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# Vegetation history and mire development in the northwestern part of the Dubringer Moor near Hoyerswerda (Sachsen, E Germany) inferred from a pollen diagram from the legacy of Klaus Kloss

Mit 6 Abbildungen

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## Kurzfassung

De Klerk, P. & Joosten, H.: Vegetationsgeschichte und Moorentwicklung im nordwestlichen Teil des Dubringer Moors bei Hoyerswerda (Sachsen, Ost-Deutschland) abgeleitet aus einem Pollendiagramm aus dem Nachlass von Klaus Kloss

Ein bisher unveröffentlichtes Pollendiagramm aus dem Nachlass von Klaus Kloss ermöglicht die Rekonstruktion der Vegetationsgeschichte und Moorentwicklung im nordwestlichen Teil des Dubringer Moores, einem der wichtigsten Moore des Bundeslandes Sachsen. Das Diagramm umfasst die letzte Phase des Weichselspätglazials sowie das gesamte Holozän, jedoch mit einem kleinen Hiatus. Pollentypen, die von Bäumen produziert werden, zeigen die Waldgeschichte auf den trockenen Böden um das Moor herum, sowie die Entwicklung von Bruchwäldern im Moor selbst. Pollentypen sonstiger Moorpflanzen zeugen von der Entwicklung einer lokalen Riedvegetation zu einem hochmoorähnlichen Habitat. Ein Vergleich mit weiteren Pollendiagrammen Nordost-Sachsens sowie Südost-Brandenburgs stellt die Daten in einen räumlichen Zusammenhang mit der regionalen Vegetationsgeschichte.

*Schlüsselwörter*: Dubringer Moor, Ost-Deutschland, Moorentwicklung/Moorökologie, Palynologie, Vegetationsgeschichte

## Abstract

A previously unpublished pollen diagram from the late Klaus Kloss allows the reconstruction of vegetation history and mire development in the northwestern part of the Dubringer Moor, one of the most important mires of the German Federal State Sachsen. The diagram covers the final time-frame of the Weichselian Lateglacial and the complete Holocene, however with a small hiatus. The pollen types produced by trees show the development of the forest vegetation on the dry grounds surrounding the basin as well as the development of carrs within the mire. The pollen types of wetland plants illustrate the development from a fen to a bog-like habitat. A comparison with other pollen diagrams from NE Sachsen and SE Brandenburg places the data within a spatial context.

*Keywords*: Dubringer Moor, E Germany, mire development/mire ecology, palynology, vegetation history

## 1 Introduction

One of the most important mires of the German Federal State Sachsen (Saxonia) is the Durbringer Moor (Dubring Mire) near Hoyerswerda (Fig. 1). The peatland has during the major part of the twentieth century been threatened by open-cast mining (Frenzel 1933, Fischer et al. 1982, Pietsch 1985, Karneth 1990, Kliemank 1992, Zscharnack 1992, Vogel 1998, 2008, Jorga 2000), which triggered scientific research before the area would be lost forever. Although the mire became a nature conservation area in 1972, which was expanded in 1981, it also became part of a priority area for mining in 1981. The threat by open cast mining did not disappear until the political changes in the German Democratic Republic in 1989/1990 (Zscharnack 1992, Vogel 1998).

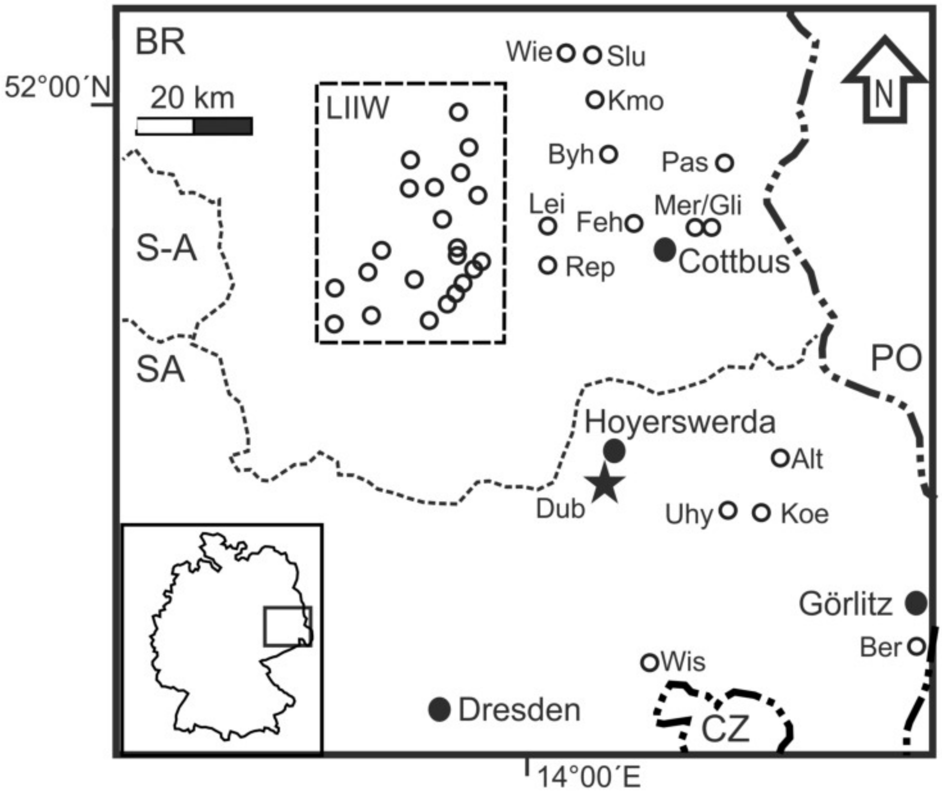


**Fig. 1:** Location of the Dubringer Moor near Hoyerswerda (Dub), and of other palynologically analysed sites in SE Brandenburg and NE Sachsen (selection). Alt: Altliebel (Warmbrunn 1999, Küster & Warmbrunn 2000) and Großteich Altliebel/Reichwalde (Friedrich et al. 2001); Ber: Moor bei Berzdorf (Müller 1968); Byh: Byhleguhrer Bagen (Strahl 2005); Feh: Fehrow (Brande et al. 2007); Gli: dune near Groß Lieskow (Bittmann & Pasda 1999); Kmo: Kleiner Mochowsee (Jahns 1999); Koe: Klein Oelsa (Warmbrunn 1999, Küster & Warmbrunn 2000); Lei: Leipe (Brande et al. 2007); Mer: Merzdorf 31 (Jahns 2004), and Merzdorf 31 profiles 1-5 (Poppschötz & Strahl 2004); LIIW: area with in total 22 palynologically analysed sites (Lange et al. 1978); Pas: Pastlingsee (Jahns et al. 2013); Rep: CRep 89/2 (De Klerk 2004a); Slu: Sawallschen Luch (Strahl 2013); Uhy: Uhyst CUh 86/1 (Kloss 1991; De Klerk 2005a); Wie: Wiese (Illig & Lange 1992); Wis: Wiesen (Müller 1968). BR: Federal state Brandenburg; S.-A.: Federal state Sachsen-Anhalt; SA: Federal State Sachsen; PO: Poland; CZ: Czech Republic.

