Palaeolimnological aspects of a Late-Glacial shallow take in Sandy Flanders, Belgium

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Abstract

A summary account is given of the development of a small Late-Glacial lake at Snellegem-St. Andries, Belgium. Sedimentation, hydrology, water quality and biotic succession clearly depended on climatic conditions and catchment processes (soil stability and leaching, vegetation). Special attention is drawn to a period oflow water level near the end of the Allemd and the abundance of *Fragilaria* in certain periods.

Introduction

After melting of the permafrost, shallow lakes and mires were formed during the Late-Glacial at suitable sites in Sandy Flanders (NW-Belgium). Although many of them were only short-lived, an almost complete Late-Glacial sequence accumulated in some of them. In the frame of palaeoclimate research several such sites are being investigated in detail. As the inference of palaeoclimatic data from limnic environments requires knowledge about basin and catchment processes, lake ontogeny is studied. Here we give a preliminary summary account of the development of a small palaeolake at Snellegem-St. Andries. A first palynological investigation at this site, indicating its interest, was made by Verbruggen (1979).

Site and core description

The former lake (lat. = 51° 10' 06" N, long. = 3° 08' 48" E; altitude 12 m above m.s.l.; surface approx. 7 ha; catchment approx. 300 ha) is situated in a shallow, closed depression, developed in Tertiary and Pleistocene sandy deposits. The lacustrine sediments are largely Late-Glacial. Holocene deposits are almost totally lacking.

At the coring site, close to the deepest part of the depression, the lowermost Pleistocene sediment consists of fine- to medium-grained sand grading into silty sand at about 188 cm depth. Around 170 cm a gradual transition to lake marl is observed, which gives way to a rather pure peat at 102.5 cm. Above 95 cm the peat becomes more and more sandy and silty. Same sand laminae of presumed aeolian origin are present between 92 and 86 cm. From 70 cm to the top of the care, the sediment consists of a rather homogeneous silty organic clay with a few thin fine-sandy lenses.

The Allemd/Dryas III boundary was dated at 10940 ± 60 y. **B.P.** (GrN 6033) by Verbruggen (1979). Further radiocarbon dating is in progress.

Methods

A 250 cm long, 10 cm diameter undisturbed and continuous care was retrieved by driving a 10 cm diameter tube into the sediment. Half of the core was cut into 0.5 cm slices and used for microfossil, sediment and isotope analyses. The remaining half was used for extraction of macrofossils, micromorphology and determination of bulk density.

Carbonate content was measured manometrically and loss-on-ignition was determined at 500 °C. Oospores of Characeae were recovered by sieving 3 g of dry or 4 cm^3 of wet sediment through a mesh of 210 *µm*. Calcareous samples were treated with HCl before sieving. Concentrations of diatom remains, chrysophyte statospores, pollen and palynomorphs were estimated with Stockmarr's (1971) method. At least 500 diatom valves were counted when possible from peroxide-cleaned material mounted in pleurax. The counts were increased considerably at levels where *Fragilaria* dominated.

Diatom zones were established by evaluating the clusters generated by a stratigraphically constrained classification (minimum variance, Euclidian distance; Grimm, 1987) of the samples. Herein only the taxa reaching 5% or more in at least one sample were used (N = 46). Inferred pH was calculated as pH = 6.4 – 0.85logB (Renberg & Hellberg, 1982). Considering the context, this estimation probably gives only a rough picture of the former pH-trends rather than yielding accurate values.

Results (Figs. 1-2)

The basal fine sand from diatom zone 1contained few diatoms, many of which originate from reworked marine-littoral Pleistocene deposits. Some subaerial taxa ar present as well. The presence of small-ripple laminations suggest deposition by gentle currents.

Zone 2 shows an assemblage of mainly *Rhopalodia operculata* (Ag). Häkansson, *Mastogloia grevillei* W. Sm. and *Navicula cryptotenella* Lange-Bertalot, reflecting mineral-rich, wet subaerial to aquatic conditions.

