

with most of the assemblages described from other onshore intertrappean beds, the best correlation can be made with the subsurface sediments of Krishna-Godavari Basin, as both of them have marine phytoplanktons in association with *A. bengalensis* related palynoflora. Accordingly, the general palynological preparations examined and the almost constant presence of phytoplanktons provides additional evidence for a marginal marine affinity to the deposition of the late Maastrichtian Nawaragan intertrappean sediments. Coastal depositional setting as evidenced by palms (*Nypa*, *Hyphaene*), intertidal forms (*Sonneratia*, *Acrostichum*) and dinocysts is thus inferred for the Nawaragan intertrappeans. Considering this environment, it is suggested that the northwestern shore of the Deccan was linked to the equatorial ocean (south western Tethys sea) probably through the Narmada valley during the Late Cretaceous period.

Session g7

TERTIARY PALYNOLOGY

Palynology of the lower Tertiary Kelalan formation, Bario, Sarawak, Malaysia

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Twenty-six outcrop samples were obtained, mostly from riverbank exposures, in the interior of northwest Sarawak, near the village Bario, approximately 3 km to the border with Kalimantan, Indonesia. These rocks were previously mapped as an equivalent of the predominantly marine, Neogene Kelabit Formation.

Thirteen suitable samples were run for palynology, foraminifera and nannofossil analysis. Only seven proved to be fossiliferous. The diversity and abundance of palynomorph and foraminifera are both moderate to good. The palynomorph and arenaceous deepwater benthic foraminifera are very well preserved. However, the calcareous planktonic foraminifera are not only rare, but also poorly preserved and have developed crystalline tests. This indicates reworking of shelf sediment prior to deposition in a deep marine environment.

The palynomorph assemblage indicates that the age of the outcrops are Early Tertiary, younging slightly towards the south becoming Late Eocene. The depositional environment indicates a deepwater deposition, (outer neritic to outer bathyal) in the north, and shallowing to more proximal deposition in the south (shallow marine and brackish water-influenced, lower coastal plain). Based on this evidence, the outcrops are thought to be equivalent to the upper part of Kelalan Formation, and may represent its southern extension.

Some of the key palynomorph assemblages recorded at this locality are comparable with the stratigraphically equivalent Kayan Formation in west Sarawak (Muller, 1968), although their diversity and abundance are less. The occurrence of pollen, resembling *Florschuetzia trilobata* tp. in Bario outcrops, together with *Psitricolpites kayaensis* and *Spinizonocolpites baculatus*, may imply an Early Eocene to Paleocene age. These taxa have not been recorded from the Kayan Formation. If the Bario outcrops proves to be correctly dated, then this study will have recorded the oldest occurrence of *Florschuetzia trilobata* tp., predating the occurrence in the Middle Eocene of Nanggulan Formation in Java and Late Eocene Mangkalihat coal in Kalimantan, Indonesia (Morley, 1998, 2000). This may also imply that the precursor of the *Florschuetzia trilobata* tp. may have become adapted to brackish water environment as early as Early Eocene and Paleocene.

Pantropical palynomorphs in the Eocene of the Malaguides (Betic Cordillera, southern Spain)

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A quite diverse palynological pantropical assemblage was found in Lower-Middle Eocene sediments of the Malaguide Complex, near Malaga. This is the highest tectonic (nappe) complex of the essentially metamorphic Internal Zones of the Betic Cordillera. In spite of the strongly tectonized, partially chaotic character and structural disorganization of the Malaguide Meso-Cenozoic outcrops around Malaga, four productive samples were collected from a quarry carved near the Harania cement factory. A relatively organized Paleogene succession several tens of meters thick was recognised there. The succession is composed by: 1) continental to very shallow marine *Microcodium*-rich calcarenites, conglomerates and marls attributed to the Paleocene; 2) very shallow marine *Alveolina*-rich limestones (sometimes bearing also red algae and small *Nummulites*) of Cuisian-lowermost Lutetian that lie unconformably and transgressively upon previous deposits; 3) the stratigraphically highest beds of *Alveolina* limestones are interlayered with greenish-grey and white marls intervals with intercalated gastropod-bearing limestones deposited in coastal marshy freshwater to moderately saline environments. This marshy facies, that become predominant upwards in the succession, also contain laterally discontinuous thin beds of lignite and black clays from which four palynologically productive samples were obtained.

The assemblage is characterized by the abundance of Angiospermae, especially the form-genus *Proxapertites* (up to 54 % of the total association) and *Diporoconia* (17 %), together with a small proportion of other taxa, mainly of Restionaceae, Icacinaceae, Bombacaceae, Sapotaceae, *Cissus*, *Ilex*, Juglandaceae and Myricaceae. *Proxapertites* is known since the Upper Cretaceous of tropical-subtropical in Africa, Asia and America. Recently it was recorded from Austria and Spain. In the Malaga outcrop *Proxapertites* is represented mostly by *P. operculatus* Van der Hammen, minor proportion of *P. psilatus* Sarmiento (only recorded in Colombia, and western Venezuela up to now) and *P. sp.*, possibly a new form. In the countries surrounding the Mediterranean sea *Proxapertites* has been only cited in Egypt (Upper Cretaceous) and Spain (Eocene). Some ferns are also present, such as Schizaeaceae, the type *Lygodium* being present in particular in a high amount, and a smaller proportion of Pteridaceae type *Acrostichum*, as well as the form-genus *Polypodiaceosporites*, Gleichenaceae and Osmundaceae. One sample has also provided one specimen cyst of *Operculodinium*, that points out to brackish water conditions, together with several specimens of fresh-water green algae *Botryococcus*. This former palynofacies bears evidence of limited taphonomic effects/perturbance: abundance of large plant tissue with cuticles, brown wood remains, palynomorphs being all well preserved, and no separation into halves of most specimens of *Proxapertites*. The lithological and palynological features confirm deposition under warm and wet tropical climate in a coastal freshwater pond within a marshy environment, that was temporarily connected with normal marine environments, as indicated by facies analysis.

Quantitative biostratigraphy for the Tertiary of the Llanos Foothills, Colombia: Improving palynological resolution for oil exploration

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Oil exploration in Colombia has traditionally taken place in areas with relatively few structural complexities. However, in the last decade, exploration has moved to regions characterized by complex structural deformation, poor seismic resolution, and many stratigraphic problems, such as in the Llanos Foothills. In this region, the major reservoirs occur in mostly continental Paleogene sequences, where palynomorphs are usually the

only fossil group found. Thus, palynology has become an important tool in controlling the stratigraphic position of a well during drilling, in testing diverse seismic and structural interpretations, and correlating reservoirs.