Results of scientific studies on vegetation, animal life, and natural and cultural history of the area were presented by Pietsch (1985, 1990), Succow (1988, 2001), Engelmann (1990), Karneth (1990), Neumann (1990), Zschieschang & Dunger (1990), Vogel (1998, 2008), Dilger (2004), Edom & Wendel (2008) and Lehmitz (2014). Furthermore, a large amount of unpublished reports exist (cf. Vogel 1998).

Palynological studies in the area were carried out by Frenzel (1930, 1933, using the name Neudorfer Moor), and by Seifert (1995) (cf. Fig. 2). Pollen analyses by Klaus Kloss in the early 1980ies were reported in a brief paper (Kloss 1990), but without presenting the pollen diagram. The pollen counts of Kloss from the Dubringer Moor were recently digitalised as part of a project to make unpublished palynological data from eastern Germany available to the scientific community (e.g. De Klerk 2004a/b, 2005, 2007, 2011/2012).

This paper presents and interprets the pollen diagram CDu 82/1 within the context of mire development.

## 2 Study area

The Dubringer Moor (Fig. 2) is positioned along the slope of the Lausitzer Urstromtal (currently occupied by the Schwarze Elster River) and has a surface elevation falling from around 135 m asl. to 119 m asl. (Figs. 3–5). Lignite occurs already at a shallow depth of 5–20 m (Frenzel 1933, Neumann 1990), and its contraction resulted in the formation of several channel-like basins (Vogel 1998, Succow 2001; cf. Figs. 3–5) where peat formation began (Frenzel 1933, Pietsch 1985, Vogel 2008).

The mire is surrounded by Saalian terminal moraines in the south, west and north, with an opening to the east. The northwestern upslope part of the mire complex consists of extensive birch carrs and bog-like patches (Fig. 2). This part of the mire is fed by groundwater discharging from the sandy moraines. Vogel (2008) classifies the Dubringer Moor as a percolation mire, whereas Succow (1988, 2001) describes it as a sequence of several slope-parallel percolation mires. Kloss (1990) discusses the possible classification as a sloping mire on the basis of vegetation, trophy and position in the landscape. In reality, the large mire complex will consist of several hydrogenetic mire types that laterally grade into one another (Edom & Wendel 2008).

A cross-section through the highest westernmost mire area by Succow (1981, 1988, 2001; Fig. 4) displays peat directly overlying the mineral subsoil. The basal layers of *Phragmites* peat grade into *Phragmites*/sedge and sedge/*Phragmites* peat, which is covered by *Sphagnum* peat, *Sphagnum/Eriophorum* peat and *Sphagnum*/sedge peat. *Pinus* wood peat and *Sphagnum/Scheuchzeria* peat occur in the left part of the cross-section. Although this wood peat indicates prominent presence of *Pinus* in the mire in the past (cf. Succow 1988), at present only few pine carrs occur (Fig. 2). Figure 3 also displays a basal layer of peaty gyttja along the slope, which seems unlikely and may represent strongly humified peat that developed a gyttja-like matrix.

The exact position of the analysed section CDu 82/1 is unclear. Kloss (1990) describes the location as the southeastern part of “Abteilung 313” at the margins of a large peat pit. According to the indication in his cross-section (Fig. 5) the profile was taken at ca. 350–375 m from the highest peatland edge, which corresponds to the uppermost channel-like basin. As the area where peat thickness exceeds 3 m is limited (Fig. 2), the approximate position could be estimated with great likelihood (Figs. 2, 3).

