# Biogeochemical and Palynological History of a Lake on Western Ymer Ø, East Greenland

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*ABSTRACT. A sediment record from a lake on western Ymer Ø, East Greenland, was investigated for chronology, lithology, biogeochemistry, and palynology. The sedimentation of lake N1 likely was influenced by deglaciation of the catchment during the early Holocene. Accumulation of organic matter and pollen grains commenced at least at 7800 cal. years BP. From that time the pollen assemblage in lake N1 reflects the general climatic development in East Greenland, with a climatic optimum until c. 5000 cal. years BP, and a subsequent cooling until the Little Ice Age. This is not indicated in the biogeochemical data, which probably reflect oscillations of the ice cap to the northeast by alternating periods of organic and clastic matter accumulation.*

*KEY WORDS: paleolimnology, biogeochemistry, palynology, Holocene, East Greenland.*

## Introduction

The Holocene environmental history of East Greenland is well known from various studies of ice cores, fossils, and marine and limnic sediments (Hjort and Funder, 1974; Funder, 1978; Björck et al., 1991; Johnsen et al., 1992; Björck et al., 1994; Bennike 1997; Wagner et al., in press). The lake sediment records are particularly based on lithological, palynological, and biogeochemical analyses. In general, they indicate a conform development of the vegetation of the surrounding areas and the bioproduction within the lake, both well reflecting the climatic changes.

