Archiv für Naturschutz und Landschaftsforschung
Volume 46, Heft 1, March 2007, pp. 27-40

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Keywords:
Brandenburg, Holocene, NE Germany, pollen analysis, Weichselian Lateglacial

Abstract

A previously unpublished pollen diagram of the late Klaus Kloss from a terrestrialised bay in the southeastern part of the Blankensee near Schönhagen (C Brandenburg) covers the complete Weichselian Lateglacial and Holocene, including the first vegetation phase of the Lateglacial that hardly occurs in pollen diagrams from NE Germany. The pollen diagram shows the typical pollen sequence of central Brandenburg and the Berlin area for the Lateglacial and Early Holocene; the middle and late Holocene are not clearly registered. The sediment sequence contains a lake marl with a clastic component corresponding to the Early Lateglacial up to the late Lateglacial Betula/Pinus forest phase ("Allerød") that is covered with pure lake marl. A dark-coloured sediment originates from the beginning of the Holocene. Peat formation at the coring location started during the Early Holocene Corylus phase ("Boreal").

Schlüsselwörter:
Brandenburg, Holozän, NO Deutschland, Pollenanalyse, Weichselspätglazial

Zusammenfassung: Spätglaziale und holozäne Vegetationsentwicklung um eine verlandete Bucht des Blankensees nahe Schönhagen (Zentral-Brandenburg, NO Deutschland) abgeleitet aus einem Pollendiagramm von Klaus Kloss

Ein bisher unveröffentlichtes Pollendiagramm von Klaus Kloss von einer verlandeten Bucht im südöstlichen Teil des Blankensees nahe Schönhagen (Zentral-Brandenburg) umfasst das gesamte Weichselspätglazial und Holozän, darunter die erste spätglaziale Vegetationsphase, welche nur selten in Pollendiagrammen von NO Deutschland auftritt. Das Pollendiagramm zeigt die typische palynologische Abfolge des Spätglazials und frühen Holozäns von Zentral-Brandenburg und Berlin; das mittlere und späte Holozän sind nicht deutlich registriert. Die Sedimentabfolge zeigt klastische Seekreide aus dem frühen Spätglazial und der spätglazialen Betula/Pinus-Waldphase („Allerød"), welche mit reiner Seekreide bedeckt ist. Ein dunkleres Sediment stammt vom Anfang des Holozäns. Torfbildung begann am untersuchten Bohrpunkt während der frühholozänen Hasel-Phase („Boreal").

1 Introduction

The late Klaus Kloss was one of the few Quaternary palynologists of the former German Democratic Republic. He worked at the “Brandenburgisches Landesmuseum für Ur- und Frühgeschichte” and much of his work was carried out in an archaeological context. Unfortunately, much of his data remained unpublished. In order to present part of his material to the scientific audience, some of his analyses were recently digitalised and reinterpreted (cf. DE KLERK 2004a, b, 2005; 2006a, b).

One of his unpublished study areas is a terrestrialised bay of the Blankensee in central Brandenburg (Figs. 1, 2). The pollen diagram “Schönhagen 96/1” from this bay provides a nice picture of the vegetation development of the Weichselian Lateglacial and Holocene and supplements the recent palynological analyses of the Blankensee of KLEINMANN et al. (2002) and SCHINDLER (2004).

The pollen diagram “Schönhagen 96/1” is, therefore, presented and interpreted in the present paper.

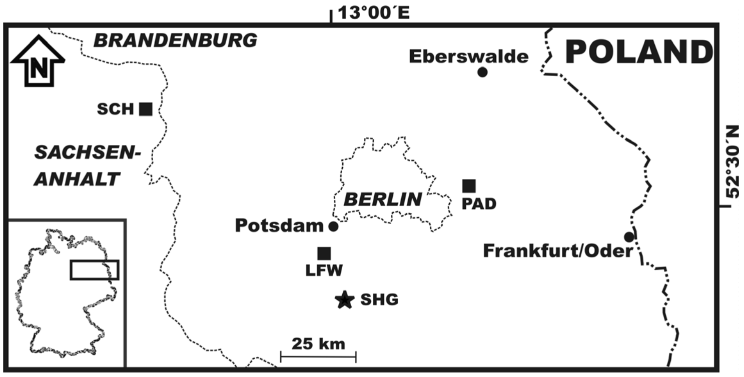


Fig. 1 Location of the study area (SHG) in central Brandenburg. Also indicated are the locations of other sites mentioned in the text: Schollene (SCH) of Mathews (2000), Langes Fenn bei Wilhelmshorst (LFW) of Müller (1970, 1971), and Paddenluch (PAD) of Strahl (2005).