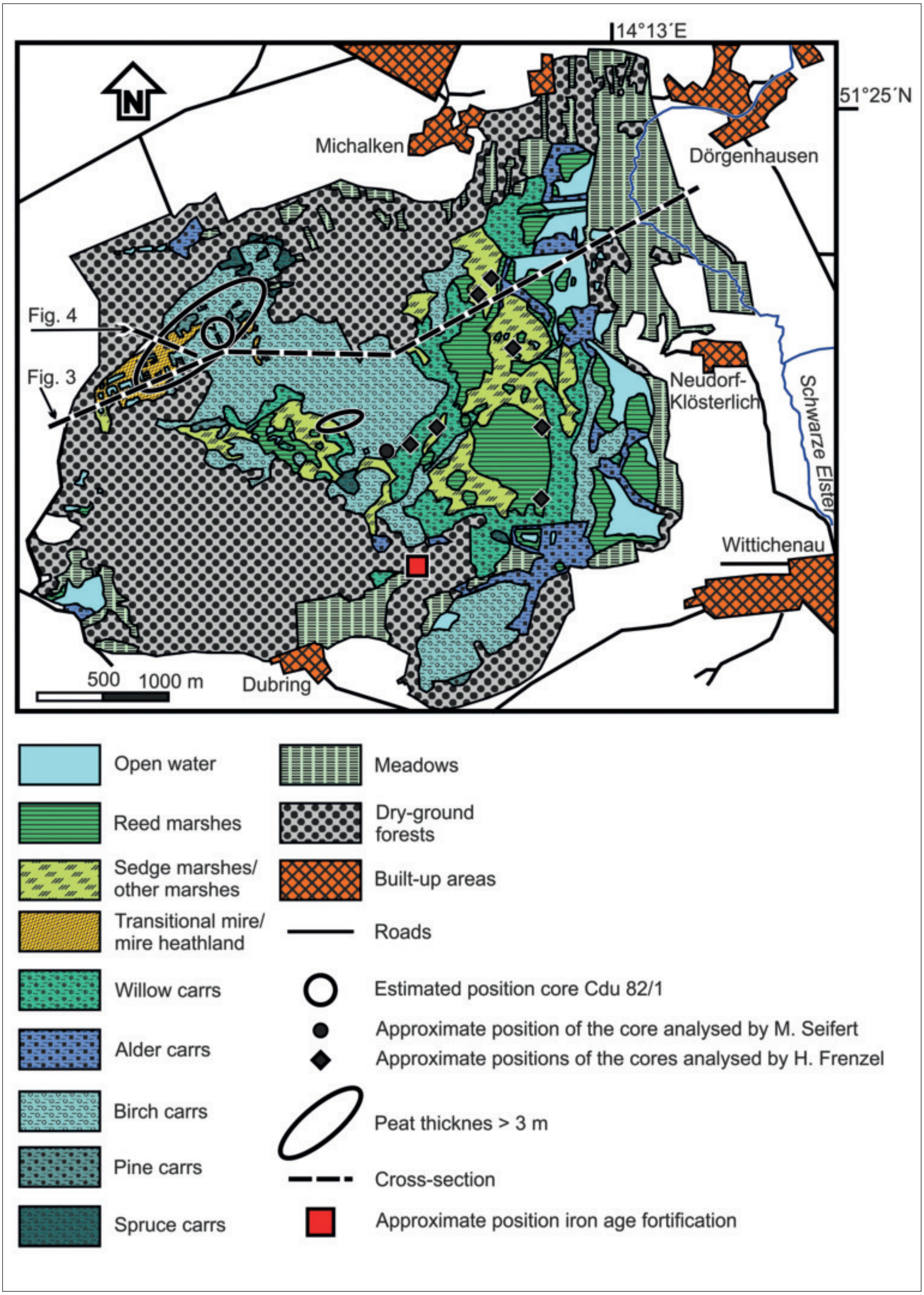


**Fig. 2:** Map of the Dubringer Moor area, modified after VOGEL (1998).

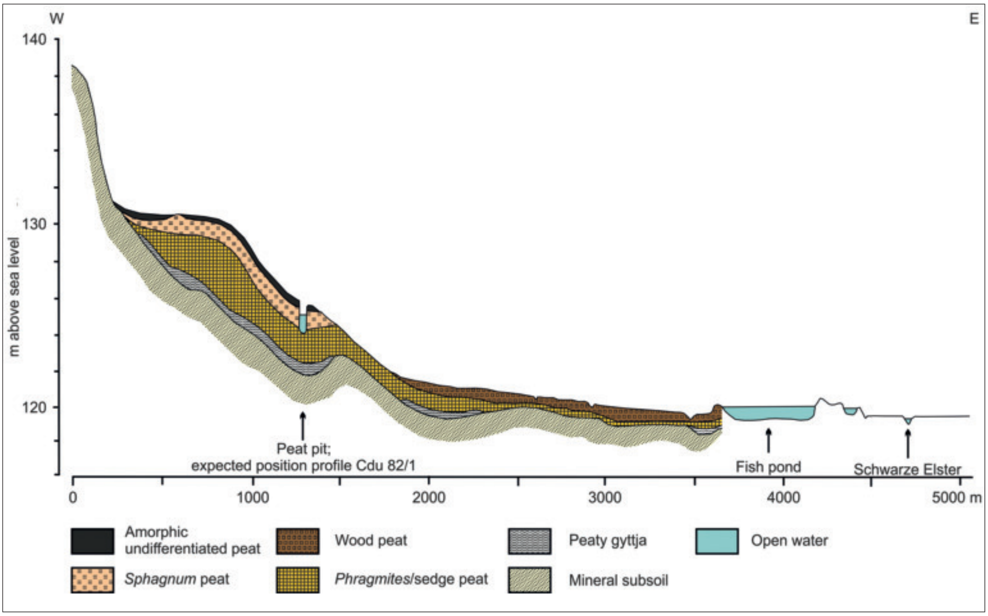


**Fig 3:** Cross-section through the complete Dubringer Moor (for location see Fig. 2), modified after Vogel (1998).

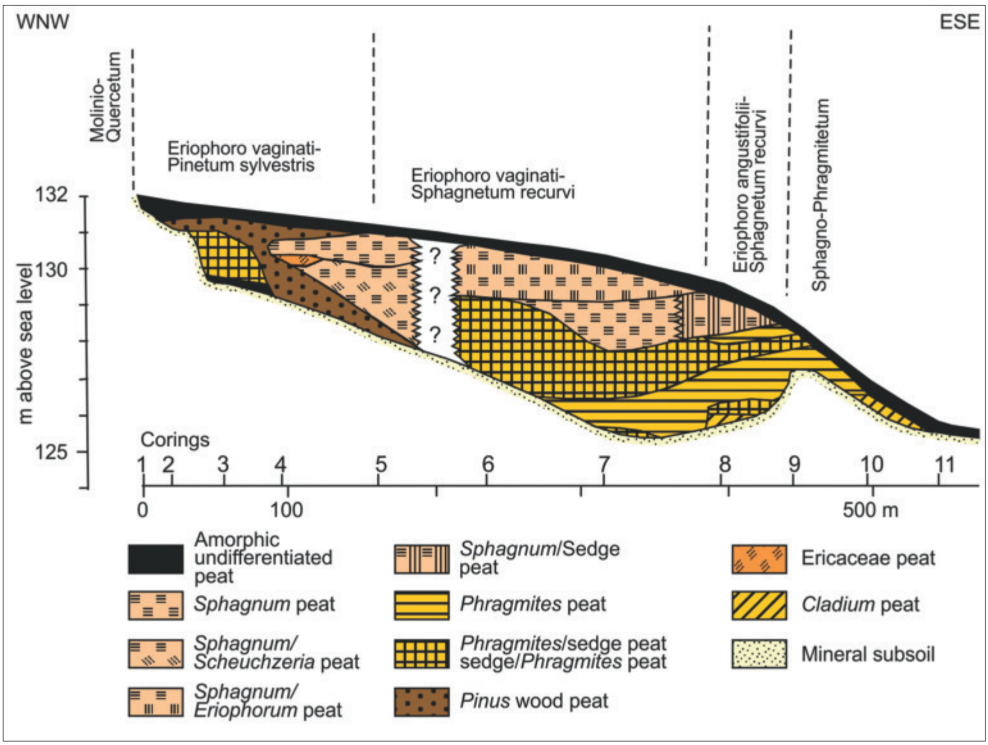


**Fig 4:** Cross-section through the northwestern part of the Dubringer Moor (for location see Fig. 2), constructed after core descriptions in Succow (1981). The cross-section deviates from the stylised version presented by Succow (1988, 2001). Vegetation types are those of peat remnants between peat extraction pits.