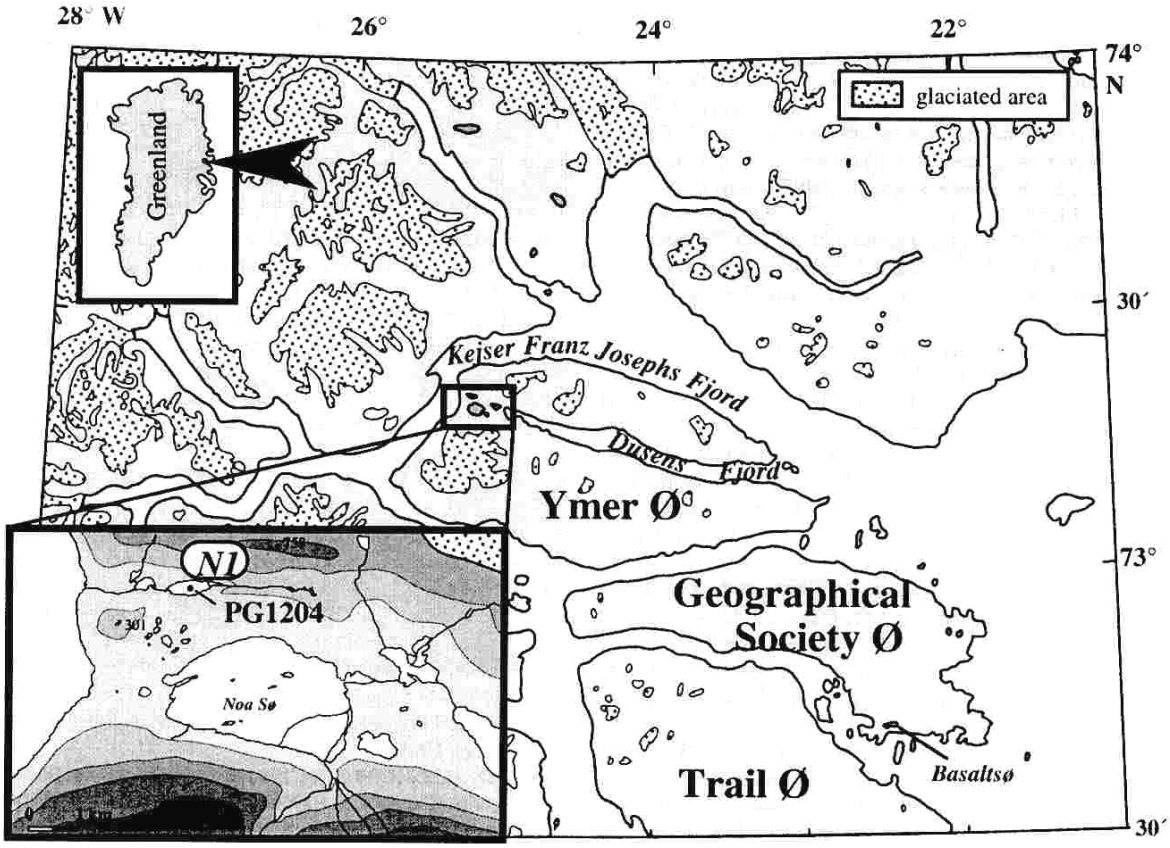


**Fig. 1.** Map of western Ymer Ø, central East Greenland, showing lake N1 embedded in the anticline between the surrounding fjord systems and the present locations of outlet glaciers and local ice caps. The black dot marks the lake sediment coring location.

| core | depth (cm) | material | sample no. | weight (mg) | $\delta^{13}C$ | $^{14}C$ age (years BP) | cal. age (cal. years BP) |
|---|---|---|---|---|---|---|---|
| PG1204 | 52 | plant remains | UtC -7417 | 1.25 | -26.0 | 1880 ± 40 | 1800 ± 90 |
| PG1204 | 195 | plant remains | UtC -7459 | 0.10 | -28.0 | 5420 ± 200 | 6220 ± 370 |
| PG1204 | 240 | pel vic spine | UtC -7460 | 0.41 | -22.9 | 6880 ± 70 | 7710 ± 130 |

**Tab. 1.** Ages determined by radiocarbon AMS dating on micro and macrofossils isolated from core PG1204, lake N1. Calendar ages (cal. years BP) were derived from calibration of the data (INTCAL98 dataset; Stuiver and Reimer, 1998). Uncertainties are reported at the 2σ level.

The aim of this study is to reveal new aspects on the deglaciation and on the Holocene environmental history of a so far unnamed lake, here referred to as lake N1, on western Ymer Ø, East Greenland. Based on radiocarbon dating of macrofossils, a comparison between palynological and biogeochemical sediment parameters enables the distinction between local and short-term factors affecting bioproduction in the lake and regional and long-term factors affecting the lake surroundings.

## Setting and methods

Lake N1 is located at an altitude of ca. 120 m a.s.l. on the northern slope of an anticline between to ice caps on western Ymer Ø (Fig. 1). The 1 km long and 0.5 km wide lake gains its main inflow from a valley that today is not affected by glacial meltwaters. A sediment sequence of 7.4 m length (PG1204) was rcored in the deepest part of the lake (27 m) by three overlapping piston core segments.

Following core opening, description, and photographic documentation, one core half was continuously subsampled in 2 cm intervals. The contents of total carbon (TC), total nitrogen (TN) and total sulphur (TS), all reflecting organic matter, were measured in intervals of 8 cm with a CHNS-932 determinator (LECO Corp.). Total organic carbon (TOC) was determined with a Metalyt-CS-1000-S (ELTRA Corp.) in corresponding samples after carbonate removal (10% HCl; 80 °C). Carbonate contents were calculated by the difference between TC and TOC. On seven samples (at depths of 60, 156, 188, 228, 276, 500 and 612 cm), the stable carbon isotope ratios ($\delta^{13}C$) of the carbonate were determined by a Finnigan MAT Delta S mass-spectrometer.

