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QUATERNARY PALAEOBOTANICAL EVOLUTION OF NORTHERN BELGIUM

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(3 figures and 1 table)

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ABSTRACT. The palaeobotanical data set of northern Belgium has to be divided into two parts: a post-glacial part including the Lateglacial and the Holocene period, and a Pleistocene part including the entire period between the beginning of the Quaternary and the end of the Weichselian glacial. A continuous and sufficiently documented record is present for the post-glacial period. As a standarised summary has been published recently (Verbruggen *et al.*, 1996), this period is not discussed systematically. This paper focusses on the Pleistocene part of the data. The main problem about this data is the fact that most of it is unpublished. By incorporating the unpublished data and confronting them with the present-day theories from the neighbouring countries, it became possible to present an overview of the Pleistocene palaeobotany of northern Belgium. Interesting new data are added for the Saalian-, Eemian- and Early-Weichselian period.

KEYWORDS: northern Belgium, Pleistocene and post-glacial stratigraphy, palaeobotanical dataset, palaeoecology.

SAMENVATTING. In zijn geheel genomen is het gegevensbestand van de paleobotanie in Laag- en Midden- België als eerder beperkt te beschouwen. Voor de postglaciale periode (= Laatglaciaal en Holoceen) zijn er voldoende gegevens die toelaten een continu verloop van de botanische en paleoecologische evolutie op te stellen. Een dergelijk overzicht (Verbruggen *et al.*, 1996) is recentelijk gepubliceerd voor Zandig-Vlaanderen, in het kader van een zeer uitgebreid overzicht van type gebieden in geheel Europa. Aangezien dit overzicht ook een vergelijking maakt met de andere gebieden van Noord-België kan het als een samenvatting voor het gehele gebied gelden. Wegens het bestaan van dit overzicht wordt de postglaciale periode hier niet opnieuw systematisch en uitgebreid besproken. Dit wordt wel voor het gehele Pleistocene gedeelte vóór het Postglaciaal gedaan. Het gegevensbestand voor deze periode dient echter als zeer beperkt te worden beschouwd. Hiervoor zijn zowel geografische als structureel wetenschappelijke oorzaken in te roepen. Verder is een belangrijk deel van de gegevens ongepubliceerd. In deze studie zijn ongepubliceerde gegevens verwerkt en is getracht het volledige gegevensbestand in de context van de actuele kennis in West Europa te plaatsen.

SLEUTELWOORDEN: Laag en Midden België, Pleistocene en postglaciale stratigrafie, paleobotanisch gegevensbestand, paleoecologie.

1. Introduction

From a geomorphological point of view, northern Belgium is mainly in an erosional position since the retreat of the Tertiary and Early Pleistocene seas. Only in the northwestern part, the surface lies several metres below the present-day sea level, so that accumulation became possible in this zone at least since the Elsterian period.

Summarizing for northern Belgium, Quaternary sediments of the Tiglian and Holsteinian period have been found.

For the post-Pleistocene period, referred to as Lateglacial and Holocene in this paper, a systematic summary of the palaeobotanical and palaeoecological evolution of northern Belgium was made (Verbruggen *et al.*, 1996), dealing with the investigation results until 1989. In the present paper, these results will be updated with results of posterior investigation. More details have been obtained specifically about the palaeoecological evolution of the Lateglacial and about the archaeobotanical aspects of the Holocene.

The palaeobotanical data set of the Quaternary of northern Belgium is restricted compared to this of the neighbouring countries. This can been explained by the number of active palaeobotanists which for the study area never exceeded two or three researchers during the last 30 years.

The objective of this paper is to present the investigation results since the beginning of palaeobotanical research in northern Belgium. A large amount of data is still unpublished, but we consider it as a necessity, and at the same time as an opportunity, to present them. In the context of this "new " data, the previous data is discussed and a possible repositioning of the strata is proposed.

The sites discussed in the text are shown on Fig. 1. This map shows the approximate limits of the deeper incised zones into the Tertiary subsoil, as well as the Belgian palaeoecological type regions like they were recognized in the above mentioned paper (Verbruggen *et al.*, 1996). Fig. 2 shows a generalized chronostratigraphical scheme, mentioning all the sites discussed in this paper.