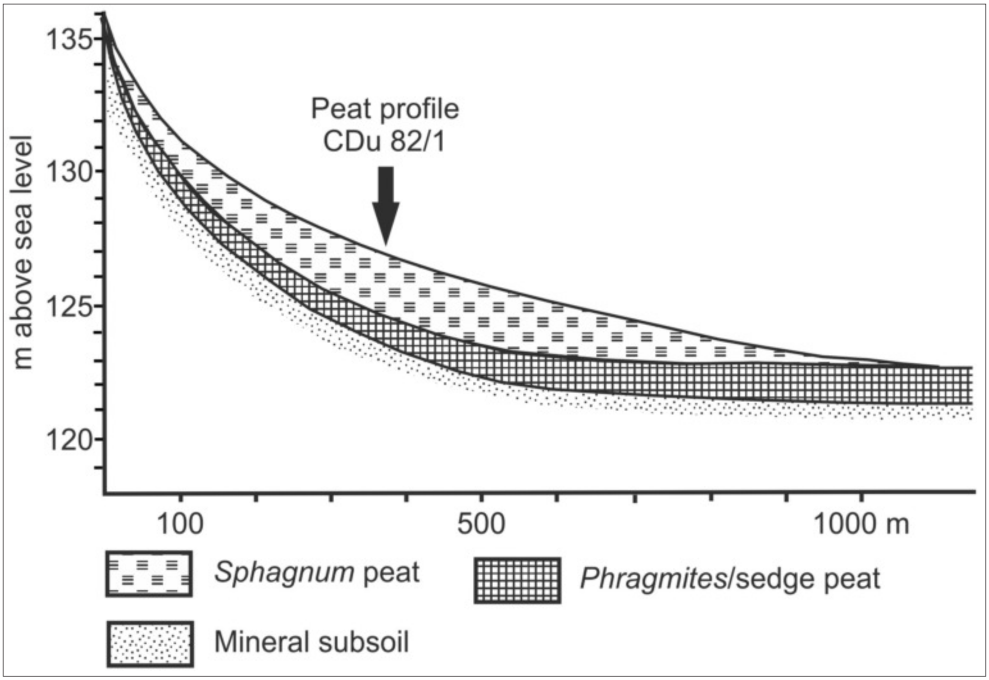


**Fig 5:** Cross-section through the northwestern part of the Dubringer Moor (precise location unknown), modified after Kloss (1990).

In contrast to the northwestern mire part, the eastern lower areas of the Dubringer Moor contain extensive reeds, marshes and willow carrs (Fig. 2; cf. Frenzel 1933, Fischer et al. 1982, Neumann 1990, Kloss 1990). Here, a gyttja layer underlies sedge peat ("riedtorf"), which shows that open water has terrestrialised to form a fen (Frenzel 1933, Neumann 1990, Seifert 1995). Coarse pollen diagrams display mire development starting at the end of the Weichselian Lateglacial or the beginning of the Holocene (Frenzel 1933, cf. Fig. 2; who only presents pollen diagrams from five of seven analysed sections). The Frenzel diagrams have a rather large sample interval and have because of the limited amount of pollen types displayed an only restricted palaeological significance. The pollen diagram by Seifert (1995) shows a well-developed Lateglacial aquatic setting, but the Holocene peat layer includes at least two hiatuses. Whereas at present birch and willow carrs surround her analysed section, high values of pollen attributable to *Alnus* reveal that in the past alder carrs must have been present as well.

The Dubringer Moor has been excessively used by humans. An important archaeological monument is a ca. 2500 year old Iron Age fortification directly south of the mire (Karneth 1990, Wetzel 1992, Heinrich 2014; cf. Fig. 2). Of more recent date are numerous ditches aimed to drain the mire (Kloss 1990, Vogel 1998, 2008), whereas also several water mills around the peatland will have affected mire hydrology (Karneth 1990, Vogel 1998, Heinrich 2014). Furthermore, peat extraction has been prominent (Fischer et al. 1982, Karneth 1990, Kloss 1990, Kliemank 1992, Zscharnack 1992, Vogel 1998, 2008), and many small patches of open water in the northwestern area are former peat pits (cf. Fig. 2). The various large ponds in the east are fish farms from nearby monasteries, which were initiated during the 16th and 17th centuries (Karneth 1990, Zscharnack 1992, Vogel 1998, 2008). At present extensive reed marshes occur along the pond margins (Fig. 2). Especially along the outermost parts of the Dubringer Moor meadows are found (Fig. 2; cf. Karneth 1990).

## 3 Methods

The analysed section was sampled from an exposed peat profile (Kloss 1990). Pollen sample preparation included treatment with KOH, gravity separation with $ZnCl_2$, and acetolysis (S. Jahns pers. com. July 2004). Kloss (1989) provides further information on his palynological methods.

For revision of the data, the original pollen counting lists were used. Sample depths of Kloss cover a depth range, of which we used the central value i.e. sample 11–13 is now named sample 12.

In order to differentiate clearly between pollen types and plant taxa, the former are displayed in small capitals (cf. Joosten & De Klerk 2002). Pollen type nomenclature does not follow the original pollen type names of the counting lists, but adopts the nomenclature as generally followed by Kloss in his publications (e.g. Kloss 1991, 1993, 1994), but translating some German terms into English (e.g. Getreide = Cerealia; Krautige = undiff.; Typ = type). As the publications of Kloss do not present a standardized pollen type nomenclature (e.g. by using different kind of abbreviations), the pollen type names used in this paper are a practical attempt to present pollen data without the pretention of referring to morphologically unambiguously defined morphotypes. The counting lists included pollen types named Campanula and Campanulaceae which were summed as Campanula(ceae). The counted values of Urtica(les) were mostly additionally marked h or u, indicating Humulus and Urtica respectively (S. Jahns pers. com. June 2004).