This study provides a biostratigraphic framework for the Tertiary of the Llanos and Llanos Foothills, making use of graphic correlation, RASC, and Constrained Optimization. We utilized 18 sections with palynological information from outcrops, well cores, and well ditch cuttings. Seventeen palynological zones are proposed. Based on the biostratigraphic model produced by this analysis, we reinterpreted a recently drilled well in the Llanos foothills upon which several previous interpretations had been made. A sidetrack of that well and a new exploratory well in the area were subsequently drilled, validating the proposed model. Also, we have used the biostratigraphic model to solve some old stratigraphic problems in the Arauca oil field. This is a positive test that the biostratigraphic framework developed for the Tertiary of the Llanos foothills is reliable and can be successfully applied to oil exploration in the region.

The Pliocene palynoflora in Moldova: reconstruction of vegetation and environment

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The Moldavian territory is a part of the Eastern Paratethys. The Pliocene sediments are widespread in its central and southern parts. According to the accepted regional stratigraphic scheme based on mollusk, mammal fauna and palaeomagnetic data, the Pliocene is divided into three stages - Early (Pontian), Middle (Kimmerian) and Late (Akhaglyian). The Pliocene is represented by marine to lagoonal, alluvial (the Danube and Prut river terraces), and subaerial sediments. A total of 70 samples were collected from eight outcrops and three borehole cores in the southern part of Moldova for palynological study. The stratification of sediments in outcrops and cores was based on fossil fauna remains. The obtained palynological data were used to characterize the Pliocene palynoflora assemblages and reconstruct the evolution of vegetation and palaeoenvironment related to climatic changes and sea-level fluctuations of the Eastern Paratethys.

Pontian Stage (5.4-4.7 Ma), as based on palynological data, was divided into three substages.

The *Early substage* corresponds to Zanclean transgression. The pine-broadleaved subtropical forests consisted of *Picea* sect. *Eupicea*, *P.* sect. *Omorica*, *Tsuga*, *Cedrus*, *Taxodium*, *Carpinus*, *Fagus*, *Zelkova*, *Magnolia*, *Myrica*, *Moraceae*, etc., predominated. Marshlands were widespread, represented by *Taxodium*, *Salix*, *Alismataceae*, *Cyperaceae*, *Sparganiaceae*, *Typhaceae*, *Sphagnum*. Diverse ferns of *Adiantum*, *Osmunda*, *Polypodiaceae* were encountered.

The *Middle substage* is related to regression. Aridification of climate took place. The open vegetation communities consisted of xerophylous and halophylous herbs (*Chenopodiaceae*, *Artemisia*) were widespread. The riparian forests represented by temperate wood vegetation were limited.

The *Late substage* coincided with marine transgression. The climate during this substage was warm and relatively humid. Broad-leaved temperate-subtropical forests consisted of *Ulmus*, *Fagus*, *Quercus*, *Tilia*, *Acer*, *Fraxinus*, *Carpinus*, *Corylus* increased. Some exotic plants, such as *Juglans*, *Castanea*, *Zelkova*, *Celtis* occurred. The proportion of mesophylous herbs increased.

Kimmerian Stage (4.7-3.4 Ma). More land emerged from sea waters. The predominance of broad-leaved forests (*Quercus*, *Fagus*, *Carpinus*, *Tilia*, *Fraxinus*, *Carpinus*, *Corylus*, *Alnus*, *Castanea*, *Zelkova*, *Morus*, *Myrica*, *Pterocarya*, *Juglans*, *Carya*), and ferns of *Adiantum*, *Polypodiaceae* attests to increase in average annual temperature and humidity. The areas of predominantly mesophylous grasslands of *Asteraceae*, *Poaceae*, *Cichoriaceae*, *Polygonaceae* and others increased. By the end of this stage, the progressive aridification of climate led to the enlargement of grasslands, augmentation in herbaceous xerophylous species and decrease in taxonomic diversity of forests. The remains of *Hipparion* fauna and rodents-inhabitants of open landscapes were found in sediments corresponded to the end of this stage.

Akhaglyian Stage (3.4-2.3 Ma). During this stage, the study area was an elevated plain, on which the present-day drainage system was formed. The mixed broad-leaved/pine forests reduced significantly, giving place to the more expanding of steppes. The thermophylous arboreous plants decreased notably in diversity (*Pinus* s/g *Diploxylon* and *P.* s/g *Haploxylon*, *Quercus*, *Ulmus*, *Fagus*, *Acer*, *Fraxinus*, *Corylus*, *Alnus*). Sometimes, *Juglans*, *Pterocarya*, *Castanea* occurred. The ferns were rare. Mesophylous herbs of families *Asteraceae*, *Poaceae*, *Polygonaceae*, *Primulaceae*, predominated, but the frequency of the xerophylous species increased. Aquatic plants of *Typhaceae* and *Cyperaceae* were rare. This stage is characterized by a notable increase in aridity and decrease in

temperature compared with the two previous stages. Mammal fauna finds attest to moderately warm but arid climatic conditions. The rich rodent assemblages confirm the predominance of steppes.

Palynological data for the Pliocene sediments in Moldova demonstrate a progressive decrease in forestation, impoverishment of the taxonomic diversity of subtropical and temperate arboreous plants, and increase in steppes. The expansion of steppes was caused by the aridification of warm climate. During the Pliocene the steppes expanded and the proportion of xerophylous herbs increased. Based on palynological data, relative climate variation curves (temperature and humidity) for the Pliocene in Moldavian part of the Eastern Paratethys were constructed.

The types of vegetation for each stage as established from pollen-and-spores assemblages correspond to the three stages of vegetation in Southern Ukraine during the Pliocene as recognized by Shehekina (1979). The obtained data agree well with the data on mammals confirm the three principal stages of environmental evolution in the Pliocene connected with climatic changes and the Paratethys sea-level oscillations.