This pioneer assemblage is soon replaced by one dominated by *Fragilaria* (mainly *F. pinnata* Ehr. in zone 3a and *F. brevistriata* Grun. in 3b). Concentrations of diatoms, *Chara* oospores and chrysophyte cysts increase steadily, as do the number of diatom taxa, indicating more limnic conditions. Oospores reach their highest concentrations in 3b and, at the same time, diatoms tolerant of moist subaerial conditions disappear almost completely.

The transition to zone 4, where there is a diverse assemblage of epiphytic and epipelic taxa and *Cyclotella kuetzingiana* Thwaites reaches modest frequencies, coincides well with the onset of the Beilling. Although alkaliphilous diatoms (*Mastogloia smithii* Thwaites var. *lacustris* Grun., *Denticula inflata* W. Sm.) remain most abundant, circumneutral ones reach considerable levels and some halophobous, acidophilous taxa appear. Oligotraphentous diatoms attain almost 20% and cyst concentrations are fairly high, perhaps indicating conditions slightly less rich in nutrients (Smol, 1985). These changes could be due to increased soil stabilisation. The decline in oospore concentrations may result from a replacement of the *Chara* beds by other aquatics, as the concentrations of their pollen suggest. However, the return of diatoms from moist habitats and the later decline of aquatic pollen indicate that a lowering of the water-table could also be responsible.

Diatom, cyst and pollen concentrations fall at the beginning of zone 5, as the older Dryas II period begins. In zones 5 and 7 only very few diatom valves could be counted, mainly of *Fragilaria.* The intermediate zone 6 at the end of the Dryas II yielded a somewhat higher number with mainly *Mastogloia smithii* var. *lacustris* and some *Cymbella microcephala* Grun. and *Fragilaria elliptica* Schumann. Considerably more cysts than frustules are found while oospores are very rare.

The first part of the Allernd shows an alternation of layers with hardly any diatom remains (zones 7 and 9) and fairly well preserved assemblages (zones 8 and 10) suggesting shallow, circumneutral to slightly acid, meso-oligotrophic conditions. Dominants are *Navicula jaagii* Meister, *N. bryophila* Petersen var. *lapponica* Hust. (zone 8), *Eunotia arcus* Ehr., *E. praerupta*