2. Lower Pleistocene

In the northeastern part of northern Belgium, Lower Pleistocene sandy clay deposits occur, which have tend to the formation of the Kempen microcuesta. Predominantly the steep (southern) front of this cuesta is exploited intensively in brickyards, revealing many exposures, which have been studied by several researchers in different periods since 1955. It is beyond the scope of this paper to discuss the investigations and proposed stratigraphies relating to the age of the two peat and intercalated sand layers. We only refer to Kasse (1988) who made a critical review and added elaborated and fundamental data to demonstrate his conclusions. According to this author, the three occurring members of the Kempen clay on Belgium territory (Rijkevorsel, Beerse and Turnhout member) respectively belong to the Tiglian C3, C4 and C5.

The vegetation composition of these three units accords with those of the Tiglian. From the analyses of Kasse (1988), the following tree taxa are derived:

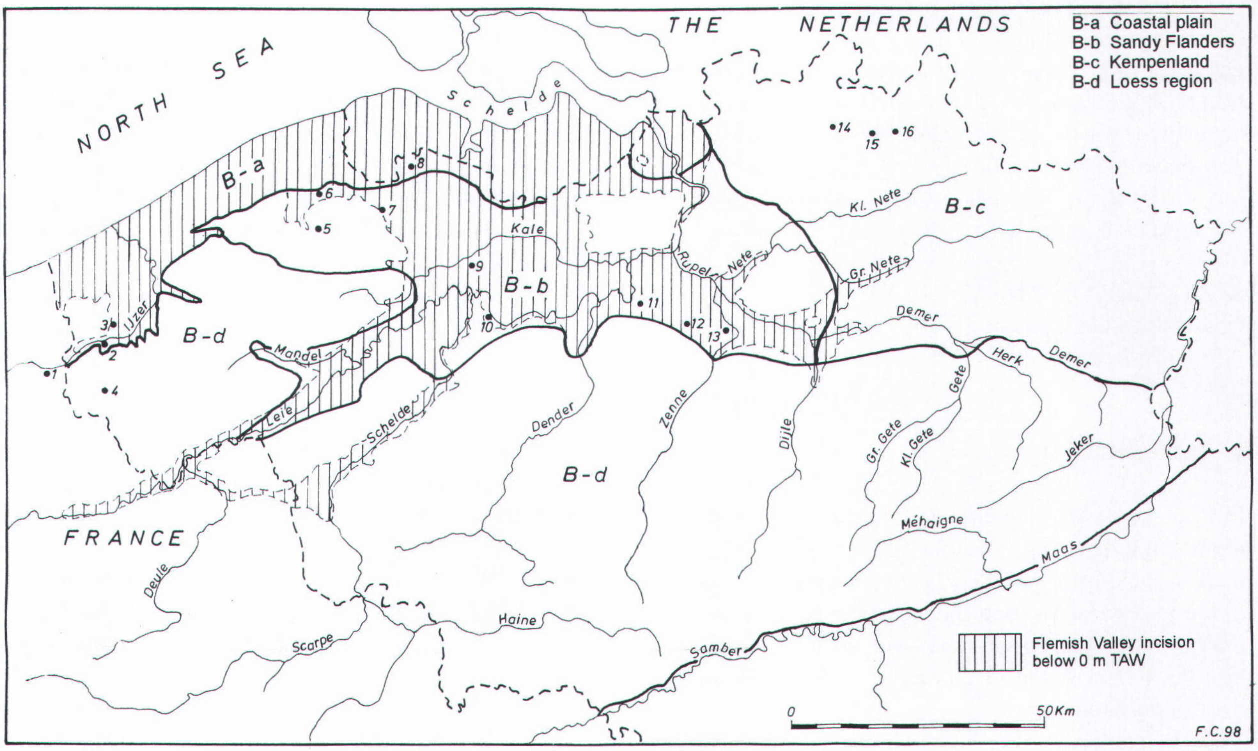

Figure 1. Location map of the sites discussed in the text: 1. Herzeele (France); 2. Stavele; 3. Lo; 4. Poperinge; 5. Beernem; 6. Vijve Kapelle; 7. Maldegem; 8. Sint Jan in Eremo; 9. Gent-Sifferdok; 10. Melle; 11. Sint Amands; 12. Nieuwenrode; 13. Zemst; 14. Rijkevorsel; 15. Beerse; 16. Turnhout.