Paleocene-Eocene palynology and palynofacies of tropical South America: northeastern Colombia and western Venezuela

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A palynological study of more than 400 samples was performed in four stratigraphic sections that include the Upper Paleocene-Eocene of tropical South America: the first section is located in the Paz de Rio region (Eastern Cordillera, Colombia); the second and third sections are in the Nuevo Mundo synclinal (Middle Magdalena Valley Basin). The fourth section is located in the Riecito Mache (western Venezuela), on the western flank of Manuleto syncline. More than 300 pollen and spore species were identified, showing the great diversity of the Paleogene South American tropical palynoflora and its great biostratigraphic potential to establish correlations throughout the basin. The sequences can be separated into an "Eocene" and "Paleocene" association based on the lithological and palynological data. The "Paleocene" sequences (Lisama, Socha and Paso Diablo Formations) are dominated by shales, coal beds and minor sandstone levels. Towards the top of the Colombian sections, mottled shales which are barren in palynomorphs are widespread. In Venezuela the coal beds become more frequent and thicker overlying calcareous sandstone beds with marine mollusks. In these "Paleocene" facies several species that are over the entire basin have their last appearances: *Bombacacidites annae*, *Foveotricolpites perforatus*, *Colombipollis tropicalis*, *Proxapertites cursus*, *Ephedripites vaneigenis*, *Retidiporites magdalenensis*, and *Diporopollis assamica*. In some levels of the Colombian sections the *Proxapertites operculatus* species (Palmae? Araceae?) can surpass 80 % of the association. The microscopic organic matter associated with the palynomorphs is mainly of terrestrial origin (e.g. wood, cuticles, spores and pollen). In the Riecito Mache section the abundance of pirofusinite in some coal beds is remarkable.

In the "Eocene" sequences (Picacho, La Paz and Misoa Formations) the coarse clastics increase. In all the studied sections many new pollen and spores species appear. Some of them have been recognized in several sections from northwestern South America: *Bombacacidites soleiformis*, *Foveotricolpites hammenii*, *Monoporopollites annulatus*, *Cricotriporites guianensis*, and *Racemonocolpites facilis*. The microscopic organic matter of this interval is characterized by terrestrial particles; the relative percentage of fungal remains (spores and hyphae) with respect to the Palaeocene sequences increases. In the Middle Magdalena section a paraconformity between the Lisama-La Paz Formation is suggested, that becomes an angular unconformity towards the west. The presence of Late Cretaceous reworked palynomorphs in the La Paz Formation indicates that deformation was taking place elsewhere affecting Late Cretaceous strata. The Graphic Correlation method was also applied for the comparison between the sections. The line of correlation allows observing great changes in the rates of sedimentation. This phenomenon could be associated to the differential tectonic activity linked to the collision of the Caribbean Plate against the South American Plate.

However, although we have quantitative data that allow to appreciate the lateral and vertical changes in the palynological Paleogene associations of northwestern South America, independent elements for an accurate

calibration of this information on the geologic time scale do not exist yet. For this reason, it is still necessary to study new sections with marine microfossils or to use other dating techniques, such as the delta ¹³C.

Climate variations and floral migration during the Miocene—evidence from pollen and spores from western Jutland, Denmark

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This recently initiated investigation on Miocene drillcore material from Jutland, Denmark, is a multidisciplinary project between the Geological Survey of Denmark and Greenland (GEUS) and Lund University. The main purposes are to establish a detailed stratigraphic subdivision, and make a paleoenvironmental interpretation of the 260 m thick sedimentary succession intersected in the Vium drillcore using fossil dinoflagellates, pollen, spores and foraminifera together with geochemistry and sedimentology.

In Denmark, the Upper Oligocene-Miocene succession is divided into six sequences, A to F. However, the lowermost sequence, A, in the Vium drillcore is represented by a non-depositional interval, correlated with a major deglaciation in Antarctica. Thus, the first sequence represented is sequence B, containing silty clay with an upwards increasing content of sand (Rasmussen, in press). In Vium, this unit is represented by a major deltaic pulse. Several local transgressions and widespread sea level changes resulted in mostly marine and deltaic sedimentation throughout the remainder of the Miocene, represented in sequences C-F. During the deposition of sequences A-F, and the climate altered dramatically from subtropical to cool temperate.

Previous studies have encountered difficulties in subdividing the Danish Miocene by means of pollen and spores, as many of the taxa have long ranges. Nevertheless, the Miocene pollen assemblages show interesting quantitative differences despite their taxonomically uniform character. My part of the project is to interpret the climatic changes that occurred during the Miocene, and to interpret floristic changes in Denmark, based on palynology. For this purpose 250 samples have been processed for palynomorphs from the drillcore which intersects the Lower, Middle and the lower part of the Upper Miocene succession. Additionally, outcrops of Miocene sediments in the eastern parts of Jutland will provide further samples for high-resolution stratigraphy. At present, taxonomic and stratigraphic work on the lowermost part of the drillcore is in progress.

The lowermost samples from 286.67 - 257.48 m have revealed a well preserved and diverse palynoflora. Marine influence is indicated by the presence of dinoflagellate cysts, acritarchs and marine algae in all samples. Marine palynomorphs constitute 3 - 39% of the assemblages. The microspore assemblages include at least 90 taxa and are dominated by coniferous forest-swamp pollen (Taxodiaceae-Cupressaceae). Riparian angiosperm tree pollen such as *Alnus* and *Betula* are also important and occur with relatively rare specimens of *Salix* and Myricaceae. Elements of mixed mesophytic forests represented by *Pinus*, *Quercus* and *Fagus* are common. In addition, several paleotropical elements such as evergreen trees and bushes are present, including *Palmae*, *Engelhardtia*, *Platycarya*, and Magnoliaceae. Thus, a relatively warm and humid climate is indicated.

This project provides a unique opportunity for both stratigraphic and paleoenvironmental pollen analysis to increase our understanding of vegetation and climatic change for the northern European Miocene.

Rasmussen, E.S., in press. The interplay between true eustatic sea-level changes, tectonics, and climatic changes: what is the dominating factor in sequence formation of the Upper Oligocene-Miocene succession in the eastern North Sea Basin, Denmark?. *Global and Planetary Change* xx. 16p.

Aspects of Caspian palynology: Tertiary to Recent

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The Caspian Sea is the world's largest inland body of water, and is bound geographically by Russia to the northwest, Kazakhstan to the northeast, Azerbaijan to the west, Iran to the south and Turkmenistan to the east.

Palynologically, the Caspian Sea has only recently been the focus of detailed studies, partly due to the importance of the offshore area to oil and gas exploration, but equally because the Caspian Sea sediments provide a unique opportunity for research into the regional vegetation and climatic history. This presentation is based on detailed palynological studies of Miocene to Recent sediments carried out by the author, on cores from offshore wells, shallow boreholes and outcrop samples from Azerbaijan.