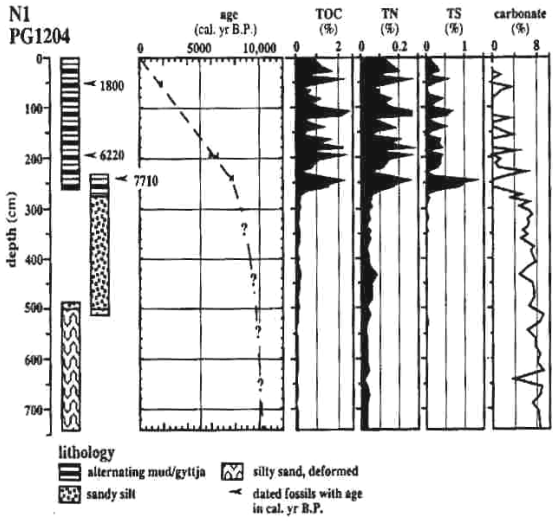


**Fig. 2.** Lithology, chronology, and sedimentological parameters of core PG1204 from lake N1. Black arrows mark the horizons of radiocarbon dated macrofossils with their age in calendar years before present (cal. years BP).

The palynological analyses were carried out by J. Hahne according to a method proposed by Hahne and Melles (1999). The determination of the absolute pollen values in each sample was enabled by adding a *Lycopodium*-tablet (12,548 spores). The palynological results are presented as total pollen diagrams, i.e. the pollen sum (100%) includes all pollen, with the exception of aquatics, spores, and algae. *Betula* is assumed to represent *Betula nana*, the dominant taxon in East Greenland from the early Holocene (Fredskild, 1991). *Salix* includes *Salix arctica* and *Salix herbacea*, both common in East Greenland during the Holocene. *Oxyria* and *Rumex* were combined to the *Oxyria/Rumex*-type due to their difficult distinction, though the majority of grains are believed to belong to *Oxyria*.

Radiocarbon dating of macrofossils from the sediment core was carried out by Accelerator Mass Spectrometry (AMS) at the Van de Graff Laboratory, University of Utrecht. Thus, a pelvic spine of *Gasterosteus aculeatus* (fish, sticklebar) from 240 cm depth and terrestrial plant remains from 195 and 52 cm depths were dated. The $^{14}C$ ages subsequently were calibrated into calendar years before present (cal. years BP) using the calibration programme CALIB 4.0 (Stuiver et al., 1998).

## Results and discussion

### Lithology and Biogeochemistry

The lower part of the core PG1204 (740–275 cm) is built up by stratified, strongly deformed silty sand and overlaying laminated sandy silt (Fig. 2). Low contents of organic matter, a relatively high carbonate content, and an obviously high sedimentation rate suggest that the sediments originate from a glacier retreat of the ice cap to the northeast of the lake. In the upper part of this unit (500–275 cm) a slight change towards more fine-grained sediments and decreasing carbonate contents indicate an increasing distance to the glacial sediment source due to progressive glacier retreat.

Above 275 cm depth in core PG1204 all sediment parameters show strong fluctuations (Fig. 2). Ochre and black horizons with high contents in water, high values in the biogeochemical parameters, and lack of carbonate alternate with grey horizons of opposite composition. The ochre and black horizons represent times of significant biogenic accumulation. This is, for instance, documented in the occurrence of a pelvic spine from a sticklebar (*Gasterosteus aculeatus*) in 240 cm depth, dated to 7710 ± 130 cal. years BP (Table 1). The occurrence of

sticklebars is often related to nutrient-rich limnic or slightly brackish conditions (Bennike, 1997), which may have been created in lake N1 by spray of a close marine limit, 40–50 m below the lake level at that time (Hjort, 1979; Björck et al., 1994; Bennike, 1995). Also the occurrence of terrestrial plant remains in 195 and 52 cm depths, dated to 6220 ± 370 cal. years BP and 1800 ± 90 cal. years BP (Table 1), is related to the ochre and black horizons that indicate biogenic accumulation. During the formation of the intervening grey horizons, in contrast, the biogenic accumulation likely is diluted by enhanced terrigenous sediment supply. This is reflected by the lower contents in organic matter, but also by the occurrence of carbonate.