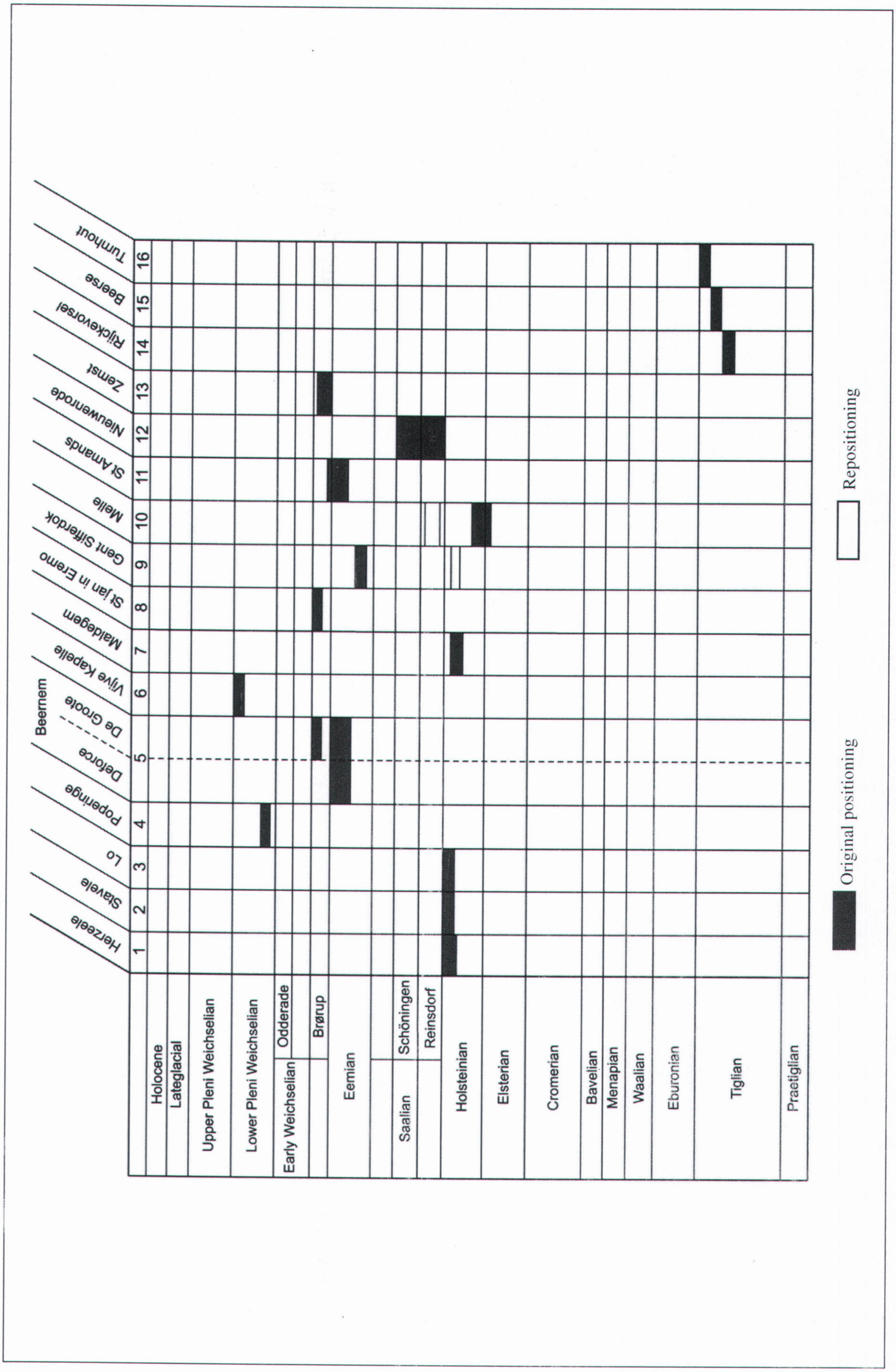

Figure 2. Chrono-stratigraphical situation of the deposits of the sites discussed in the text.