Abb. 1 Lage des Untersuchungsgebiets (SHG) in Zentral-Brandenburg. Ebenfalls angegeben ist die Lage von anderen Lokalitäten, welche im Text erwähnt werden: Schollene (SCH) von Mathews (2000), Langes Fenn bei Wilhelmshorst (LFW) von Müller (1970, 1971), und Paddenluch (PAD) von Strahl (2005).

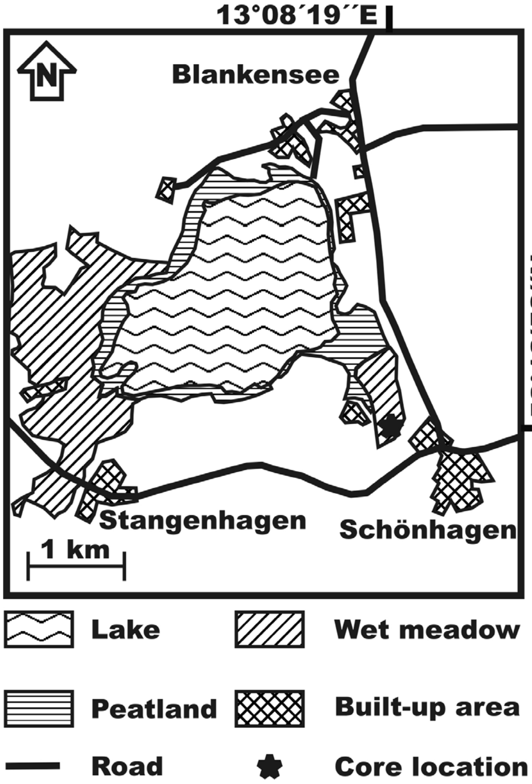


Fig. 2
Map of the Blankensee area. Indicated is the location of the investigated core in the terrestrialised southeastern bay of the lake.

Abb. 2
Karte des Blankensees und Umgebung. Angegeben ist die Lage des untersuchten Bohrkerns in der verlandeten südöstlichen Bucht des Sees.

2 Description of the study area

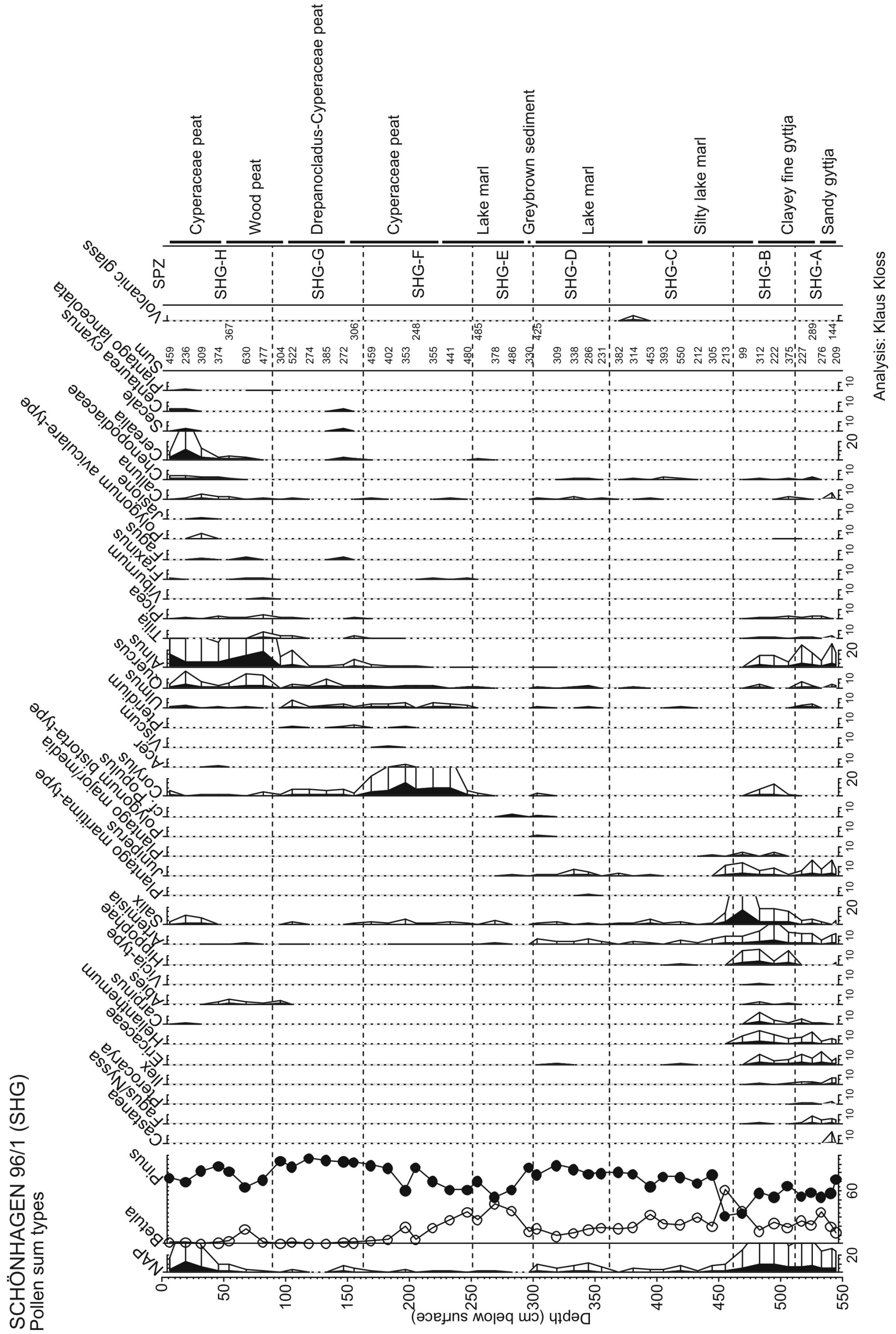
The Blankensee is a lake with a diameter of several kilometres between the villages Blankensee, Stangenhagen and Schönhagen (Fig. 2) within a vast complex of Urstromtäler in front of the Frankfurtian terminal moraines (cf. STACKEBRANDT et al. 1997).

