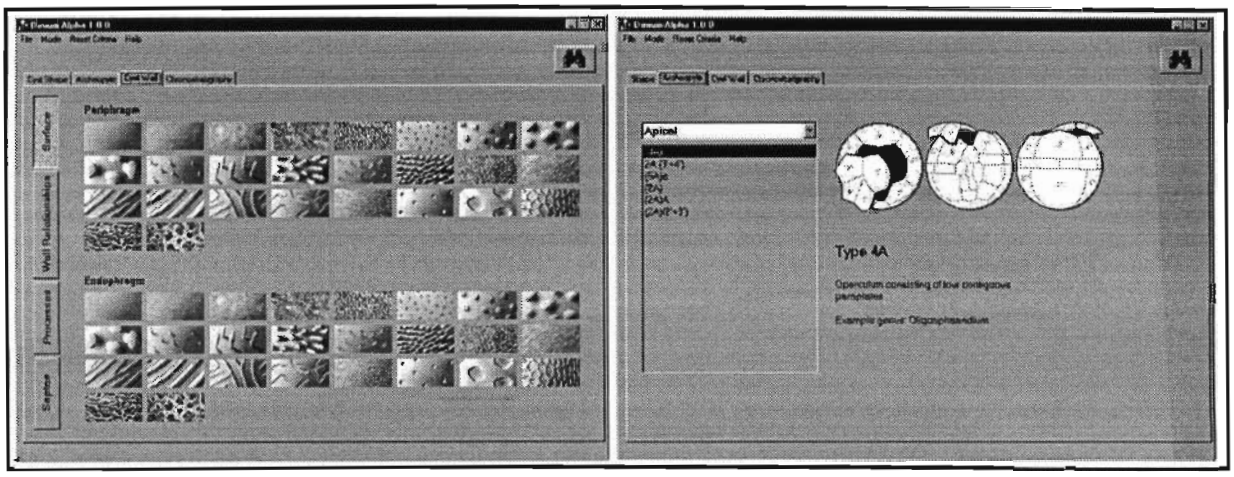

Fig. 1. Two panels from the Dinium-Alpha graphical interface showing icons for selecting surface ornament and archeopyle type.

Upper Jurassic and Lower Cretaceous dinoflagellates, spores and pollen from the Texas, Arkansas and Louisiana Gulf Coast, United States

Wood, G.D., Benson, D.G., Jr., Guillory, R. & Miller, M.A. 1998. Upper Jurassic and Lower Cretaceous dinoflagellates, spores and pollen from the Texas, Arkansas and Louisiana Gulf Coast, United States. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 148-149.

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The Jurassic-Cretaceous boundary interval (Kimmeridgian through Valanginian) from the subsurface of Arkansas, Louisiana and Texas contains diverse and well-preserved palynomorph assemblages. The stratigraphic interval examined includes the Bossier/ Cotton Valley through Sligo/Travis Peak formations, and their equivalents. The biostratigraphic interpretations are based on tops, or Last Appearance Datums (LAD), in cuttings and core samples. Dinoflagellates are represented by *Achomosphaera*, *Amphorula*, *Batioladinium*, *Canningia*, *Cantulodinium*, *Cleistosphaeridium*, *Cribroperidinium*, *Ctenidodinium*, *Cyclonephelium*, *Dichadogonyaulax*, *Ellipsoidictyum*, *Dissiliodinium*, *Druggidium*, *Endoscrinium*, *Fromea*, *Gardodinium*, *Gonyaulacysta*, *Hystrichodinium*, *Kleithriasphaeridium*, *Microdinium*, *Muderongia*, *Occisucysta*, *Pareodinia*, *Phoberocysta*,