Pollen frequencies are calculated relative to a pollen sum including types attributable to trees and shrubs (AP) and dry ground herbaceous taxa (NAP). Whereas ideally a pollen sum should only include pollen types that originate from plants growing outside the mire in order to avoid disturbing (extra)local effects (sensu Janssen 1973), selecting such pollen sum is somewhat complicated for the Dubringer Moor as the mire contained and contains extensive wetland forests of pine, birch, spruce, willow and alder. Since the analysed section does not include wood peat (Figs 2, 6), these taxa were obviously not present directly around the sampled spot, and their pollen types were therefore included in the pollen sum.

The NAP values are an indication of the openness of the dry ground vegetation (with a mathematical uncertainty because of inclusion of wetland tree pollen types in the sum). Pollen types that might originate from both dry ground herbs and wetland herbs (e.g. Poaceae and Cyperaceae) were excluded from the NAP. Cerealia, including pollen grains attributable to cereals, was included in the sum, whereas Cerealia-like and Cerealia-type were excluded since these types may also include grains of wild grasses (cf. De Klerk in press-a).

Pollen percentages in the diagram (Fig. 6) 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 Site Pollen Zones (SPZ's; cf. De Klerk 2002) that are a combination of informal acme zones and informal interval zones sensu Hedberg (1976) and Salvador (1994). The lithology in Fig. 6 is based on original field notes.

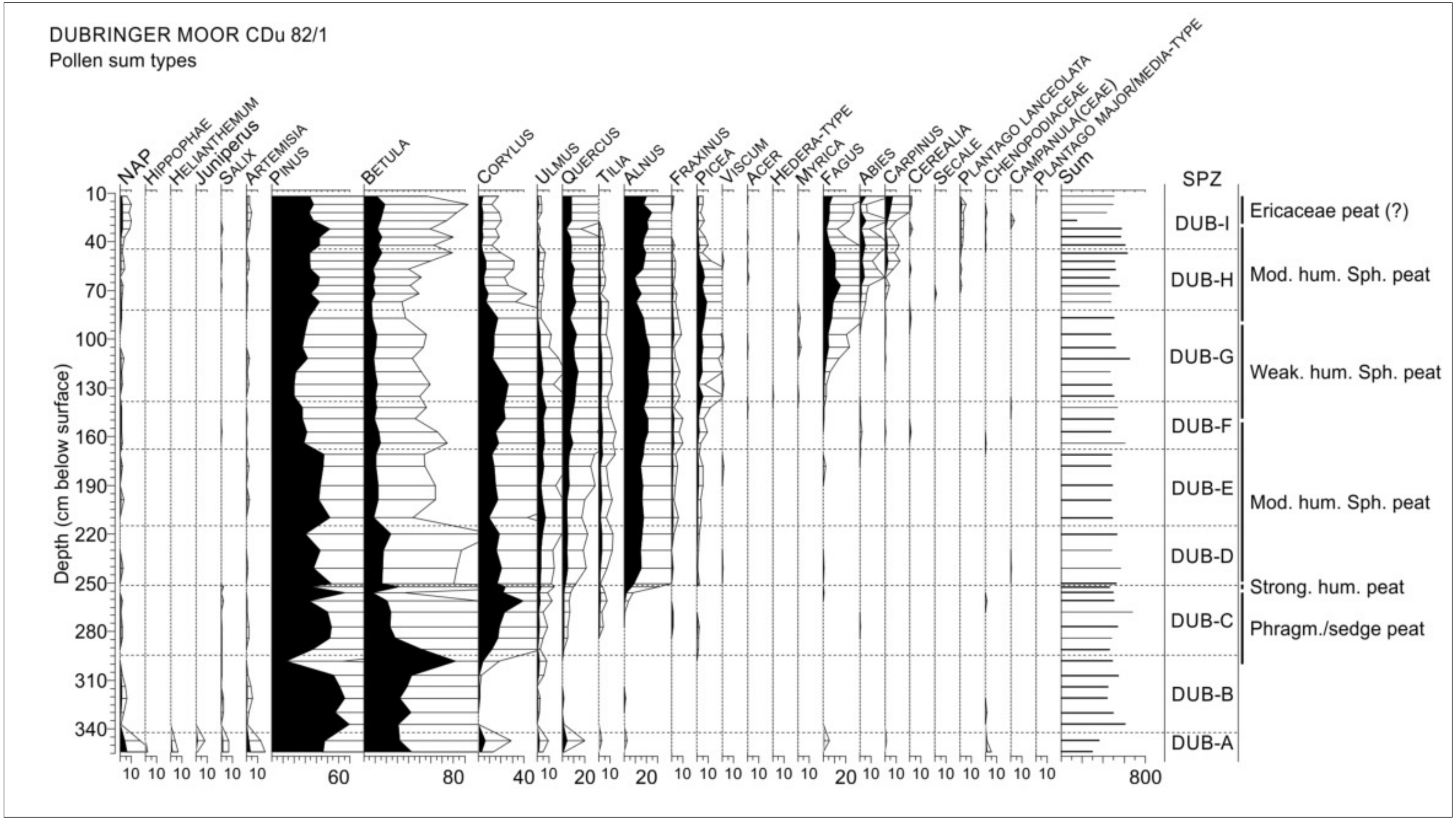


**Fig 6a:** Pollen diagram CDu 82/1. Analysis: KLAUS KLOSS, diagram construction: PIM DE KLERK. Pollen sum includes pollen types produced by trees (AP) and pollen types produced by plants of dry grounds (NAP). Pollen curves are displayed with actual values (silhouettes) and a 5-time exaggeration (open curves with depth bars). The lithological description of the section is based on the original field notes by KLAUS KLOSS.