Alnus, Betula, Corylus, Quercus, Ulmus (relatively abundant), *Tilia* (scarce), *Fraxinus, Acer, Ilex, Castanea, Carpinus, Ostrya, Carya, Pterocarya, Eucommia, Celtis, Vitis, Viscum, Hedera, Parthenocissus, Pinus, Picea, Abies, Taxus, Tsuga* and Cupressaceae. Determination of wood fragments (Greguss and Vanhoorne, 1961) revealed different species of the latter taxon as well as *Sciadopytis*. This latter species is not assumed to belong to the Tiglian vegetation, so that the question arises about the Tiglian origin of the investigated layer. Among the NAP, specific taxa which disappeared during the long period afterwards until the Holocene are *Bruckenthalia, Stratiotes, Salvinia natans* and the guide fossil of the Tiglian *Azolla tegeliensis*. The abundance of the latter fossil species has been the overall criterion for the recognition of the Tiglian age of the Kempen clay since these deposits were palaeontologically investigated. According to Kasse (1988), C3 and C5 are warm periods, while C4 is definitely cold. This obvious alternation is certainly responsible for the confusion that was created by previous investigators in relation to the stratigraphical position of the various members. It is also proved now that the clay members have been formed in varying fresh- and brackish-water conditions.

3. Middle Pleistocene

3.1. Elsterian and Holsteinian

The following sites in northern Belgium are recognized as belonging to the Holsteinian period.

1. In the western part of Flanders, a thin and local layer of peat was encountered at Lo (Vanhoorne, 1962). The Holsteinian position is based on the presence of *Azolla filiculoides* and/or *Salvinia natans* and the possible palaeogeographical relationship with the Herzeele Formation found in a brickyard close to the border in northern France. The palaeobotanical evidence of the Holsteinian age of the latter formation is proved by the occurrence of *Buxus* and the expansion of *Taxus* and *Abies* in the uppermost zone (Sommé *et al*, 1978). Vanhoorne (1992) suggests the possibility of a Cromerian age for the Lo site. However this statement is based on very restricted palaeobotanical data. At Stavele, between Herzeele and Lo, a handauger coring also revealed Holsteinian deposits (Ponniah, 1977).

2. In Maldegem (Heyse, 1979), on the edge of the Flemish Valley, a bore hole showing a complex of clayey and peaty sediments occurring between -5 and -15 m TAW (Tweede Algemene Waterpassing, Belgian ordnance datum) was investigated palynologically on only 10 samples. The high values of *Taxus* pollen and the occurrence of *Azolla filicul* are the best arguments for a Holsteinian age (De Groote, 1977)

3. At the site of Melle, (De Groote, 1977) the Holsteinian period is not so evident. The lowermost part of the sequence is dominated by taiga-like vegetation. First *Betula* and then *Pinus* are the main tree representants. The herbs are important (NAP>50%) and *Artemisia* shows a continuous curve. Due to the presence of an intermittent phase with *Alnus* and scarce thermophilous elements, De Groote (1977) assigns an Elsterian age to this lowermost part. The uppermost part is characterized by the dominance of *Pinus* and the presence of several tree species (*Picea, Abies, Quercus, Tilia, Corylus, Alnus*) as well as the water ferns *Azolla filicul.* and *Salvinia natans*. De Groote (1977) had no other choice than a positioning in the beginning of the Holsteinian: Ho 1 and Ho 2a according to Zagwijn (1973); I, II, II a, b according to Turner (1970).

The geomorphological situation of the Melle deposits between +9 m and +13 m TAW points to a continental origin in an area that escaped from the later (Saalian and Early Weichselian) deep erosion of the so-called Flemish Valley. The discovery of the existence of well pronounced Saalian interstadials certainly inspired Vanhoorne to assign a Wacken age to the uppermost layer of the Melle deposits (Vanhoorne, 1992) and to change his previous Holsteinian interpretation (Vanhoorne, 1987a). However, referring to Urban (1995), it should be more logical to choose for a Reinsdorf age, since this interstadial is intercalated between the Holsteinian and the Wacken periods. Based on our actual knowledge (also see below) it seems likely to position the Melle deposits in the Saalian, rather than in the Holsteinian .