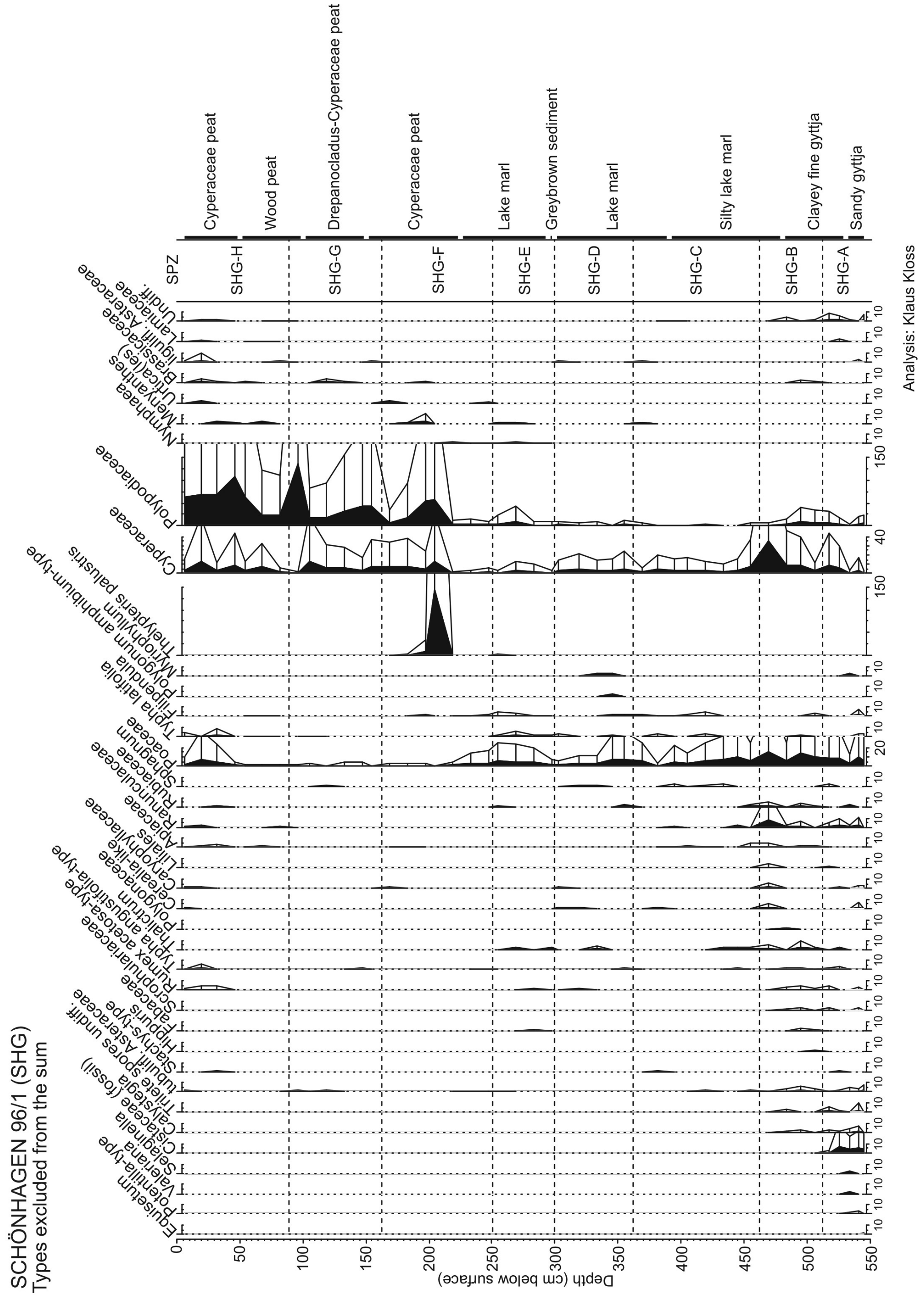
A girdle of peatlands and areas of wet meadows surrounds the lake and indicates that in former times the lake was larger (cf. Fig. 2). Cores from the central part of the lake show a basin depth up to 15 m and a basin fill of predominantly lake marl (KLEINMANN et al. 2002).