Prolixosphaeridium, Pseudoceratium, Scriniodinium, Subtilisphaera and *Systematophora*. Spores/pollen include *Callialasporites, Ceratosporites, Cicatricosisporites, Classopollis, Concavissimisporites, Deltoidospora, Ephedripites, Gleicheniidites, Klukisporites, Kraeuselisporites, Taurocusporites, Trilobosporites* and *Verrucosisporites*. Key cored intervals in wells located in Union Parish, Louisiana, combined with cuttings samples from nearby areas provided the principal framework for this zonation. A tentative Valanginian age is characterized by the LAD of a new species of *Druggidium*. This interval is typically seen in the lower Hosston Formation. The provisional Berriasian, is picked by the LAD of a new spore which marks the top of the Cotton Valley Formation in this area. Down dip this new spore is associated with a well preserved and diverse marine assemblage that includes *Achomosphaera neptunii, Dichadogonyaulax, Gonyaulacysta diutina, Kleithriasphaeridium, Systematophora* and several unde-scribed dinocysts. The Tithonian is marked by a new species of *Ellipsoidictyum*. The LAD of *Subtilisphaera? paeminosum* marks the Bossier-Cotton Valley transition and is interpreted as the Tithonian-Kimmeridgian boundary. Species commonly observed with, or just below *Subtilisphaera? paeminosum,* include *Subtilisphaera? inaffecta, Ctenidodinium? chondrum* and a new species of *Krauselisporites*. The oldest consistent dinoflagellate LAD in the basal Bossier to Haynesville transition is *Gonyaulacysta jurassica*. The next phase of this study involves examining cores to calibrate the dinoflagellate succession against the Tethyan nannofossil zonation.

Dinoflagellate cysts, spores and pollen from the North Gabon Subbasin and their bearing on the opening of the South Atlantic Ocean

Wood, G.D., Miller, M.A. & Krebs, W.N. 1998. Dinoflagellate cysts, spores and pollen from the North Gabon Subbasin and their bearing on the opening of the South Atlantic Ocean. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 149-150.

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Outcrop sections within the suture zone between the Congo and the Sao Paulo cratons are instrumental in elucidating the developmental history of the South Atlantic Ocean. Two stratigraphic units, the Presalt Cocobeach Group and Postsalt Madiela Formation, were examined for palynomorphs, palynofacies and organic geochemistry to compare and contrast the pre and post salt environments.

The Cocobeach Group consists of conglomerates, sandstones, siltstones, shales (including varved bituminous intervals) and thin carbonates representing fluvial-lacustrine deposition within a rift-valley. The Madiela Formation is typified by calcareous shales and carbonates (e.g., reefal and oolitic) deposited in shallow marine depositional settings.

Distinctive palynomorphs recovered from the Cocobeach Group include the pollen *Afropollis jardinus, Uesuguipollenites callosus* and chlorococcalean algae (e.g., *Botryococcus*). The assemblage is dominated by *Classopollis* and *Ephedripites* but pteridophyte spores (e.g., *Cicatricososporites, Cyathi-*

dites, Dictyophyllidites, Gleichiniidites) may be well-represented. The presence of *Classopollis* and striate ephedroid pollen, in combination with geological data, suggests that that the climate was arid tropical-subtropical with probable monsoonal events. The variety of pollen/spore taxa also reflects fluvial-lacustrine flora and habitats associated with effects of topography. Palynofacies and organic geochemistry of the Cocobeach sequence indicate that samples with high total organic carbon (TOC) and Hydrogen index (HI) are dominated by amorphous debris or organic sheets (of possible algal or cuticular origin) that fluoresce (Type 'I' kerogen-liquid prone). Low TOC/HI samples usually contained more abundant woody and inertinitie debris (Type III-gas prone and Type IV kerogen).

The Madiela Formation palynomorph assemblage consists of pollen, spores, microforaminiferal linings and dinoflagellate cysts. The latter includes representatives of *Cribroperidinium, Florentinia, Odontochitina, Oligosphaeridium, Spiniferites, Subtilisphaera* and *Trichodinium.* Geochemical analyses indicate Type I/II kerogen, however, TOC values from the samples studied extremely low (e.g., 0.40 %).

These palynological assemblages closely correspond to published geological and geophysical data from the area. The Cocobeach Group microflora is devoid of marine palynomorphs whereas the Madiela Formation contains marine dinocysts and microforaminiferal linings. The former represents non-marine environments associated with a rift-valley system and the later is indicative of the first open marine transgression related to the formation of the South Atlantic.

Dinoflagellate biostratigraphy and palynofacies analysis of a low latitude Campanian-Maastrichtian section from Colombia, South America

Yepes, O. 1998. Dinoflagellate biostratigraphy and palynofacies analysis of a low latitude Campanian-Maastrichtian section from Colombia, South America. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 150.