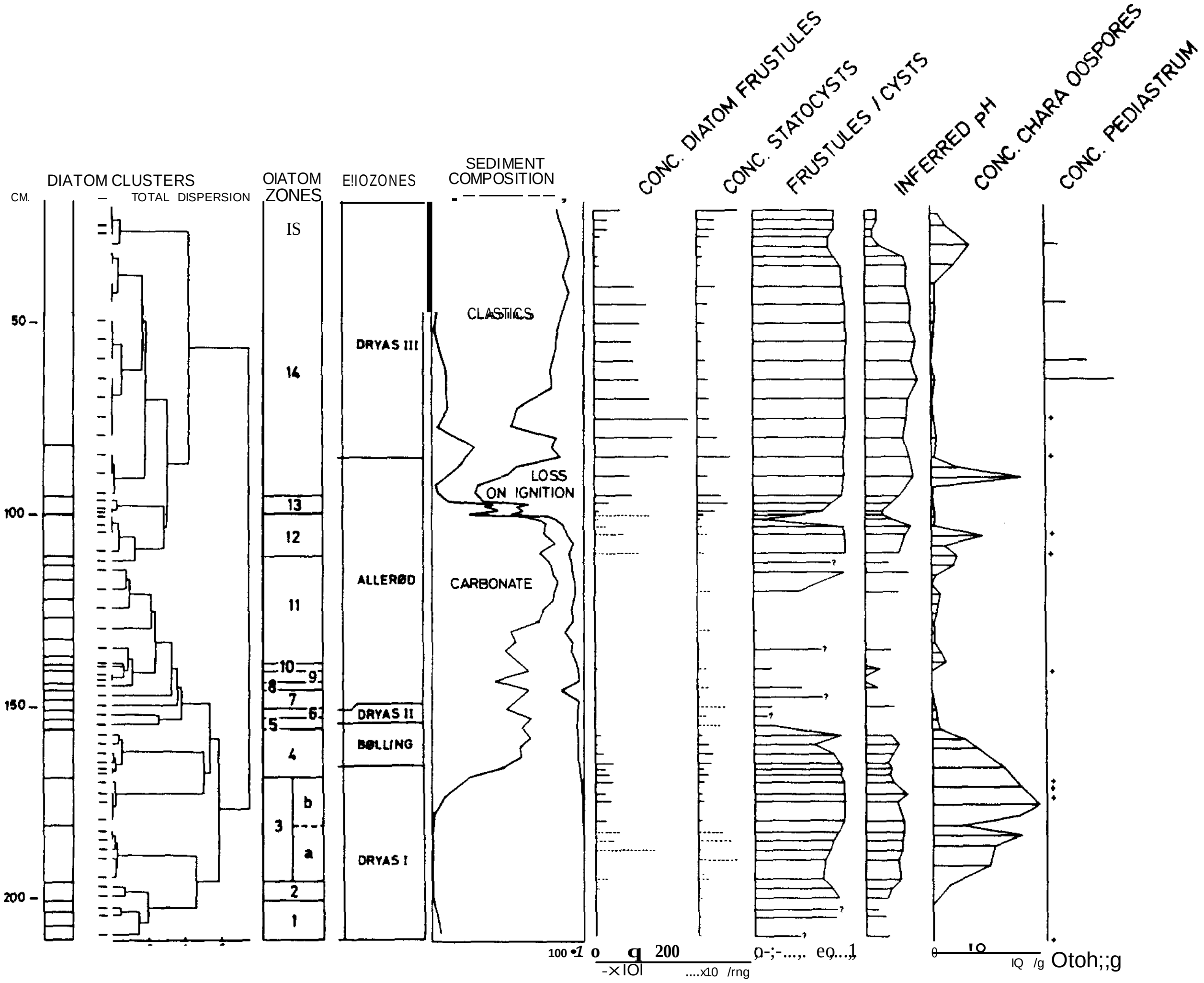

Fig. 1. Zonation, sediment composition, algal remains and diatom inferred pH of the Snellegem-St. Andries core.

Ehr., *Tabellaria fenestrata* (Lyngb.) Kütz. and *Fragilaria brevistriata* (zone 10). Aquatic pollen are badly represented and oospores largely absent, demonstrating also that the water-level has dropped. Stable isotope data (unpublished) point to increased evaporation at the time these deposits formed. It may be that the intermittent diatom preservation results from periodic exposure of the sediment to the air.

Zone 11 is again very poor in diatoms. There is evidence for leaching of biogenic silica from this part of the core (unpublished) which again could imply a fluctuating water-table. Oospore concentrations remain low throughout, hut aquatic pollen is more frequent in the lower part of the zone.

In zone 12 diatom preservation is quite well again. The assemblages, dominated by *Fragilaria elliptica* and *F. pinnata*, are indicative of an alkaline and rather nutrient-rich limnic environment. The diatom/chrysophyte cyst ratio is very high. Oospores become more abundant and a peak of aquatic pollen is reached. The permanent inundation inferred from all this agrees well with the wetter climate derived from the stable isotope ratios.