The core “Schönhagen 96/1” (52°12´52´´N, 13°08´19´´E) originates from a marginal part of the terrestrialised southeastern bay of the lake (cf. Fig. 2). The core has a length of ca. 5.5 m and consists of 3.25 m of lake marl (partly with a clastic component) covered with approximately 2.25 m of various peat types (cf. Fig. 3).

Fig. 3(a/b) Pollen diagram “Schönhagen 96/1” (SHG). Pollen curves are drawn with actual values (closed curves) and a 5-times exaggeration (open curves with depth bars).

Abb. 3(a/b) Pollendiagramm “Schönhagen 96/1” (SHG). Die Kurven sind mit wirklichen Werten (geschlossene Kurven) und mit einer 5-fachen Überhöhung (offene Kurven mit Tiefelinien) dargestellt.


SCHÖNHAGEN 96/1 (SHG)
Pollen sum types
Analysis: Klaus Kloss
Cyperaceae peat
Wood peat
Drepanocladus-Cyperaceae peat
Cyperaceae peat
Lake marl
Greybrown sediment
Lake marl
Silty lake marl
Clayey fine gyttja
Sandy gyttja
SPZ
SHG-H
SHG-G
SHG-F
SHG-E
SHG-D
SHG-C
SHG-B
SHG-A
Volcanic glass
Sum
Plantago lanceolata
Centaurea cyanus
Secale
Cerealia
Chenopodiaceae
Calluna
Polygonum aviculare-type
Jasione
Fagus
Fraxinus
Viburnum
Picea
Tilia
Alnus
Quercus
Ulmus
Pteridium
Viscum
Acer
Corylus
Populus
cf. Polygonum bistorta-type
Plantago major/media
Juniperus
Plantago maritima-type
Salix
Artemisia
Hippophae
Vicia-type
Abies
Carpinus
Helianthemum
Ericaceae
Ilex
Pterocarya
Fagus/Nyssa
Castanea
Pinus
Betula
NAP
Depth (cm below surface)


SCHÖNHAGEN 96/1 (SHG)
Types excluded from the sum
Analysis: Klaus Kloss
SPZ
SHG-H
SHG-G
SHG-F
SHG-E
SHG-D
SHG-C
SHG-B
SHG-A
Cyperaceae peat
Wood peat
Drepanocladus-Cyperaceae peat
Cyperaceae peat
Lake marl
Greybrown sediment
Lake marl
Silty lake marl
Clayey fine gyttja
Sandy gyttja
Depth (cm below surface)
Polypodiaceae
Cyperaceae
Thelypteris palustris
Poaceae
Sphagnum

3 Methods

Coring and palynological analysis of core “Schönhagen 96/1” occurred probably in 1996 as the suffix of the core name suggests. It is unknown how the analysed section was cored, but it seems most likely that a chamber corer was used. Preparation of palynological samples included treatment with KOH, gravity separation with $ZnCl_2$, and acetolysis (S. Jahns pers. comm. July 2004). KLOSS (1989) provides information on his palynological methods.