3.2. Saalian

In a geomorphological study based on bore holes carried out by the Belgian Geological Survey (1972-1976) in the eastern part of the Flemish Valley, Bogemans (1988) discussed the origin of peaty and loamy organic sediments, which have been the subject of elaborated palynological study by this author. A part of the organic deposits, with a thickness ranging from a few dm to max. 1 m, could be recognized by us as belonging to the Eemian, Early Weichselian and Weichselian periods (see below). However, around Nieuwenrode three longer sequences overlain by a course gravel bed, yielded pollen diagrams which are definitely pre-Eemian, but lack some specific Holsteinian characteristics. Based on their geomorphological situation (at a higher topographical level and consequently older than the deep post-Eemian incision of the nearby river Zenne), the Nieuwenrode peat beds have been assigned to the Saalian. One sediment sequence of 4,5 m thick

<table>
<tr><th>Nieuwenrode</th><th>AP</th><th colspan="2">Schöningen</th></tr>
<tr><td>Betula-Pinus-Alnus
Quercus-Carpinus-Tilia-Picea-Corylus</td><td>< 70 %</td><td>S8 b (5b)</td><td>Pinus</td></tr>
<tr><td>Alnus-Pinus
Betula-Tilia-Quercus-Carpinus
Picea-Corulus</td><td>> 90 %</td><td rowspan="2">S8 a (5a)</td><td rowspan="2">Carpinus-
Picea-
Tilia</td></tr>
<tr><td>Alnus
Carpinus-Quercus-Tilia
Corylus-Pinus
Picea-Betula</td><td></td></tr>
<tr><td rowspan="2">Alnus-Quercus
Pinus-Tilia-Corylus
Picea-Carpinus-Betula</td><td rowspan="2"></td><td>S7 (4b)</td><td>Alnus-Pinus-
Corylus</td></tr>
<tr><td>4</td><td>Corylus-Alnus-
QM-(Taxus)</td></tr>
<tr><td>Quercus
Pinus-Corylus-Betula
Alnus-Picea-Tilia</td><td>> 90 %</td><td rowspan="2">3</td><td rowspan="2">QM, Alnus-
Pinus</td></tr>
<tr><td>Quercus-Betula
Pinus</td><td>+/- 50 %</td></tr>
<tr><td colspan="2">HIATUS</td><td rowspan="2">2</td><td rowspan="2">Alnus-Pinus</td></tr>
<tr><td rowspan="2">Betula-Pinus-Alnus
Picea-Carpinus-Corylus-Quercus</td><td rowspan="2">+/- 50 %</td></tr>
<tr><th colspan="2">Reinsdorf</th></tr>
<tr><td>Juniperus-Betula
Pinus-Alnus</td><td></td><td rowspan="2">R5</td><td rowspan="2">Pinus-Ericaceae</td></tr>
<tr><td>Pinus-Betula-Alnus
Picea-Corylus-Carpinus</td><td>Ericaceae</td></tr>
<tr><td>Pinus-Betula-Alnus
Picea-Carpinus-Corylus</td><td></td><td rowspan="3">R 3/4</td><td rowspan="3">Carpinus-Picea-
Abies-Pinus</td></tr>
<tr><td>Pinus
Picea-Alnus
Tilia-Carpinus-Quercus-Corylus-Betula</td><td>> 90 %</td></tr>
<tr><td>Alnus-Pinus
Carpinus-Picea
Tilia-Corylus-Quercus</td><td></td></tr>
<tr><td>Alnus
Corylus-Carpinus-Pinus
Tilia-Quercus-Picea</td><td></td><td rowspan="2">R2</td><td rowspan="2">Corylus-Alnus</td></tr>
<tr><td>Alnus-Corylus
Pinus-Carpinus
Tilia-Picea-Quercus-Ulmus</td><td></td></tr>
</table>

Table 1. Main tree phases of the section Nieuwenrode compared to those of the Schöningen and Reinsdorf interstadials (Urban, 1995).

contains an interglacial peat layer in the lowermost part and one at the top. The latter is truncated by an erosional event. Table 1 shows the main tree phases of the entire section of Nieuwenrode based on our pollen analyses (unpublished data). It enables a comparison to be made with the schemes of the Reinsdorf and Schöningen interstadials (Urban, 1995). The agreement is quite good, specifically for the high *Tilia* values and the succession of the different tree phases. It supports the idea proposed by Urban, that the Saalian glacial is preceded by a pre-glacial period with pronounced interglacial intervals and colder sub-arctic conditions. A preliminary macrobotanical check by Van der Putten (unpublished) has shown the presence of *Salvinia nat.* in these Nieuwenrode deposits.