Structurally, the Caspian Sea is divided into two parts; the shallower North Caspian (maximum depth 788m) and the deeper South Caspian (maximum depth 1025m). The two regions are separated by a sub-sea ridge, where the water depth is less than c.200m, which extends eastwards from the Apsheron peninsula. Temperature and salinity gradients also exist between the northern and southern regions. Surface water temperatures vary from below zero to around 26° C in the north, compared with 7 to 28° C in the south. Salinity is also lowest in the north due to the freshwater influx from the Volga. During the summer months, when the Caspian is ice-free, salinities at surface are very low (1-5 ‰) in the extreme north and increase gradually southwards, becoming relatively stable at around 12 to 14 ‰ (just less than half the normal salinity of ocean waters). Salinity in the Caspian Sea does not increase greatly in the bottom waters, although there are areas, such as the Kara Bogaz inlet on the eastern coast, where salinity may be very high. The majority of incoming rivers flow from the northern and western coastlines. Of these, the Volga is by far the most significant and contributes around 80% of the total fluvial discharge to the Caspian Sea.

In Azerbaijan, much of the emphasis of palynological studies has been placed on the sediments which make up the so-called "Productive Series" which are predominantly of Early Pliocene age and contain most of the onshore and offshore hydrocarbon reserves. The onset of deposition occurred approximately at the end of the Miocene, when the Caspian Sea became cut off from any open marine connection. This isolation of the Caspian Sea can be demonstrated palynologically in sediments of Late Miocene (Messinian) age, which show a gradual change from marine-dominated to non-marine, low salinity palynological assemblages. The associated terrestrial pollen component typically includes relatively common *Artemisia*, which indicates a dry climate at this time. The *in-situ* dinocyst components present include the "cruciform" types of the *Spiniferites cruciformis* complex, confirming that these types evolved in the pre-Pleistocene.

The palynological assemblages from the "Productive Series" are usually very rich and contain varying proportions of extra-regional pollen (e.g. *Pinus*) and regionally / locally derived pollen components. The quantitative palynological records can be used to show cyclicity and change in palaeo-vegetation and climate. The relative proportions of brackish water dinocysts (e.g. *Spiniferites cruciformis*) and freshwater algae (e.g. *Pediastrum*) give an indication of palaeo-salinity and can be used to infer periods of relative highstand and lowstand within the Caspian Sea. Another feature is the frequent presence of reworked pollen, spores and dinocysts of Permo-Triassic, Jurassic, Cretaceous and Early Tertiary age.

Sediments of Late Pliocene age in the region include the Akchagyl Beds which are marked palynologically by a re-appearance of open marine dinocysts, signalling a brief period of open marine connection, probably via the Black Sea. The Pleistocene succession can be sub-divided palynologically into several glacial and inter-glacial stages, although these cannot be accurately dated on the basis of palynology alone.

The peculiarities of vegetative cover and change of environmental conditions in the Epochs of Cenozoic coal accumulation

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Till the present time the stratigraphy of coal-bearing deposits of the continental part of the Far East is one of the important problems when searching the fuel minerals.

On the Priamurye territory two large centers of the Late Cretaceous-Cenozoic coal accumulation the Zeya-Bureya and the Amur-Zeya coal basins are located. From the beginning of the eighties the biostratigraphic and palinological investigations were carried out by the author at different areas of Priamurye jointly with geologic-survey expeditions and prospecting companies.

Since 1998 the author takes part in the program "Paleogene of Russia". The aim of the program is investigation of the Late Cretaceous-Paleogene classic sections of the Zeya-Bureya sedimentary basin. The characteristic of 6 brown coal deposits is given. Their stratigraphy is defined more exactly.

These investigations were continued in the International Project "The Cretaceous Biota and Boundary of Cretaceous-Paleogene in the basin of the Amur river". The sections of the boundary Cretaceous-Paleogene

formations at the right bank of the Amur river in the Heilongjiang province (P.R.C.) were described and palynologically studied.

On the whole, the paper presented by the author sums up the palynologic investigations for more than 20 years. It is dedicated to the problems of stratigraphy and paleofloristics of Priamurye.

The author has carried out the analysis of facies conditions, reconstruction of evolutionary landscape development stages, ecogenesis of a coal deposit, individualization of the coal bands and determination of coal-forming plants complex (by palynologic and paleobotanic data) in the concrete workable seams. As it was ascertained, the complex of the coal-forming plants essentially influenced the physical-chemical and technological characteristics, which are not the same in the coals of different age. Before this fact has not been taken into consideration: all coal-bearing bands were united into the Kivda formation.

Cretaceous/Tertiary boundary from middle part of Poland in the palynofacies record

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Cretaceous/Tertiary boundary deposits from Kamienny Dol outcrop (middle part of Poland) has been palynological studied. Among palynomorphs the main role plays phytoplankton – mostly dinoflagellate cysts. Pollen grains of vascular plants, Bryophyta spores and hyphae were met sporadically. Single palynoclasts were the black, not transparent, probably wood debris. Analysis of the dinocyst assemblages permitted to divide two different assemblages. The first one, from the lower part of profile, noticed: *Dinogymnium* sp., *Hafniasphaera* sp. and *Trityrodinium* sp. The second one from the upper part of profile contains abundant dinocysts: *Carpatella cornuta*, *Senoniasphaera incornata* and *Fibracysta ovalis* – species are present in the lowest Paleocene (Danian).

Boundary between two assemblages runs in the top of "hard grand". Palynological matter composition was typical for sediments origin in marine environment. Dinocyst assemblages characterized outer shelf zone. Vestigial quantity continental origins sporomorphs and phytoclasts testifies about far distance from the land.

Palynological matter composition		Environment	
Danian	Sporomorphs Sporadically	<i>Pinuspollenites</i> , Normapollens	
	Phytoplankton Common, Equal quantity of main dinocysts morphotypes gonyaulacoid and peridinioid	Dinocysts: <i>Carpatella cornuta</i> , <i>Fibracysta ovalis</i> , <i>Senoniasphaera inornata</i> , <i>Achomosphaera ramulifera</i> , <i>Areoligera senonensis</i> , <i>Cladopyxidium reticulatum</i> , <i>Cordosphaeridium fibrospinosum</i> , <i>Cyclonephelium</i> cf. <i>expansum</i> , <i>Hystrichocolpoma bulbosum</i> , <i>Hystrichosphaeridium tubiferum</i> , <i>Palaeotetradinium silicornum</i> , <i>Spiniferites</i> , <i>Acritarcha Pterospermella australiensis</i> , <i>Paralecaniella</i> cf. <i>indentata</i> Prasinophyta <i>Cymatiosphaera eupeplos</i> , <i>Letosphaeridia</i>	marine, shelf, far distant from offshore, deep
	Phytoclasts common	black, non transparent wood debris, fungal hyphae	
	Others	single glauconite grains	
Sporomorphs Sporadically	<i>Pinuspollenites</i>		
Maastrichtian	Phytoplankton Frequent, peridinioid dinocysts morphotype predominated	Dinocysts – frequent: <i>Adnatosphaeridium robustum</i> , <i>Dinogymnium</i> sp., <i>Hafniasphaera</i> sp., <i>Isabelidium bujakii</i> , <i>I. cooksoniae</i> , <i>Trityrodinium</i> sp. <i>Acritarcha - Michrystidium piliferum</i>	marine, shelf, far distant from offshore, not so deep
	Phytoclasts abundant	black, non transparent wood debris	

Tab. Palynological matter and depositional environment in Kamienny Dol.