For revision of the data, the original pollen counting lists of Kloss were used. Sample depths are a medial value (i.e. sample 5-7 cm depth is now sample 6). In the original counting lists incidentally a + was noted for pollen types observed after the counting was finished. For graphical reasons this use was omitted in the present study. Pollen types that were only observed after finishing of the counting were incorporated with value 1 in the revised dataset, whereas a + was ignored for pollen types of which also counted data were available.

In order to differentiate clearly between pollen types and plant taxa, the former are displayed in the text in SMALL CAPITALS (cf. JOOSTEN & DE KLERK 2002). In the revised pollen diagram and in this paper, pollen type nomenclature does not follow the rather outdated nomenclature of the original counting lists (using names like CYPERALES and AMMIACEAE). Instead of this, it was attempted to adopt the nomenclature as generally followed by Kloss in his publications (e.g. KLOSS 1991, 1993, 1994). As these publications do not present a common pollen type nomenclature (e.g. using different kind of abbreviations), the pollen type names as used in this paper should be considered as a practical attempt to present pollen data, not as morphologically unambiguously defined morphotypes. For some of the German pollen type names a more appropriate English equivalent was used (e.g. TYP = TYPE, GETREIDE = CEREALIA, GETREIDEART. = CEREALIA-LIKE, SPOREN TRILETE = TRILETE SPORES, KRAUTIGE = UNDIFF.).

The data were calculated and presented with the computer programs TILIA 1.12, TILIA GRAPH 1.18, and TGView 1.6.2 (GRIMM 1992, 2004). Pollen frequencies were calculated relative to a pollen sum including pollen types attributable to trees and shrubs (AP) and upland herbs (NAP). The NAP values are an indication for the openness of the upland vegetation. Pollen types that might originate from both upland and wetland herbs (e.g. POACEAE and CYPERACEAE) were excluded from the sum since (extra)local effects (sensu JANSSEN 1973) might erroneously indicate an opening of the upland vegetation when in reality a change in the wetland vegetation occurs (cf. DE KLERK 2004c). CEREALIA, including pollen grains attributable to cereals, was included in the sum, whereas CEREALIA-LIKE was excluded since it can be expected that this type also includes grains of wild grasses. In the publication of KLOSS & WECHLER (1987) the pollen type “GETREIDEART.-TYP” (possibly encompassing both the GETREIDE-TYP - that does not occur in the Schönhagen diagram - and GETREIDEART.) was additionally named “BROMUS-AGROPYRON-POLLENTYP” (cf. DE KLERK 2006a).

Pollen percentages in the pollen diagram (Fig. 3) are presented with actual values (closed curves) and a 5-time exaggeration (open curves with depth bars). Pollen types are ordered stratigraphically in order to facilitate a successional interpretation. The diagram is divided into several Site Pollen Zones (SPZ’s) (DE KLERK 2002) that are a combination of informal acme zones and informal interval zones sensu HEDBERG (1976) and SALVADOR (1994).

In order to avoid the widespread confusion on the stratigraphic and geochronologic terminology of the Weichselian Lateglacial (cf. ERIKSEN 2002; DE KLERK 2004c; TERBERGER et al. 2004), the part of the pollen diagram covering the Weichselian Lateglacial and early Holocene is interpreted in terms of “Vegetation phases of Vorpommern” (DE KLERK 2002) that allow the interpretation of pollen diagrams independent of the existing terminology, and that appear to be valid also for the regions south of Vorpommern (cf. DE KLERK 2006b). A correlation of these vegetation phases with the “traditional” stratigraphic and geochronologic terminology is presented by DE KLERK (2002 p. 297; 2004d p. 32) and TERBERGER et al. (2004 p. 140). For readers not familiar with the vegetation phases of Vorpommern, in the text additionally the more traditional terminology is mentioned.