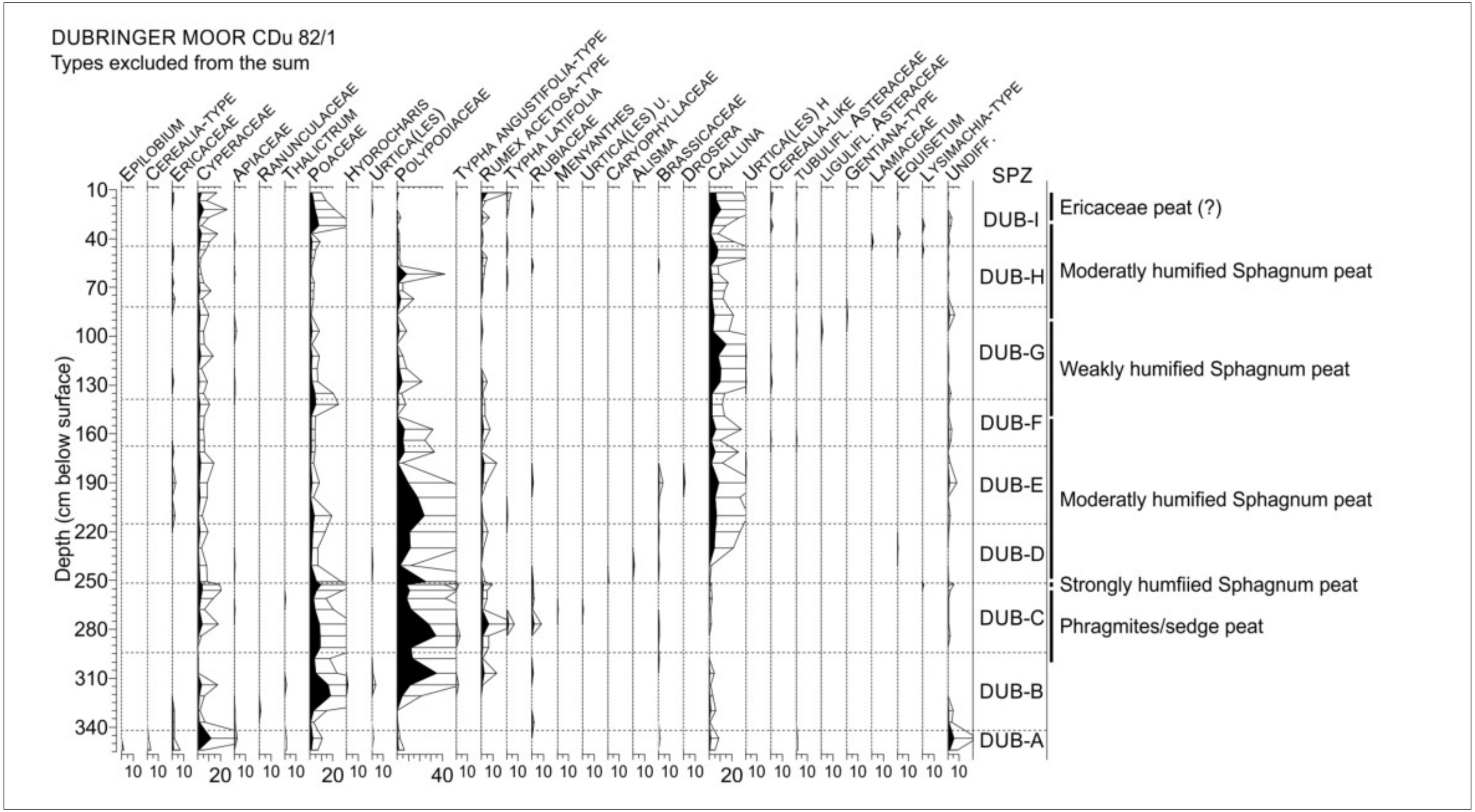


**Fig 6b: Continued**

## 4 Interpretation of the pollen diagram (Fig. 6)

SPZ's DUB-A: Weichselian Lateglacial (342.0–354.0 cm depth)

The lowest pollen zone is characterised by high NAP-values (compared to the overlying zones), especially of Helianthemum, Artemisia, and Chenopodiaceae pollen, and of Juniperus and Salix pollen. These pollen types are typical for the Weichselian Lateglacial, and zone DUB-A is therefore tentatively correlated with the Younger Dryas (or more appropriately named Late Dryas). Presence of pollen types attributable to thermophilous deciduous trees, i.e. Corylus, Ulmus, Quercus, Tilia, Fagus, and Carpinus, results probably from erosional redeposition (cf. Iversen 1936, Joosten & De Klerk 2002): the Saalian glaciers built their moraines from deposits that were originally formed during the Tertiary.

Nothing can be said about the local wetland vegetation at that time, since none of the pollen types attributable to wetland plants show values that are high enough to be unambiguously interpreted as originating from sources directly around the sampled spot.

The original field notes of section CDu 82/1 do not provide information on the type of deposits corresponding to this pollen zone, but Kloss (1990) mentions that the lowest samples originate from the mineral subsoil underlying the peat.

SPZ DUB-B: early Holocene (294.5–342.0 cm depth)

SPZ DUB-B contains high values of Betula and Pinus pollen, whereas NAP values decrease at the lower zone boundary. This zone is correlated with the beginning of the Holocene during which forests of birch and pine dominated the dry grounds. The basal pine wood peat in Fig. 4 (cores 4 and 5) indicates that the pine pollen signal may also originate from pine stands in the mire. However, it is not certain that the formation of pine wood at these cores is synchronous with the time-frame recorded in zone DUB-B.

The conspicuous higher values of Ulmus pollen in the top two samples suggest that elm was already expanding in the regional vegetation, which is in good accordance with Ulmus curves in some other pollen diagrams from SE Brandenburg and NE Sachsen, including sites Alt (Warmbrunn 1999, Küster & Warmbrunn 2000, Friedrich et al. 2001) and Mer (Jahns 2004, Poppschötz & Strahl 2004) (cf. Fig. 1).

Slightly higher values of Artemisia pollen in the central part of the zone (samples 321/314) indicate a slight opening of the vegetation on the dry grounds and might correspond to the minor open vegetation phase commonly known as Rammelbeek, Piottino, or Preboreal Oscillation (cf. Behre 1966, 1967, 1978, Van Geel et al. 1981, Björck et al. 1996, 1997). This phase is generally not inferable from pollen diagrams from eastern Germany (cf. De Klerk 2002, Jahns 2004, Theuerkauf et al. 2014), but it is also visible by increased NAP values in two other pollen diagrams of Kloss (De Klerk 2004b, 2005), of which one is positioned around 20 km east of the Dubringer Moor (site Uhy in Fig. 1). The phase may also be reflected in the diagram Altliebel 1 (site Alt) by Warmbrunn (1999) and Küster & Warmbrunn (2000), but cannot be unambiguously identified. Bittmann & Pasda (1999) discuss the possibility that a peak of Betula pollen in their diagram (site Gli in Fig. 1) represents changes in birch population during the short phase, i.e. a change in the tree vegetation may have occurred without resulting in an opening-up of the forests. However, the relevant peak in the Gli diagram is only minor, and may be the result of natural forest dynamics independent of climate. Other diagrams from the region, e.g. CDu 82/1 (this paper), Alt (Warmbrunn 1999, Küster & Warmbrunn 2000, Friedrich et al. 2001), Koe (Warmbrunn 1999, Küster