The thermophilous character of these interstadials is certainly the most striking aspect. The now defined existence of these interstadials may give rise to reconsider the positioning of not clearly defined pre-Holocene sequences.

Two pronounced Saalian interstadials (Landos and Le Bouchet) are also present in the scheme of de Beaulieu and Reille (1995), but botanical comparison so far is impossible. Referring to the Melle diagram (De Groote, 1977), indications that support a Saalian-interstadial interpretation for these deposits are: the constant importance of *Pinus*, the presence of *Alnus* and the relative high values of *Tilia* in the "thermophilous" upper part.

4. Upper Pleistocene

4.1. Eemian - Early Weichselian period

The number of organic layers assigned to the Eemian is relatively abundant, compared to the previous periods. However, there remains an important problem regarding their geomorphological situation. The topographical level of the Flemish-Valley area at the end of the Eemian may be compared with the present-day one. This means that the lowest sedimentation level on land was above 0 m. As all the Eemian peat deposits of northern Belgium known so far are younger than the E4a period, and as this period is assumed to correspond with the maximum sea level, it must be concluded that no continental and perimarine Eemian deposits can occur *in situ* lower than ± 0 m TAW.

Since the Eemian-Weichselian incision/ aggradation cycle is the last that happened, it can be geographically located and relatively dated. Consequently all the Eemian deposits that have been found in the Early-Weichselian deep valley incisions have to be considered as reworked.

One site appears to disagree with this theory. In Gent-Sifferdok, the stratigraphic and palaeobotanical evidence is extremely complex. At a depth of -9 m to -11 m TAW, scattered clayey peat blocks were found. They are embedded and overlain by freshwater and marine Eemian E5 sediments, which in turn are covered by Weichselian peaty loam and coversands. The results of the palaeobotanical investigation by Vanhoorne (Paepe and Vanhoorne, 1967) show the presence of the following pre-Holocene aquatic species: *Brasenia schreberi, Aldrovanda vesiculosa* and *Salvinia natans*. Based on the stratigraphical position and the pollen content, the clayey peat blocks have been assigned an E2-E3 age. However the restricted palynological evidence on the one hand, and the presence of *Fagus* on the other hand, impose to make some reservation to this positioning and to keep open the possibility of an older, Holsteinian age.

The discussion about the Eemian vegetation evolution is predominantly based on three existing long sedimentary sequences that have been analysed so far: Bn 3 St-Amands (bore hole Belgian Geological Survey, this author, unpublished) and the Beernem deposits (investigated in open sandpits, De Groote, 1977 and Deforce, 1997). In the Beernem sandpits several exposures have been investigated which probably resulted in a rather complete picture of the botanical evolution. All these sequences cover the whole or the greater part of the upper Eemian period and part of the Early Weichselian period and will be discussed .

4.1.1. Eemian period and transition to the Weichselian period

As mentioned above, the oldest pollen association starts with the *Corylus*-dominance phase E4a. At the inland site of St Amands, *Tilia* is much better represented than at Beernem located at the coast at that time. On the other hand, *Ilex* shows a clear presence at Beernem, while it is nearly absent at St Amands.

The E4 b *Taxus* phase is sufficiently pronounced, but short. In the E5-phase, *Carpinus* may reach until 10% of the pollen sum (AP + NAP), but its importance does not exceed considerably the values of *Picea*. In the neighbouring countries, the *Carpinus* percentages are considerabely higher (Zagwijn, 1996). *Pinus* is, by far, the main tree component at St Amands; at Beernem *Betula* and *Alnus* are also important. At St Amands, *Tilia* survives the best the strong decrease of the Quercetum mixtum. *Abies* is only present in fairly amounts at Beernem. Also in fairly amounts, but nevertheless important, *Viscum* and *Buxus* are represented. In E6, *Picea* shows its highest pollen percentage, while *Pinus* and *Betula* are, by far, the main tree components.