Eocene to Miocene vegetation history and climate, Ross Sea Region, Antarctica

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Terrestrial palynomorphs from the recent Cape Roberts Project (CRP) drillholes (RAINE & ASKIN 2001) supplement palynofloras from glacial erratics (ASKIN 2000) and CIROS-1 drillhole (MILDENHALL 1989) to provide an emerging picture of vegetation history and climate for coastal Victoria Land from the mid-Eocene to early Miocene. Palynological evidence suggests loss of mesothermal and appearance of microthermal taxa, with general diversity reduction through this period, consistent with increasing glaciation recorded in the sediments. Sparse recovery, and recycling by glacial processes remain continuing problems in interpretation.

Assemblages of middle to late Eocene age from the McMurdo Sound glacial erratics, dated by associated dinoflagellate cysts, are characterized by diverse and common *Nothofagus* pollen, along with that of podocarps, diverse (though uncommon) Proteaceae and other angiosperms, and rare cryptogam spores. Similar assemblages, which reflect a cool temperate *Nothofagus*-broadleaf-podocarp forest, occur in the late Eocene part of CIROS-1.

Early Oligocene palynomorph assemblages, known from erratics, CIROS-1, and CRP drillholes, are much reduced in diversity compared to those of the Eocene, with loss of most ferns, some previously important podocarpaceous conifers, *Casuarina*, the previously diverse Proteaceae, the *brassii* group of *Nothofagus*, and other angiosperms. The Early Oligocene vegetation may have resembled present-day Magellanic *Nothofagus* woodland. Climatic conditions were likely cold temperate-periglacial, with warmest month mean daily temperatures at sea level about 10-12°C.

In the youngest part of the CIROS-1 and CRP succession, late Oligocene and early Miocene assemblages are similar to those of the Sirius Group in the Beardmore Glacier area, of questionable Pliocene age. These are typified by one or more species of *Nothofagus* and podocarp conifers, with some distinctive accessory angiosperms and bryophytes. Taxa represented by pollen also include Ranunculaceae, Styliaceae, Caryophyllaceae, and Ericaceae/Epacridaceae. The assemblages reflect low diversity mossy tundra vegetation, with dwarf woody plants in more protected locations. Mean summer temperatures for this sparse periglacial vegetation were in the range 2-7°C, similar to present-day temperatures in the Subantarctic islands.

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Palynology Solimões Formation Neogene sediments in northwestern Amazonas State, Brazil

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The Solimões Formation, situated in western southern Amazônia, occupies an expanse of about 1,000,000 Km² and extends up to Peru and Colômbia. This formation is known to present a rich fossiliferous content recorded by the presence of vertebrates and invertebrates in addition to the abundance of plant macrofossils and palynomorphs. Van der Hammen (2001) claims that plant diversity over the Miocene in

Amazônia was greater than that at the present moment with 280 pollen types recorded relative to half of the types found for the Holocene sediments.

Sediment samples, which were deposited since the Andean uplifting during the late Tertiary, which determined the onset of a new landscape for the Amazonian forest by bringing about changes in the river drainage flows and rainfall patterns, are examined in the present study for the purpose of intensifying the pollen study in Amazônia.

A total of fourteen sediment samples from cores distributed at approximately 132 m deep in well IAS-32-AM (coordinates: Lat: S= 04°32' Long W= 71°24') located at the Upper Solimões region in the Brazilian /Colombian border were provided by CPRM and DNPM. Fifty spores and fifty-two pollen types were studied and illustrated.

The pollen diagram suggests that the abundance of the biostratigraphic marker *Grimsdalea magnaclavata* throughout the studied period and of *Crassoretriletes vanraadshoovenii* from 71m deep downwards allowed dating the sediments as belonging to the Middle/Late Miocene period. The presence of *Echitricolporites spinosus* upwards from 25m deep in sediments collected in Amazonas State suggest the Late Miocene age of the Upper part of the studied well samples.

The palynological data shows that the Amazonian paleoenvironment during the Middle/Late Miocene and Late Miocene was characterized by flooded swampy regions confirmed by the great amount of spores and areas covered by arboreal and shrubby vegetation represented by Angiosperm pollen. There is no indication of savannah or coastal environments represented by *Rhizophora* and *Acrostichum* association in the studied samples.

Palynology of the Rupelian to Burdigalian (Oligocene to Lower Miocene) interval of the Alma-1X well, Danish North Sea

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A palynological study of cuttings samples from the North Sea well Alma-1X documents the succession of last occurrences of dinoflagellate cysts and acritarchs in the Oligocene to Lower Miocene interval of the Central North Sea. The interval is characterised by a poor foraminifera assemblage yielding a relatively low stratigraphic resolution, whereas the palynomorph assemblage is rich: more than two hundred phytoplankton taxa were encountered in the study interval, amongst them a number of yet undescribed species. The distribution of dinoflagellates and acritarchs in the well demonstrates the potential for the development of a detailed subdivision of the Oligocene to Lower Miocene interval in the Central North Sea based on first downhole occurrence of key taxa. Four regional intra-Lark Formation seismic and petrophysical log markers can be dated using dinoflagellate biostratigraphy.

Seismic section (from the seismic line RTD81-RE94-17B) showing the position of major post-Balder Palaeogene marker horizons. The gamma log trace is superposed on the seismic section. A white frame indicates the study interval of the well.