4 Discussion: interpretation of the pollen diagram

4.1 Open vegetation phase I - “Earliest/Oldest Dryas”, earlier part of the “Meiendorf” (SPZ SHG-A)

The lowest pollen zone SHG-A is characterised by high NAP values, high values of BETULA and PINUS pollen, and the absence of HIPPOPHAË pollen. Since values of HIPPOPHAË pollen rise prominently in the subsequent zone, the basal zone is correlated with Open vegetation phase I. The upland vegetation consisted mainly of herbs of open vegetation types such as *Artemisia* and *Helianthemum,* and shrubs such as *Juniperus*.

Many pollen types that occur in this zone that are produced by thermophillous trees (e.g. CASTANEA, FAGUS/NYSSA, PTEROCARYA, ILEX, QUERCUS, and TILIA) are the result of erosional redeposition and/or of long distance transport (cf. IVERSEN 1936; JOOSTEN & DE KLERK 2002). This might also apply for ALNUS pollen that occurs with relatively high values, but it is also possible that *Alnus viridis* was present in the Lateglacial vegetation (cf. DE KLERK 2002).

The pollen record does not allow the inference of a local wetland vegetation during this vegetation phase, since pollen types that are possibly produced by wetland plants occur with too low values to definitely conclude their local presence at the coring location.

This earliest vegetation phase of the Lateglacial occurs only in few pollen diagrams from eastern Germany. Fortunate exceptions (partly after revision of the published geochronology) are the pollen diagrams Schollene (MATHEWS 2000), Langes Fenn bei Wilhelmshorst (MÜLLER 1970, 1971), and Paddenluch 2 (STRAHL 2005) (cf. Fig. 1) and some pollen diagrams from northern Brandenburg and northern Vorpommern (DE KLERK et al. 2001a; DE KLERK 2002; STRAHL 2005; KRIENKE et al. 2006). It can be expected that this phase is also registered in the Blankensee core of KLEINMANN et al. (2002), but the low temporal resolution of their pollen diagram does not allow its recognition.

4.2 Hippophaë phase and Open vegetation phase II – second part of the “Meiendorf”/“Bølling” (SPZ SHG-B), and “Earlier/Older Dryas”

SPZ SHG-B contains high values of HIPPOPHAE pollen around 5 %. Considering the low pollen production and bad pollen dispersal of *Hippophaë* (cf. FIRBAS 1934) already values of a few percent are indicative for large dense stands. These could develop due to the absence of shadow-casting competitive taxa (cf. SKOGEN 1972). High relative NAP-values indicate that the vegetation remained mainly open. It is assumed that this phase corresponds with a relatively warm period and starts with a rise in temperature around 12450 ^{14}C years B.P. (cf. DE KLERK et al. 2001a; DE KLERK 2002).

A peak of SALIX pollen in the top sample of SPZ SHG-B points to a temporal expansion of *Salix* species in or around the study area. The same sample contains peaks of RANUNCULACEAE and CYPERACEAE pollen that point to a short-lived expansion of Ranunculaceae and Cyperaceae taxa near the coring location. CYPERACEAE pollen peak regularly in the upper part of pollen zones correlated with the Hippophaë phase in several diagrams from NE Germany (cf. e.g. BRANDE 1980, 1995a; BRANDE et al. 1990; KRIENKE et al. 1999; SCHULZ & STRAHL 2001; DE KLERK & STOLZE 2002; DE KLERK 2004e). Since SALIX, CYPERACEAE and RANUNCULACEAE pollen might originate from both upland and wetland taxa, it is unclear whether this peak represents an opening of the upland vegetation (and thus might represent the “Open vegetation phase II” that is only incidentally observed in pollen diagrams from southern Mecklenburg, northern Brandenburg and the Berlin area (cf. DE KLERK 2004e, 2006b)), an expansion of a local wetland vegetation, or a combination of both possibilities.

4.3 Lateglacial Betula/Pinus forest phase – "Allerød" = "Bölling-Alleröd complex" sensu USINGER (1985) = sequence of "Bølling – Older Dryas – Allerød" sensu LITT & STEBICH (1999) (SPZ SHG-C)

Pollen zone SHG-C is distinguished from the preceding zone by a lower amount of NAP pollen that indicates a closing of the upland vegetation and an expansion of upland forests. This zone is therefore correlated with the Lateglacial Betula/Pinus forest phase ("Allerød").