As shown by $\delta^{13}C$ measurements the carbonates in the upper sediment sequence have the same range in carbon isotope ratios as those deposited in the basal sediments (3.88–4.29‰). This suggests that they originate from the same terrigenous source, likely the Limestone-Dolomite Series exposed to the northeast of lake N1. Thus, one reason for the fluctuating terrigenous sediment supply could be fluctuations in the size of the ice cap on the mountains to the northeast of the lake, leading to repeated ice advances into the catchment of lake N1. Today, the ice cap is located outsite the N1 catchment (Fig. 1), which corresponds with the lack of carbonate and relatively low concentration of biogenic matter in the surface sediments (Fig. 2).

## Palynology

The sediments below 280 cm core depth are characterized by low pollen concentrations, probably due to a sparse vegetation cover in the surrounding of lake N1 or to a high terrigenous sediment supply that dilutes the pollen grain accumulation. The dominant taxa are Poaceae, Rosaceae, Saxifragaceae, Caryophyllaceae, and spores (Fig. 3), being typical for an early Holocene fell field vegetation that is reported from other sites in East Greenland during the pioneer stade (Funder, 1978; Wagner et al., in press).

A distinct change of the pollen assemblage in core PG1204 takes place at a depth of 240 cm, corresponding to 7710 cal. years BP (Fig. 3). Whilst herbs and spores sharply decrease, *Betula* increases and dominates the pollen assemblage by more than 70%. From other studies *Betula* is known to represent a warmer period than today in East Greenland, in particular in the more interior regions, where a more continental climate exists since deglaciation (Funder, 1978; Fredskild, 1991; Wagner et al., in press). The delay between the onset of biogenic accumulation (280 cm), indicating increased bioproduction within the lake, and the distinct increase of birch pollen (240 cm), indicating warm temperatures, may be explained by delayed immigration of landplants. Thus, the settlement birches that arrived at c. 9000 cal. years BP in the coastal East Greenland may have been hampered in the more interior regions by the general east-west direction of glacier retreat and, in consequence, delayed soil formation. This longitudinal delay is evidenced by comparison of pollen records from a similar latitude, for instance, between the interior lake N1 and the coastal Basaltsø (Wagner et al., in press; Fig. 1), or in the Scoresby Sund region, c. 250 km to the south (Funder, 1978).

Between 150 cm, corresponding to ca. 5000 cal. years BP, and the sediment surface, a slight decrease of *Betula* coincides with an increase of *Salix*, Cyperaceae and *Dryas* (Fig. 3). This vegetational change is also observed elsewhere in East Greenland, and reflects a cooling trend that culminates during the Little Ice Age (Wagner et al., in press). However, *Betula* remains relatively common in the interior region until today, in contrast to the cooler and moister coastal region.