Palynostratigraphy and palynofacies of the Cretaceous-Tertiary boundary sediments in Se Sirt Basin, Libya

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The Cretaceous-Tertiary boundary sediments subcropping in the southeastern part of Sirt Basin have been assessed palynologically based on study of fourteen conventional core samples from SE Sirt Basin. Based on

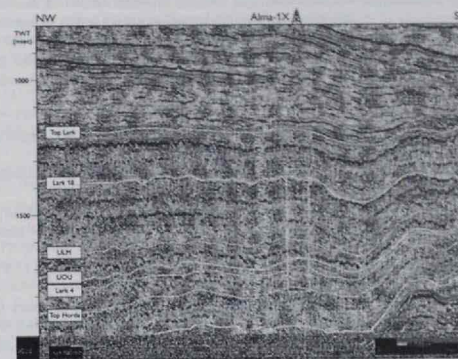
the recorded dinoflagellate cysts, sporomorphs and other palynodebris the palynostratigraphy and palynofacies of the study section have been interpreted.

The dinoflagellate cysts appear to be unaffected by, or shown no major extinctions across the K/T boundary. Nine environmentally controlled palynomorph (dinoflagellate cysts, sporomorphs) associations have been recognised, five of which from the Late Cretaceous (late Maastrichtian) and four from the Early Paleocene (Danian). These associations have been correlated to the known nannofossil and planktic foraminiferal zones.

The studied K/T boundary section is dominated by amorphous debris (kerogen Type I) with more than 95 % marine dinoflagellate cyst taxa. Peridinioid dinoflagellate cysts dominate the upper Maastrichtian section, while the Danian section dominated by gonyauloid cysts.

Three transgression and regressions marine phases and low and high salinity periods are recognised based on the integration of the dinoflagellate cyst forms and their established dinoflagellate cyst complexes with previously recorded calcareous nannofossils assemblages.

The K/T boundary hiatus indicated by the missing of calcareous nannofossil *Markalius inversus* NP1 Zone and the lower part of the *Cruciplacolithus tenuis* NP2 Zone (El-Mehdawi, 1996) is also supported in this study.



Palynofacies and paleoenvironmental changes across the Cretaceous-Tertiary boundary in New Zealand

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A high-resolution study of the palynofacies and quantitative distribution of organic-walled dinoflagellate cysts in three eastern New Zealand Cretaceous-Tertiary boundary sections has resulted in the establishment of a new palaeoenvironmental model for the Late Maastrichtian to Paleocene interval. Five palynodebris intervals were recognised: Palynodebris Intervals I and II in the Late Maastrichtian and Palynodebris Intervals III, IV and V in the Early Paleocene.

The onset of a regression in the latest Maastrichtian was recorded at the base of Palynofacies Interval II. The latest Maastrichtian regression was followed by a transgression in the earliest Paleocene, and the

depositional environment became progressively deeper during the Paleocene Palynofacies Intervals III to V. A distinct change directly below the Cretaceous-Tertiary (K/T) boundary, within Palynofacies Interval III, could reflect a period of global warming preceding the boundary event by ca. 0.3 to 0.1 Ma (Wilf et al. 2003).

No evidence is found for mass extinction of the cyst-forming dinoflagellates across the K/T boundary. Typical latest Maastrichtian to earliest Paleocene species disappear ca. 0.5 Ma after the K/T boundary event. The K/T boundary level is marked by a shift from high diversity/low dominance cyst assemblages to low diversity/high dominance assemblages. This pattern is accompanied by a change from a negative P/G log ratio to a positive P/G log ratio lasting through the first ca. 1.5 Ma of the Early Paleocene. This shift has been interpreted to reflect the onset of a ca. 1.5 Ma period of bottom water upwelling along the east coast of New Zealand (Hollis et al. 2003). The Early Paleocene dinoflagellate cyst assemblages are either dominated by *Trithyrodinium evittii* or *Palaeoperidinium pyrophorum* (Willumsen, 2000). Intervals with dominance of *T. evittii* has been interpreted to reflect periods with warmer sea surface water conditions, whereas high relative abundance of *P. pyrophorum* reflect colder and perhaps also more nutrient rich and unstable sea surface water conditions.

Previous palaeoecological interpretations of various cysts were compared with the findings from the New Zealand region and significant discrepancies were recorded. High abundance of the genus *Manumiella* has previously been interpreted to indicate marginal marine to brackish water conditions (e.g. Hultberg 1987; Firth 1993). However, in this study *Manumiella* was most abundant in distal sections located on the outer shelf to slope. High relative and absolute abundance of *Palaeoperidinium pyrophorum* was recorded in sediments deposited in an outer shelf to slope environment in an upwelling influenced area. Thus, the species does not appear to reflect marginal marine to brackish water conditions as has been suggested by Harding (1990). The genus *Spiniferites* was most abundant in sections located on the slope and it does not increase in relative abundance towards the shore.

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At the edge of a new ocean – Dinoflagellate cysts of the Middle Eocene Kap Dalton Group, East Greenland

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The post-basaltic sediments at Kap Dalton, East Greenland represent one of the few possibilities to study the post-basaltic depositional evolution of the western margin of the juvenile northern North Atlantic Ocean.

Extensive flood basalt volcanism accompanied the onset of sea-floor spreading and arrival of the Iceland hot spot in the North Atlantic region. At Kap Dalton, extrusion of earliest Middle Eocene, Chron 21r flood basalts into shallow marine environments (HEILMANN-CLAUSEN ET AL. 2003; TEGNER ET AL. 1998) was followed by uplift and subaerial erosion creating a hummocky relief dissected by fluvial channels. The area was transgressed again during the Middle Eocene forming a muddy, poorly oxygenated shelf. The sediments, the Kap Dalton group, are preserved in a down-faulted 3km wide, N-S trending graben of younger age, and represent the

remains of a much more widespread sedimentary succession covering the coastal areas of East Greenland during Eocene times.

The Kap Dalton Group is dated on basis of dinoflagellate cysts to be of Middle Eocene age, NP14–15 Chronozones. The lower part of the succession is characterised by a low diversity and moderately to badly preserved assemblage. This assemblage occurs in the Bopladsdalen Formation. It is clearly no older than the upper part of the NP14 Chronozone, Lutetian, Middle Eocene based on the presence of *Araneosphaera araneosa* and absence of *Homotryblum tenuispinosum* and the genus *Apectodinium* (e.g. BUJAK ET AL. 1980; ISLAM 1983; HEILMANN-CLAUSEN & COSTA 1989; KÖTHE 1990).

The upper dinoflagellate assemblage is characterised by a more rich and diverse flora with frequent *Deflandrea phosphoritica*, *Glaphyrocysta exuberans*, *Heterulacysta campanula* and *Spiniferites* spp. associated with a maximum of *Paralecaniella indentata* in the topmost 15 m of the Bopladsdalen Formation. It is followed by abundance of *Phthanoperidinium regalis* and common *Systematophora placacantha* and *Glaphyrocysta* spp. throughout the Krabbedalen Formation. The age of this upper assemblage is clearly intra-NP15 Chronozone, Lutetian, Middle Eocene, equivalent to the E4e-d and E5a dinoflagellate subzones of BUJAK & MUDGE (1994).