& Warmbrunn 2000), Slu (Strahl 2013), Wie (Illig & Lange 1992), and some of the diagrams from the LIIW-area (Lange et al. 1978) (cf. Fig. 1) display changes in the relative values of Betula pollen that from a palynostratigraphic viewpoint cannot be synchronous with the peak in the Gli-diagram. Some other diagrams, however, do display minor Betula peaks that tentatively may be synchronous with that of the Gli diagram, e.g. Byh (Strahl 2005), Feh (Brande et al. 2007), Kmo (Jahns 1999), Rep (De Klerk 2004a), and Mer (Poppschütz & Strahl 2004) - but note that the Merzdorf 31 diagram of Jahns (2004) displays three Betula peaks in the relevant pollen diagram section. Further research is necessary to get more insights in the significance of pollen fluctuations during the Early Holocene in eastern Germany.

The lithology of SPZ DUB-B is unknown, but since Kloss (1990) describes that the sampled location contained ca. 1 m of *Phragmites*/sedge peat, it can be assumed that this peat reached back to the base of this pollen zone. Peat formation started probably in the form of spring mires at places of groundwater outflow, e.g. at the globular shaped *Phragmites*/sedge peat around cores 6 and 7 in Fig. 4. A spring mire has probably also been present around core 3 of Fig. 4, but this may also have been later after the lower spring mire deposits had forced the groundwater to discharge at a higher elevation (cf. Schult 2003).

The peak values of Poaceae pollen in the central part of zone DUB-B most likely originate from local *Phragmites* populations. Since the peak occurs simultaneous with the slightly higher values of Artemisia pollen, however, the possibility cannot be ruled-out that an expansion of grasses in the open dry vegetation also contributed to higher Poaceae pollen values.

Simultaneous peaks of Polypodiaceae and Rumex acetosa-type in the upper part of the pollen zone indicate expansion of ferns (probably *Thelyptris palustris*) and *Rumex* species in the wetland vegetation. The values of Rumex acetosa-type are so low that a regional dry ground origin cannot be ruled out.

SPZ DUB-C: Corylus phase of the Early Holocene (251.5–294.5 cm depth)

Pollen zone DUB-C is characterised by gradually increasing values of Corylus pollen reaching a peak in sample 261. Also values of Ulmus and Quercus pollen increase, although less prominently. A closed curve of Tilia pollen starts in sample 277, and of Alnus pollen in sample 268.

This sequence shows a marked expansion of hazel, whereas oak, lime and alder immigrated into the region but had not established themselves firmly. The Early Holocene rise in Corylus pollen was radiocarbon-dated in the Cottbus area 9041±45 $^{14}$C-years B.P. (Jahns 2004: site MER in Fig. 1), which corresponds to ca. 10200 calendar years B.P.

SPZ DUB-C corresponds entirely with *Phragmites*/sedge peat, indicating continuous presence of reed marshes at the sampled spot. Values of Poaceae and Cyperaceae pollen are, however, rather low, although higher than in the overlying pollen zones. Since Cyperaceae species mainly flower under stress situations (cf. Segerström & Emanuelsson 2002), these low values indicate stable habitat conditions, typical for percolation mires. High amounts of Polypodiaceae spores show that ferns remained present in the wetland vegetation. A peak of Rumex acetosa-type pollen accompanied by small peaks of Typha latifolia and Rubiaceae pollen in sample 277 indicate the presence of *Rumex, Typha latifolia* and *Galium* in the mire.

The Pinus pollen probably reflects both forest pines on dry mineral grounds, pine stands along the mire margins (cf. Fig. 4), and pines on hummocks in the centre of mire alternating with peatforming *Sphagnum*/*Scheuchzeria* vegetation (cf. Fig. 4), which is typical for acid and wet conditions. The older water discharging around cores 6 and 7 (Fig. 4) probably had a higher $CaCO_3$ content, which led to the development of a reed vegetation downstream of its outflow, whereas between cores 3 and 5 a more acid *Sphagnum*/*Scheuchzeria* vegetation thrived. However, synchronity of these peat layers with zone DUB-C is uncertain.

Transition between zones DUB-C and DUB-D (251.5 cm depth)

The top of the peat corresponding with SPZ DUB-C consists of strongly humified peat indicating a marked decrease in peat accumulation rate. The sharp changes in the curves of e.g. Corylus, Fraxinus, Picea, Poaceae and Polypodiaceae pollen and spores point to a hiatus. Comparison with the pollen records from sites Byh (Strahl 2005), Kmo (Jahns 1999), Lei (Brande et al. 2007), Mer (Jahns 2004), Pas (Jahns et al. 2013), Slu (Strahl 2013) and Wie (Illig & Lange 1992) (cf. Fig. 1) shows that this hiatus only covers a short time period. The hiatus reflects drier conditions and a stop of peat accumulation, possibly as a result of a drier climate at the end of the Corylus phase. The pollen diagram of Seifert (1995), however, displays two prominent hiatuses in this time frame, which are clearly asynchronous with that of the Kloss-diagram, illustrating that mire hydrology in the large Dubringer Moor must have been rather complex and resulted in interruptions in peat accumulation at different spots at different times.

SPZ's DUB-D, -E and -F: the middle Holocene (138.5–251.5 cm depth)

SPZ DUB-D starts with increasing values of Alnus, Fraxinus and Picea pollen. An increase in the values of Alnus pollen was dated at 8299±51 $^{14}$C-years B.P. in the Cottbus area by Jahns (2004, site Mer in Fig. 1), i.e. approximately 9350 calendar years B.P. Because of the hiatus discussed above, the lower boundary of SPZ DUB-D may actually date somewhat younger.

SPZ-DUB-E is characterized by decreased values of Betula and Corylus, and DUB-F by higher values of Fraxinus and Picea whereas values of Corylus gradually increase in the latter zone.

In the time reflected by these pollen zones, deciduous forests dominated the dry grounds surrounding the peatland. Pollen attributable to spruce and pine originate probably partly also from tree populations within the Dubringer Moor, as will the stable and hardly changing values of Alnus pollen. Extensive alder carrs in the lower eastern mire areas are represented by very high Alnus values in the pollen diagrams of Frenzel (1933) and Seifert (1995).