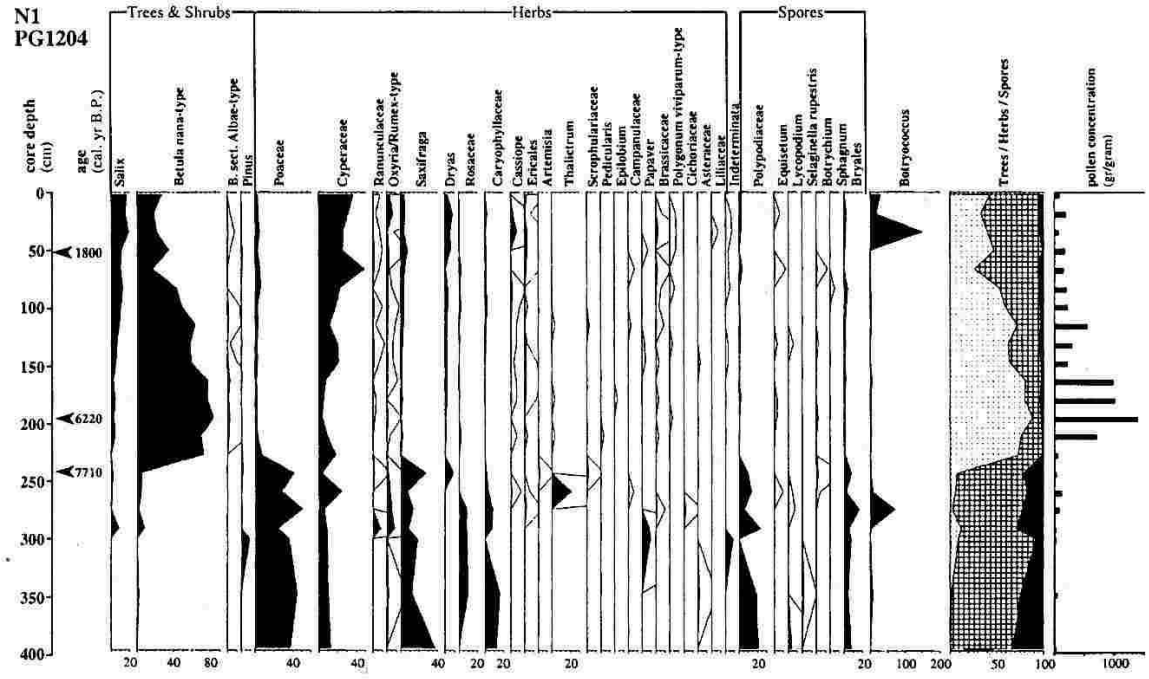


**Fig. 3.** Pollen percentage diagram for the core PG1204 versus age of the sediments (cal. years BP). Pollen concentration is given in grains/gram.

## Conclusions

Prior to c. 8000 cal. years BP sedimentation of a lake sediment record from western Ymer Ø, East Greenland, was strongly influenced by a high terrigenous sediment supply, probably due to glacier retreat in the catchment. From at least 7800 cal. years BP, the pollen record well reflects the general climatic development of interior East Greenland during the middle and late Holocene, in contrast to the biogeochemical record that indicates strong fluctuations of the organic matter deposition. These differences may be due to differing areas and time scales being represented by both records. The pollen record obviously indicates the slower reaction of landplants on environmental changes, and integrates over a larger area. The biogeochemical record, in contrast, probably reflects oscillations of the ice cap to the northeast of the lake, which created a periodically increase of a local terrigenous sediment supply and, in addition, affected the faster reacting bioproduction within the lake.

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# Mineral Dust Record from the Antarctic Epica Ice Core


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*ABSTRACT. Insoluble dust concentration and size distribution of particles from the Epica ice core drilled at the Dome C (Antarctica) has been investigated over the first 580 meters. The ice core provides an atmospheric aerosol record from the Last Glacial Maximum (LGM) period to the present. The sampling resolution is about one sample per four metres for the Holocene period (i.e. one sample per 150 years) and one sample per 3 metres for LGM (i.e. one sample per 300 years) respectively. Samples have been analysed using a 256-channel Coulter Counter Multisizer IIe, allowing detection of particles with diameter greater than 0.7 microns. Both the profiles of the total microparticle number and mass concentration evidence a sharp decrease from high LGM value to the Holocene value. The mean dust number and mass concentration of Holocene samples are about 4000 particles/g and 15 10-9 g per g respectively both represent a value 50 times lower than LGM concentrations. The volume-size distribution of the particles shows a mode centred around 2 microns and fairly changes over the different climatic period. Moreover, at the end of the climatic transition, the Epica core suggests a slight increase in dust concentration during the Antarctic Cold Reversal that is new from Antarctic records. This event seems analogous to the dust reappraisal recorded in Greenland ice at the time of the cool period of the Younger Dryas. Beside the natural variability of data, the Holocene record suggests a slight but significant general decreasing tendency with the time. This trends seems also observed in several others record from East Antarctica.*



*KEY WORDS: ice core, dust concentration, Antarctica, Last Glacial Maximum, Holocene.*