NP16–17 Chronozones, and indicate that the entire Kap Dalton Group was deposited during a fairly short timespan, of less than 3 Ma during the Middle Eocene, Early Lutetian, upper NP14 – lower NP15 Chronozones. Despite different in composition, the two assemblages share important marker species, and it is therefore unlikely that any major hiatus is present within the succession.

The presence of clean quartz sandstones within the post-basaltic succession of Kap Dalton indicates a potential Middle Eocene hydrocarbon play-type in the northern North Atlantic region e.g. in the Faeroe Islands region.

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Early-Mid Eocene dinoflagellates from the Aktulagay section (Kazakhstan): new information on marine connections between the eastern Peri-Tethys and the North Sea Basin

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A 60m thick well exposed, marine Lower-Middle Eocene section at Aktulagay (Western Kazakhstan, W Asia) yields well preserved foraminifera, calcareous nannoplankton and dinoflagellates. In this study we have described the rich succession of dinoflagellate cysts and calibrated them with the calcareous nannoplankton zonation and foraminifera events of the section. Dinocyst assemblages allow to recognise Ypresian, Lutetian and

Bartonian zones established in Western Europe. Successions of dinoflagellate and foraminifera events show many similarities with coeval North Sea Basin sections in Denmark and North Germany. Our combined results throw new light on the Eocene palaeogeography and strongly suggest the existence of marine connections across Eastern Europe between the eastern Peri-Tethys and the North Sea Basin.

Overview of the biostratigraphy and paleoecology of the uppermost Cretaceous and Lower Tertiary strata in the northern Mississippi Embayment

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Few reliable palynofloral data exist on the uppermost Cretaceous and lower-most Tertiary strata of the Mississippi Embayment. Well-preserved palynomorphs occur in core and outcrop samples from the northernmost part of the Mississippi Embayment. The uppermost Cretaceous Owl Creek Formation has a low diversity assemblage of pollen and lacks spores, dinoflagellate cysts and acritarchs. The overlying Lower Paleocene Clayton Formation contains a diverse palynomorph assemblage and has four distinct informal zones: stillstand, grey, glauconitic, and tsunami. The Upper Paleocene Porters Creek Formation is characterized by a variety of palynomorphs that fluctuate in abundance and diversity up-section.

Dinoflagellate cysts dominate the palynomorph assemblage in the Lower Eocene Ackerman Formation, whereas the overlying Holly Springs Formation has a much poorer palynomorph assemblage. The palynomorph patterns can be related to fluctuations in sea level. In addition, evidence of the impact event at the Cretaceous-Tertiary boundary can be found in the Clayton Formation. The palynomorph assemblages are being compared with those from correlative strata in the U. S. Gulf Coast to the south of the study area.

Atlas of Pollen and Spores of the Polish Neogene, vol. 1-Spores; vol. 2- Gymnosperms

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With the two volumes a group of Polish palynologists begun the edition of an Palynological Atlas of the Polish Neogene. The main goal of this series is to present a synthesis of all identified pollen and spore taxa from more than 300 microfloras of the Polish Neogene carried out during the last 50 years. Part of the synthesis is based on data published before in international and Polish journals, another part comes from the archives of Polish geological and botanical institutes. All described taxa are revised according to the rules of the International Code of Botanical Nomenclature. The description of every species is preceded by a list of synonyms, followed by remarks concerning the botanical affinity, geographical distribution of corresponding recent taxa, palaeofloristic element, and stratigraphical distribution in general and in Poland.

The volume 1 contains 63 pages with simple descriptions of 176 species of spores referred to 48 genera illustrated on 42 plates with microphotographs. In the taxonomical part one genus and five species have been new described and for 28 taxa new combinations have been established.

The volume 2 contains 61 pages with descriptions of 97 species referred to 20 genera illustrated on 82 plates with microphotographs. In the taxonomical part six species and two genera have been new described, one new subgenus is raised to generic rank, and for 20 taxa new combinations have been established.

Actually in preparation are two volumes of the atlas containing descriptions of angiosperm pollen.

Palynostratigraphy of Ganga Basin, India exploring evolution of flora and depositional environment in the Basin during Tertiary

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Evolution of Ganga Basin in the central part of Indian subcontinent coincides with the tectonic evolution of the Great Himalayas. Palynostratigraphy worked out with the samples of five borecores from western to eastern part of the Ganga Basin has revealed unique data on the first occurrence of Normapollis group of pollen grains in the Early Tertiary palynoassemblage of Indian subcontinent and evolution of flora in the Basin. The sequences of climatic changes related to successive events of Himalayan upheaval also are explored from the study.

Diverse, rich palynoflora belonging to 311 species under 199 genera are recorded from the entire Cenozoic sediments of Ganga Basin. The assemblages include 61 species of pteridophytic spores under 32 genera; 8 genera with 14 species of gymnosperm pollen, 180 species under 111 genera of angiospermic pollen grains mostly belonging to tropical, evergreen, moist climate loving plants, besides 7 algal taxa and 24 species under 18 genera of fungal spores. In addition to palynomorphs, several planktonic forms, foraminifera like structure, ostracoda, nanofossils are also recorded.

A total number of ten palynostratigraphic zones (GBTPNZ I-X) are identified from the Tertiary succession of the Basin. The index taxa of the respective palynostratigraphic zones are utilized to identify the stratigraphic age of the sediments. The Palaeocene - Eocene age (GBTPNZ I-VI) of the Early Tertiary sediments is identified through the marker taxa viz., *Dandotiaspora plicata*, *Proxapertites curvus*, *P. microreticulatus*, *Matanomadhiasulcites* sp., *Palmaepollenites eocenicus*, *Dicolpopollis* sp., *Lakiapollis ovatus*, *Minuticolporites minutus*, *Striacolporites striatus*, *Psilodiporites hammenii*, *P. erdtmannii* and also the Normapollis group of pollen grains.

The 6 genera of Normapollis pollen grains recorded are *Choanopollenites consanguineus*, *Extremipollis versatilis*, *Interporipollenites* sp., *Oculopollis lapillus*, *Semioculopollis verrucosa* and *Trudopollis pertrudens*. The present assemblage is considered significant in understanding evolution of angiosperm in the Indian subcontinent and palaeophytogeography as the group was so far known to be the marker of Late Cretaceous-Early Tertiary Euramerian 'Normapollis' phytoprovince.