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Dinoflagellate biostratigraphy of twenty outcrop samples of black shales from Los Pinos Formation, Chiguata Creek, Colombia yielded rich assemblages *of Palaeocystodinium/Andalusiella* group, and *Cerodinium/Senegalinium* group. The Campanian-Maastrichtian boundary was placed 40 meters above the base of Los Pinos Formation based on the last occurrence of *Trichodinium castanea.* Qualitative and quantitative analysis of the dispersed organic matter showed a general shallowing upward sequence. This is indicated by an increase of terrestrial-derived organic matter and a decrease of amorphous marine-derived organic matter in the upper part of the section with respect to the lower part. A comparison between eight samples that were sonicated with a subset of the same eight samples that were not sonicated showed that sonication before heavy liquid separation does not effect the preservation of dinoflagellate cysts but helps to efficiently remove clays and colloids.

The role of dinoflagellates in the phytoplankton of the Baltic Sea (1980-1995)

Zernova, V.V. 1998. The role of dinoflagellates in the phytoplankton of the Baltic Sea (1980-1995). - NTNU Vitensk.mus. Rapp. Bot. Ser. 1998-1: 151.

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During last decades the development of the Baltic phytoplankton is under the influence of growing eutrophication both anthropogenic and connected with changes of hydrological conditions. The modern phytoplankton structure is unstable. The interregional and annual fluctuations are high. Year after year the composition of dominant species and main groups of algae changes. The significance of nondiatom phytoplankton (dinoflagellates, flagellates, green algae and cyanobacteria) is raising. The south limit of dominating of nondiatom algae lies approximately on 56 N. Usually considerable (more than 50 %) part of total biomass in spring-summer period is formed by dinoflagellates.

Among most abundant species which we must name first is *Peridinella catenata* and *Dinophysis* spp. During the last years the positive trend in *P. catenata* developing was noted not only in coastal, but also in open Baltic waters. In June 1995 in the Gulf of Finland and in the Central region the quantity of *P. catenata* was 565 600-17 800 cells/l, *D. acuminata* 0-82 000 cells/l and *D. norvegica* 220-13 830 cells/l. Total quantity of dinoflagellates in the Gulf of Finland was 648 000 cells/l - 21 % and 49 117 mg/m^3- 86 %, in the Central region 171 350 cells/l - 68 % and 49 117 mg/m^3 - 86 %. In July 1996 in post-maximum period the total quantity of dinoflagellates was lower, but their relative value was approximately high: in the Gulf of Finland 4 710 cells/l - 4 % and 52 mg/m^3 - 35 %, Central region - 4400 cells/l - 8% and 37 mg/m^3 - 53%, West region - 560 cells/l - 8% and 9 mg/m^3 - 12%. Only single cells of dinoflagellates were met in October 1997 in the Gdansk Bay.

Correlation of Oligocene through Early Pliocene dinoflagellate cyst associations from The Netherlands with Italy

Zevenboom, D. 1998. Correlation of Oligocene through Early Pliocene dinoflagellate cyst associations from The Netherlands with Italy. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 151-152.

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In cooperation with the Dutch Geological Survey four wells have been examined for their foraminefers and dinocysts content. These wells containing Oligocene to Lower Pliocene strata of the Netherlands have been correlated with outcrop sections of Italy. All four wells contain rich and divers dinoflagellate cyst associations, which enabled the recognition of quite a number of dinocyst zones established for Italy by Zevenboom (1995). This scheme permitted long distance correlation between Italy and Northwest Europe, and an age assessment for the shallow marine sediments of the Netherlands, ranging from Oligocene through early Pliocene. Differences in qualitative and quantitative

dinocyst distribution patterns are discussed in terms of differences in paleo-bathymetric and climatic setting. Moreover, using different dinocyst groups from the two areas as palaeotemperature indicators the same temperature trends could be observed.

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Zevenboom, D. 1995. Dinoflagellate cysts from the Mediterranean Late Oligocene and Miocene. - CIP-gegevens Koninklijke Bibliotheek Den Haag. 221 pp. (Published Ph.D. thesis Utrecht University)

What can dinoflagellates tell us about climate? An example from the Arabian Sea monsoonal system during the last deglaciation

Zonneveld, K.A.F. 1998. What can dinoflagellates tell us about climate? - An example from the Arabian Sea monsoonal system during the last deglaciation. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 152-153.

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In recent years, it has become apparent that climate is highly related to the complex interactions between ocean and atmosphere. In order to understand these interactions it is essential to know how both systems behave in relation to climate change. This information can be obtained by establishing detailed reconstructions of these systems in relation to past climatic variations. Changes in fossil dinoflagellate cyst assemblages have proved to be useful in reconstructing palaeoceanological conditions. For these reconstructions, information on the (palaeo-)ecology of individual species as well as information on their transport and preservation in ocean sediments has to be used.