The Schönhagen pollen diagram shows the "classical" sequence for this time-frame for the areas of S Mecklenburg, N Brandenburg and Berlin: a short phase with high values of BETULA pollen followed by a long phase with high values of PINUS pollen (cf. FIRBAS 1949; DE KLERK & STOLZE 2002). In many pollen diagrams from C Brandenburg the values of BETULA pollen increase again towards the end of the Lateglacial Betula/Pinus forest phase which is interpreted to represent an (extra)local expansion of birch carrs along the margins of many basins (cf. e.g. WOLTERS 2002; THEUERKAUF 2003; DE KLERK 2006a). Since such an increase of BETULA pollen does not occur in the "Schönhagen 96/12" pollen diagram, birch carrs did probably not play an important role along the shores of the southeastern bay of the Blankensee.

A prominent chronostratigraphic marker in many basins of NE Germany is the Laacher See tephra that originates from a volcanic eruption in the Eifel (cf. VAN DEN BOGAARD & SCHMINCKE 1985; THEUERKAUF 2003). Though it occurs in the Blankensee core of KLEINMANN et al. (2002), this tephra was not found in core "Schönhagen 96/1" probably because its colour is very similar to that of the lake marl that forms the basal part of the core. Tephra particles that probably had washed-in from the surrounding basin slopes, were, however, found in the sample at 381 cm depth. This level, thus, dates shortly after the volcanic eruption.

At approximately the same level the sediment changes from silty lake marl to pure lake marl, indicating that upland erosion diminished greatly and soils stabilised.

4.4 Open vegetation phase III – "Younger Dryas" (SPZ SHG-D)

SPZ SHG-D can be distinguished from the previous zone by higher NAP values that are mainly attributable to higher values of ARTEMISIA pollen. This zone is therefore correlated with Open vegetation phase III (the "Younger Dryas"), the last cold phase of the Weichselian Lateglacial (cf. ISARIN 1997). Since the NAP-values rise only slightly, the upland tree vegetation must have remained denser than in regions further northward where this vegetation phase is registered with much higher NAP-values (cf. LANGE et al. 1986; BRANDE 1995b; DE KLERK et al. 2001a, b; DE KLERK 2002; DE KLERK & STOLZE 2002; TERBERGER et al. 2004). From the BETULA and PINUS pollen values of SPZ SHG-D it can be concluded that pine was the most important tree species in the vegetation, whereas birch was less prominently present.

The sediments corresponding with SPZ SHG-D are pure lake marl: a clastic component was not noted in the field notes of Kloss. KLEINMANN et al. (2002) mention that the Younger Dryas section of their core section consists of silty/sandy lake marl. This indicates differences in depositional environments within the Blankensee. Normally - contrary to the data of the Blankensee - the most clastic sediments are deposited near the lake shores, not in the centre of a lake (cf. DIGERFELDT 1986).

4.5 Early Holocene Betula/Pinus forest phase – "Preboreal" (SPZ SHG-E)

Zone SHG-E contains prominently lower NAP values than the previous zone. This indicates that the vegetation closed-up and that forests expanded on the upland. This zone is therefore correlated with the beginning of the Holocene.

It is not possible to draw conclusions about the wetland vegetation at the beginning of the Holocene, since pollen types produced by wetland taxa occur with too low values to definitely conclude their (extra)local presence around the coring location.

The base of zone SHG-E corresponds with a thin layer of greybrown sediment that was not further identified. Its deposition might be connected to sudden changes in hydrological conditions and/or sediment influx related to the abrupt environmental changes at the beginning of the Holocene. KLEINMANN et al. (2002) mention darkgrey lake marl corresponding with the beginning of the Holocene. This indicates that the deposition of dark sediments was not restricted to the marginal parts of the lake but occurred widely in the Blankensee basin.

4.6 Early Holocene Corylus phase – "Boreal" (SPZ SHG-F)

The next zone SHG-F is characterised by – compared to both adjacent zones – relatively high values of CORYLUS pollen. This zone is therefore correlated with the hazel phase of the Early Holocene, the "Boreal". Rising values within this SPZ of ULMUS, QUERCUS, and ALNUS pollen indicate that elm, oak and alder immigrated into the region. The high values of PINUS pollen demonstrate that pine was the dominant upland tree taxon. Since the pollen diagram of KLEINMANN et al. (2002) contains much lower values of PINUS pollen and higher values of other pollen types, this dominance of pine was not a general characteristic of the regional vegetation surrounding the Blankensee, but was a peculiarity of the extralocal vegetation directly surrounding the "Schönhagen 96/1" location.