Comparison of the palynological record with extant taxa suggests tropical, humid, near-shore condition to tropical, humid, fresh water environment. The basin was lying in the tropical latitude with sufficient rainfall and with occasional effects of marine incursion in the Paleocene-Eocene age. Oligocene palynoassemblage with abundance of *Siriatriletes* spp. suggests a fresh water environment. The earliest appearance of conifer plant pollens viz., *Pinuspollenites*, *Abietinaepollenites* with some tropical moist environment plant pollens and significant abundance of shallow marine microfossils viz., *Leiosphaeridia*, Dinocyst, *Veryhachium* are indicative of the first occurrence of the high mountains around the basin and also episode of marine transgression.

Entire succession of Mio-Pliocene has revealed sequential and continuously higher frequency, diversity of cool climate loving plant pollens suggesting the occurrence of higher altitudinal areas in the region. Influence of marine incursion has gradually decreased and disappeared by Mid. Miocene.

Palynofacies trends from recent shelf and deep-water sediments in the North Atlantic

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Quantitative analyses of POM variations have been made on late Holocene (last 1500 cal. yr BP) top-core material from Greenland and Faroe Islands fjords and North Atlantic deep-water sites. The results from the different sites were compared, thereby providing a tool using palynofacies analysis for assessing at high latitudes the depositional setting, water depth and terrestrial influx for sediment strata of the geologic past.

The sediments studied consisted of olive grey to brown, muddy silt occasionally mottled and faintly laminated. Black specks, shell fragments and macroalgae plant debris characterised the sediments from the shelf trough and fjords. The chronology was based on ^{210}Pb and ^{137}Cs measurements and Accelerator Mass Spectrometry ^{14}C dating of shells and plant remains.

The distribution of POM in environments ranging from coastal water to deep-sea showed regular changes controlled by the distance from the shore. Phytoclasts represented the major component in the total POM assemblage in fjord and shelf trough settings. In the fjords, the phytoclasts were dominated by leaf and membranous tissue characterised by well-preserved clasts of variable size (up to 400 μm in diameter). At the shelf trough site, wood and charcoal dominated the phytoclast assemblages; leaf and membranous tissue represented a minor component of the assemblages and were characterised by small clasts (15–30 μm in diameter). Phytoclasts were rare to absent in the sediments from the North Atlantic deep-water site.

The palynomorph assemblages from the fjords and shelf trough site were dominated by dinoflagellate cysts and acritarchs and showed a similar distribution pattern in the sites. The palynomorph assemblages from the North Atlantic deep-water site consisted of a selection of organic material, which could result from transport or grading. Dinoflagellate cysts were the dominant component of the total POM and represented 55–65% of the assemblages.

Prasinophyte algae occurred in all study sites ($\leq 4\%$ of the total POM). According to TYSON (1995), prasinophytes represent one of the major phytoplankton component in cold waters at high latitudes together with diatoms; however, they can be abundant in the water column but scarce in the sediments. In the study sites, the highest percentages of prasinophytes were recorded from the shelf trough site off West Greenland and Igaliku Fjord, South Greenland.

As a result, the relative abundance of foraminiferal linings, dinoflagellate cysts, acritarchs and other marine algae in the total POM assemblage increased with the distance from the shore and can thus be used as a proxy for the distance from the shore in past depositional environments at the high latitudes.

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DYNAMIC OF ECOSYSTEMS: PALYNOLOGY AND GENETICS

Reconstructing the past: the evolving roles of the pollen record and extant and fossil DNA

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Data on the genetic structure of plant populations at the continental scale have accumulated dramatically over the last decade. However, our ability to make inferences on the impact of the last ice age still crucially depends on the availability of informative pollen fossil data. When the pollen record is non-informative, inferences on past history are difficult to draw from the sole genetic data. On the other hand, when the fossil record is informative, new approaches, based on the coalescent process, allow the testing of well-defined historical hypotheses and the estimation of demographic parameters. Examples will be provided. We will also discuss the promises and limitations of ancient DNA in the reconstruction of past history.

Fossil and genetic data outline the late-Quaternary history of *Fagus* in Europe

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The European vegetation of the present interglacial is characterized by a widespread diffusion of *Fagus sylvatica*, extending from the Cordillera Cantabrica to the Carpathians and from Sicily to northern Sweden. Such extensive geographical distribution is very recent, dating back to the last few millennia, while a continuous presence of beech during the last glacial-interglacial cycle can be traced only in restricted geographical areas. These observations stimulate the discussion on the timing and mode of the postglacial spread of *Fagus* populations and on the influence that the past beech distribution may have had on its modern genetic characters.

For that purpose, a group of geneticists and palaeobotanists working within the EU FOSSILVA project have joined their efforts in carrying out new analyses and collecting unpublished and published data from hundreds of sites in Europe. Four data-sets have been compiled, including fossil pollen and plant macrofossils for the palaeobotanical side, and chloroplast and nuclear markers for the genetic side.

The fossil data indicate that beech survived at multiple sites during the last glacial period. However, contrary to what is generally thought, the refuge areas located in the Italian, Balkan and Iberian peninsulas were not source areas for the postglacial colonization of central Europe by beech. In fact, the patterns of migration indicate that *Fagus* spread from Slovenia and from other minor refuge areas in mountain regions of central Europe. Beech migrated along mountain chains until ca. 4 kyr BP, when it reached the plains of central-northern Europe.

The modern genetic variability, evaluated by means of markers with different modes of inheritance and mutation rates, processed by various numerical methods, supports the general pattern shown by the fossil data, and in a number of cases defines with better precision the postglacial migration routes followed by beech.

The multidisciplinary analyses of European beech offer a new scenario for the location of glacial refugia and the postglacial routes of colonization for beech, at more northern latitudes than previously thought, and at the same time open new methodological perspectives for a better understanding of: i) type and quality of fossil and genetic data best suited to detect areas of long-term persistence of deciduous trees, ii) geographical and biological barriers to colonization, iii) relation between the postglacial rates of spread and the modern genetic structure and patterns of diversity, iv) influence of refugia in protecting or in shaping biodiversity, v) importance of the time factor and of climate changes over multiple glacial-interglacial cycles in determining genetic divergence.

The FOSSILVA project (dynamic of forest tree biodiversity: linking genetic, palaeogenetic and plant historical approaches): an overview

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The first aim of FOSSILVA was the study of past biodiversity in fossil tree material across a network covering south-western and central Europe: a better knowledge of the historical parameters behind the present day