The base of SPZ DUB-D corresponds with the base of the layer of *Sphagnum* peat in the section analysed by Kloss, which shows that around or after 9350 calendar years B.P. moister conditions developed and peat accumulation reinitiated. The *Sphagnum* and *Sphagnum*/*Eriophorum* vegetations (cf. Fig. 4) were – next to by rainwater – probably also fed by groundwater. This groundwater must, in contrast to the earlier discharging, have been less calcareous, and more nutrient-poor and acid, possibly because carbonates had already fully leached out from the groundwater recharge area, or because of a change of recharge area. Anyhow, after 9350 calendar years B.P. *Sphagnum* peat started to cover the *Phragmites*/sedge and sedge/*Phragmites* peat deposits in the channel-like basin.

Conspicuously, no Sphagnum spores were noted by Kloss. Although peatmoss populations may be extremely stable and hardly sporulating over longer time (cf. Hölzer & Hölzer 1995; Hölzer 2010; De Klerk in press-b), zero regional deposition of Sphagnum over such a long time is unimaginable in the Dubringer Moor region, so we assume that Kloss for one reason or another refrained from noting Sphagnum spores.

Increased values of Calluna pollen in the upper part of SPZ DUB-D and in DUB-E show that *Calluna* occurred in the peatland vegetation, whereas the relatively high values of Polypodiaceae spores up to the mid of pollen zone DUB-E demonstrate ongoing presence of ferns. *Thelypteris* might have remained initially present in the hollows within the peatland while gradually drier and more acid hummocks developed. However, also more acid ferns like *Dryopteris* might have been responsible for the Polypodiaceae spore signal.

SPZ DUB-G: after the elm-decline (82.0–138.5 cm depth)

The boundary between zones DUB-F and DUB-G is marked by a decline in values of Ulmus pollen, which is correlated with the mid-Holocene elm decline of ca. 5000 $^{14}$C-years B.P. (i.e. around 5750 cal yr BP) (cf. Birks & Birks 1980, Parker et al. 2002, Clark & Edwards 2004). Within zone DUB-G, values of Fagus pollen gradually increase, indicating an expansion of beech in the regional vegetation. This zone corresponds to the Neolithic, the Bronze Age and the Pre-Roman Iron Age. Although the presence of humans in the region during the Iron Age is demonstrated by the fortification directly south of the Dubringer Moor (Fig. 2), the pollen diagram does not reflect prominent human activities.

The local peatland vegetation continued to be dominated by *Sphagnum* and *Calluna*, as is indicated by the peat composition of the analysed section and the high values of Calluna pollen (compared to the other pollen zones) up to sample 105. Other information on the wetland vegetation cannot be deduced from the pollen diagram since observed pollen types occur with too low values to infer local or only regional origin. The sporadic Rumex acetosa-type pollen indicates that a diminishing occurrence of *Rumex* as a natural fen species may not have been compensated by its expansion on anthropogenic meadows.

SPZ DUB-H: Roman period and early Medieval (44.5–82.0 cm depth)

The lower boundary of pollen zone DUB-H is defined by a marked decrease in Corylus pollen. Values of Abies pollen increase gradually. Fagus pollen values rise towards a peak in sample 67, after which they decline towards the top of the zone. Carpinus pollen values increase in the upper part of the zone. This zone is interpreted to represent the Roman Period and Early Medieval, during which beech, fir and hornbeam were important members in the regional vegetation.

The pollen types excluded from the sum provide only limited information on the wetland vegetation. The decreased values of Calluna pollen compared to the underlying zone may indicate a decline of *Calluna* populations or a reduced flowering possibly as a result of locally wetter conditions, whereas an increase of Calluna pollen in the top of the zone point to a return to drier conditions. The ongoing formation of *Sphagnum* peat shows that *Sphagnum* remained the dominant peatforming taxon on the sample spot.

SPZ DUB-I: The Late and post Medieval (10.0–44.5 cm depth)

The top pollen zone DUB-I is distinguished from the underlying zone by lower values of Fagus and higher values of Plantago lanceolata and Chenopodiaceae pollen than in zone DUB-H. Cerealia pollen occurs more frequently than previously, and Artemisia values rise in sample 37. This zone is therefore correlated with the period starting in the Late Medieval after beech populations declined and agriculture intensified. However, the pollen values of NAP types are rather low in comparison with other pollen diagrams from the region, including e.g. sites Ber and Wis (Müller (1968), Koe (Warmbrunn 1999, Küster & Warmbrunn (2000), and some of the diagrams from the LIIW-area (Lange et al. 1978) (cf. Fig. 1), which means that human impact was either less intensive around the Dubringer Moor than around other sites (cf. the large expanse of current pine forests on infertile land, Fig. 2), or that the NAP values are proportionally supressed because the large and expanding wetland forests of birch or pine in the northwestern part of the mire (and elsewhere in the region) may have led to an increase of these tree pollen types in the regional deposition. Values of Corylus, Ulmus, Fraxinus, Picea and Tilia pollen decrease asynchronously in the upper part of zone DUB-H and the lower part of DUB-I, showing that hazel, elm, ash, spruce, and lime lost importance in the region, although these percentage values may also reflect a mere proportional decrease.

The types excluded from the sum do not give much indication on local wetland vegetation. Increased values of Poaceae and Rumex acetosa-type pollen in the middle and upper part of the zone may indicate increased importance of grasses and *Rumex* in the mire, but may also relate to an increased importance of relevant plant taxa in the cultivated regional landscape. There is a lithological transition from *Sphagnum* peat to Ericaceae peat in the middle part of the zone, although this later peat is marked with a question mark in the field notes. The prevalence of “amorphic” (= strongly humified) peat in the peat stratigraphy (Figs. 3 and 4) may explain this question mark.

## 5 Concluding remarks

The Dubringer Moor is an important and diverse mire complex. The comparison of the pollen diagram CDu 82/1 with a lithological cross-section from the northwestern part of the peatland provides insights in the vegetation history and peat formation processes of these high-lying mire parts. In this way the pollen diagram of Klaus Kloss contributes greatly to a better understanding of a part of the large and complex mire. The pollen diagrams presented by Frenzel (1933) and Seifert (1995) show that peatland development in the lower parts considerably differed from that of the upslope parts. A thorough and spatially-based palaeoecological research of the mire may be a great challenge for future scientific.

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