A change from lake marl to Cyperaceae peat occurs at 225 cm depth and indicates that at the coring location a sedge vegetation expanded. At the same level in the pollen diagram a slight increase in the values of CYPERACEAE pollen occurs. High values of POLYPODIACEAE spores show that ferns were also locally present. The peak of THELYPTERIS PALUSTRIS spores at the base of the peat indicates that these ferns were mainly *Thelypteris*. A small peak of MENYANTHES pollen at a slightly higher level shows that *Menyanthes* also grew locally.

4.7 Remaining part of the Holocene (SPZ's SHG-G and SHG-H)

Zone SHG-G is distinguished from its predecessor by lower values of CORYLUS pollen. SPZ SHG-H is distinguished from zone SHG-G by its lower values of PINUS pollen and higher values of QUERCUS and ALNUS pollen.

These upper zones are difficult to interpret. The high values of PINUS pollen obscure the general trends of vegetation development and prohibit a correlation with other pollen diagrams from central Brandenburg and the Berlin region. PINUS pollen occurs with such quantities that its exclusion from the pollen sum would lead to a statistically unreliable calculation basis that would also prohibit an inference of the general vegetation development, so a solution for this problem does not exist. Also the diagram of KLEINMANN et al. (2002) does not provide sufficient information for a more detailed interpretation of the "Schönhagen 96/1" diagram for these time frames. A more complete picture of the regional vegetation development during the later part of the Holocene is given by the pollen diagram of SCHINDLER (2004), but with such differences between her regional upland pollen deposition values (as registered in the centre of the lake) and the extralocal upland pollen deposition values registered in the Schönhagen section that a correlation of both diagrams can hardly raise above a level of hypothesis.

It can be tentatively assumed that the elm decline - that occurs in pollen diagrams all over Europe around 5000 ^{14}C-years B.P. (cf. BIRKS & BIRKS 1980) – is registered immediately below the top sample of SPZ SHG-G. The peak of CEREALIA, SECALE, CENTAUREA CYANUS, and PLANTAGO LANCEOLATA pollen in the upper part of SPZ SHG-H probably represents increasing agricultural activities in the late Holocene.

The types excluded from the sum (Fig. 3b) show that ferns remained locally prominently present throughout the time frame covered by both upper pollen zones. Changes in the local peatforming vegetation are indicated by a change from Cyperaceae peat to *Drepanocladus*-Cyperaceae peat, a subsequent change to wood peat, and a renewed formation of Cyperaceae peat. Slightly above the base of the wood peat, values of ALNUS pollen rise. This might indicate that the wood peat was formed in an alder carr and that the basal part of the peat originates from roots penetrating a deeper peat matrix (displacement or replacement peat) (BARTHELMES et al. 2006; GROSSE-BRAUCKMANN 2006). Values of ALNUS pollen remain that low in SPZ SHG-H (not exceeding ca. 15%) that an exclusion from the pollen sum seemed unnecessary.

The wood peat is covered with a new layer of Cyperaceae peat, indicating that water levels rose and drowned the wetland forest to make place for a herbaceous wetland vegetation. This might be connected to a changed hydrology in the landscape under influence of increased human activities, but might also represent a natural process in alder carrs where forest phases regularly alternate with phases of herbaceous wetland vegetation (cf. POKORNÝ et al. 2000; STEGNER 2000).

5 Concluding remarks

The pollen diagram “Schönhagen 96/1” from the southeastern bay of the Blankensee covers the complete Weichselian Lateglacial, including its first vegetation phase that occurs in only few pollen diagrams from NE Germany. It shows the typical pollen sequence of central Brandenburg for the Lateglacial and Early Holocene.

The middle and late Holocene are badly represented in only few samples and with such overrepresentation of PINUS pollen that the typical pollen sequence of these time frames remains obscured.

The sediment sequence shows deposition of lake marl with a clastic component in the Early Lateglacial up to the late Lateglacial Betula/Pinus forest phase (“Allerød”), followed by the deposition of pure lake marl. A dark-coloured sediment was deposited in the beginning of the Holocene. Peat formation in the southeastern bay started in the Early Holocene Corylus phase (“Boreal”).

Acknowledgements

The “Brandenburgisches Landesamt für Denkmalpflege und Archäologisches Landesmuseum” gave access to the original data of Klaus Kloss and permitted publication; Susanne Jahns is kindly acknowledged for intermediation. Anja Prager corrected the German texts. Hans Joosten provided valuable comments on the manuscript.

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