As the sediment changes from marl to a rather pure and compact fen peat (zone 13), a number of

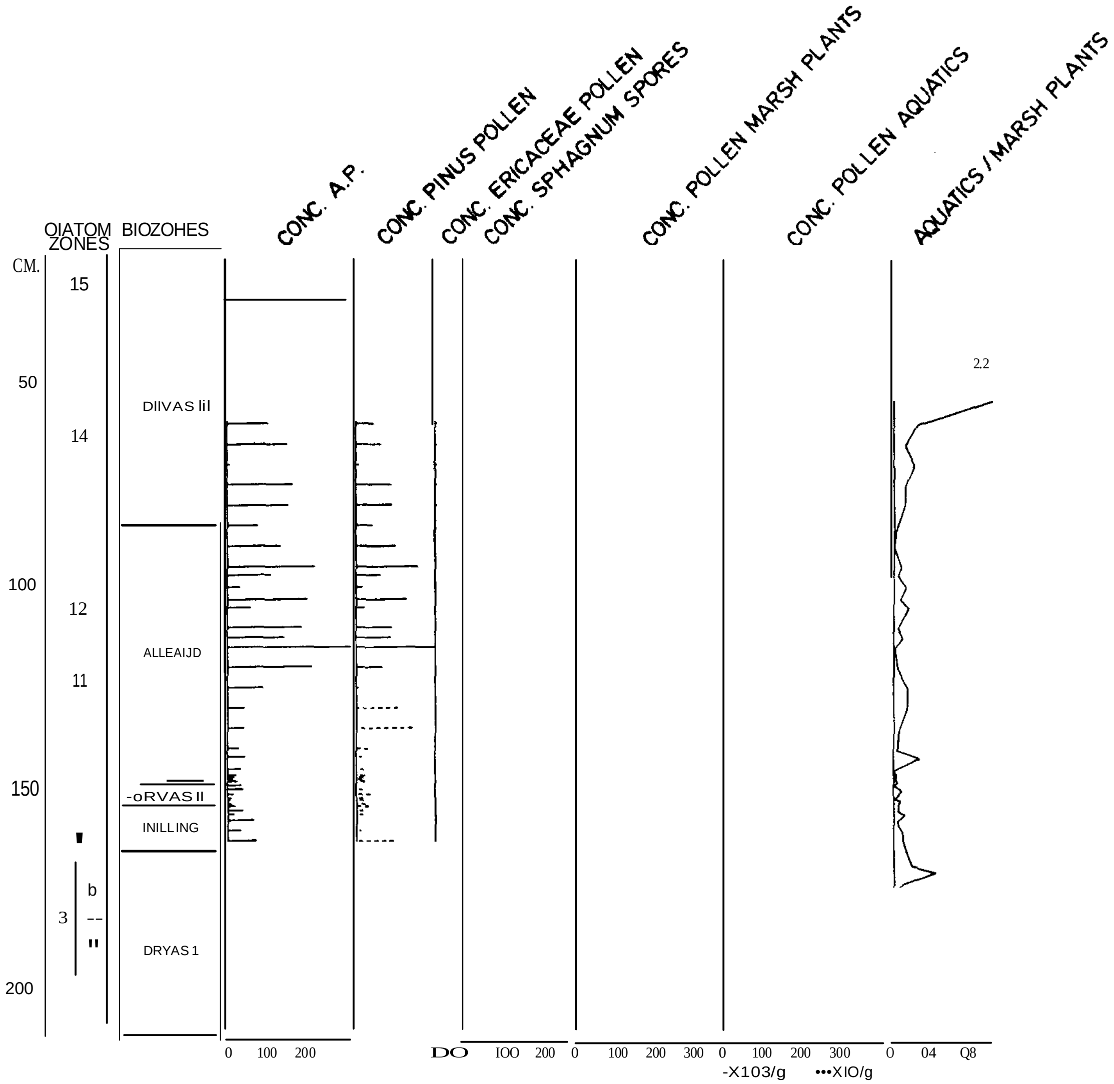

Fig. 2. Genera! pollen and spore date from the Snellegem-St. Andries core.

other diatoms also become frequent *(Fragilaria construens* (Ehr.) Grun. var. *venter* (Ehr.) Grun" *Opephora martyi* Hérib" *Gomphonema angustatum* (Kütz.) Rabenh" *Achnanthes minutissima* Kütz.). The pH declines (cfr. also *Sphagnum)* and a more mesotrophic marshy situation arises. Statocysts predominate over diatoms and oospores decline markedly. The peat occurs throughout the whole lake basin and most probably reflects a lowering of the water-level. A break in the presence of aquatic pollen at the beginning of the next diatom zone also points in this direction. The well-sorted fine sand interspersed in the peat was most likely brought in by wind and indicates decreased soil stability on higher grounds.