In the present paper an example will be presented from the construction of a detailed climatic reconstruction of the northwestern Arabian Sea monsoonal system during the last deglaciation. For this purpose, Arabian Sea surface sediment samples, samples from three sediment traps at two northwestern Arabian Sea sites as well as sediments from a piston core deposited during the last deglaciation in the northwestern Arabian Sea have been studied on their organic-walled dinoflagellate cyst content.

Information on the (palaeo-)ecological characteristics of individual cyst species is obtained by relating their lateral and spatial distribution patterns in samples from surface sediments and traps to environmental characteristics of surface waters at times of deposition. By studying the cyst content of traps at different water depths at one site, insight is obtained in transport and preservation processes within the water column. Information on secondary transport and preservation of cysts in bottom sediments is obtained by comparing the cyst associations recovered from the traps with those of the underlying sediments.

The Arabian Sea climatic system is strongly influenced by the semi-annual reversal of wind patterns; the Southwest (SW) monsoon in boreal summer, and the Northeast (NE) monsoon in boreal winter. The SW monsoonal winds initiate intense upwelling along the Somali coast, the intensity of which is related to the strength and duration of the SW monsoon. During the NE monsoon and intermonsoonal periods surface waters are relatively stratified. Combined results from the previously discussed studies are used to define cyst species groups characteristic for upwelling and non-upwelling situations. The

ratio between these species groups is used to reconstruct palaeo-upwelling and palaeo-monsoon intensity along the Somali coast. The established reconstruction will be compared with other reconstructions available for the region and time interval.

Production and distribution in recent sediments of the South Atlantic Ocean of *Sphaerodinella albatrosiana* (Kamptner) Keupp and Versteegh in relation to temperature gradients

Zonneveld, K.A.F., Höll, C., Janofske, D. & Willems, H. 1998. Production and distribution in recent sediments of the South Atlantic Ocean of *Sphaerodinella albatrosiana* (Kamptner) Keupp and Versteegh in relation to temperature gradients. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 153.

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A group of organisms that has generally been overlooked in the past is that of the calcareous cyst forming dinoflagellates. As result of their cyst-size between about 20-60 µm they appear to be too small to have beeen included in foraminiferal studies and too large for studies of the nannoplankton community. Furthermore, they are dissolved during preparation methods for studies on organic-walled dinoflagellate cysts. Recent studies on sediment trap material have shown that, even today, calcareous dinoflagellate cysts form a considerable flux from surface waters to the deep sea in the particle size fraction between 20 and 125 µm. As such, they may form a significant, and until now probably underestimated, contribution of the total carbonate flux to the ocean floor.

In order to develop the full potential of calcareous dinoflagellate cysts as tools for palaeo-oceanographic and -productivity reconstructions, it is essential to determine the ecological characteristics of living taxa. In the present paper the combined results are presented from a field study of and culture experiments with *Sphaerodinella albatrosiana*. In order to obtain insight in the relationship between the production of this cyst and temperature, the present day distribution pattern of *Sphaerodinella albatrosiana* in surface sediments of the South Atlantic Ocean is compared to temperature gradients in the upper water column. Furthermore, motiles of a unicellular culture have been grown under different temperature regimes ranging from 4 to 34 °C and the relationship between cell growth, the amount of cyst production and different temperatures has been established. Combined results from both studies enabled the determination a temperature range in which the motiles were able to produce cysts, as well as the optimal temperature conditions for cyst-producing.

Addition (due to late delivery):

Harmful dinoflagellates in the Northern Adriatic Sea

Cabrini, M. 1998. Harmful dinoflagellates in the Northern Adriatic Sea.. - NTNU Vitensk.mus. Rapp. bot. Ser. 1998-1: 154.

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Toxic dinoflagellates have been regularly detected in the Northern Adriatic Sea from 1982 (Boni 1983, Honsell et al. 1992). The occurence of *Dinophysis* species cause the contamination of mussels on shellfish farms from ten summers and *Alexandrium* species have also been detected in the Gulf of Trieste (Cabrini et al. 1995). In this area up to now five species belonging to *Alexandrium* genus have been identified. In this work these species are described by light, epifluorescence and scanning electron microscopy and information is given about their ecology and toxicity.

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