At the start of the Dryas III the water rises anew and more minerogenic material is washed in. An organic silty clay with low carbonate content is deposited from naw on. *Fragilaria* has regained predominance (zone 14) and attains very high concentrations. *Pediastrum* flourishes as well. Ericaceae (mainly *Empetrum)* profit from the climatic deterioration. Their expansion here is much more marked than in the adjacent alluvial plain of Scheldt and Lys (see Verbruggen, 1979), which can be related to a more intense local soil decalcification. Initially the oospores show peak concentrations hut their numbers soon fall back which may be due to unfavourable light conditions caused by increased turbidity and to shading by other aquatics, especially *Ranunculus* sect. *Batrachium,* whose pollen are present in quantity. At the top of zone 14 a minimum in diatom and statospore concentrations accompanies a transient increase of oospores.

In zone 15 diatom and chrysophyte cyst concentrations gradually recover. The *Fragilaria* are replaced in part by epiphytic and epipelic taxa resistant to periodically moist conditions. Besides the predominant diatoms, among which are *Fragilaria elliptica, F. brevistriata, Achnanthes minutissima* and *Gomphonema angustatum,* a number of acidophilous subaerial moss dwellers are rather frequent *(Pinnularia subcapitata* Greg., *Eunotia paludosa.* Grun., *E. exigua* (Bréb.) Rabenh.). Together with an increase of circumneutral forms they suggest microbiotope differentiation and a less alkaline situation connected to a reduction of the open water, immediately prior to the onset of the Holocene.

Discussion

Cores from very shallow lakes offer a far more local, and often more complicated and less well preserved record, than those taken in <leep and large basins. On the other hand the rapid and marked response of small waterbodies to environmental changes justifies their palaeolimnological study. As could be expected from such a hydrologically and ecologically sensitive system, the ontogeny of this small lake strongly depended on regional climatic changes and basin processes such as vegetation and soil development.

Of special interest is the lowering of the watertable and the consequent formation of peat near the end of the Allernd. Usinger (1981) has drawn attention to a widespread sedimentary hiatus occurring near the Allernd/Dryas **111** transition in northem German and Danish lakes which he explains as the result of an important lowering of contemporary lake levels. Low lake levels in north-western Europe near the end of the Allernd were reported by several other authors as well (see Bohncke & Wijmstra, 1988). Although a climatic cause seems obvious we feel that a second, vegetational possibility requires examination as well. Indeed the 'dry' conditions shortly follow the local expansion of *Pinus* which by then had accumulated its greatest biomass before its cover was degraded by the intense cold of the Dryas 111. Lockwood (1983) suggested that *Pinus* stands have even greater evapotranspirative capacities than deciduous woods. It is therefore not unreasonable to suspect that the dense cover of mature *Pinus* trees attributed to, or even caused, a lowering of the groundwater table of regional importance, affecting susceptible sites such as wetlands and lakes.

In the diatom record, the abundance of *Fragilaria* in certain Late-Glacial environments stands out once again. Here this genus was especially abundant during the Dryas periods. Several hypotheses can be formulated in this respect, including competitive development in a short vegetation season (extensive ice cover) (Smol, 1988), outstanding minerotrophy (Haworth, 1976; Round, 1957; Stabell, 1985) and adaptation to ecologically unstable 'extreme' environments (cfr. Denys, 1990).

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