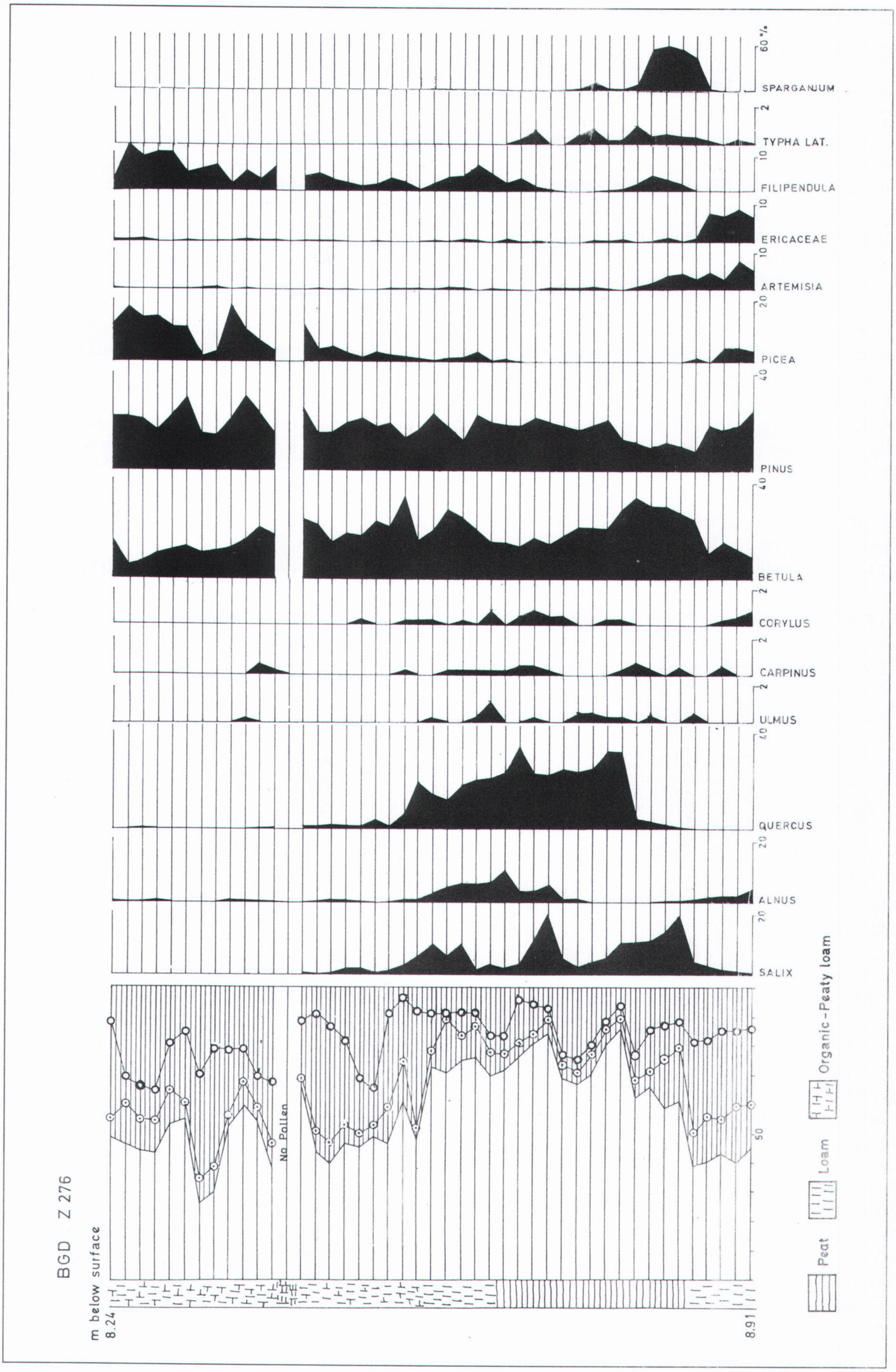

Figure 3. Pollendiagram of a peaty layer from the boring Z 276 Zemst (Belgian Geological Survey).

Specifically in Beernem, Ericaceae have taken a considerable part of the NAP ever since E5.

The transition to the Weichselian certainly is interrupted in the St Amands sequence. The Eemian part of the sequence is truncatated at the beginning of the E5-phase and overlain by a sub-aquatic organic loam and a peat layer. This mire deposit in turn was covered by aeolian sands in which a podsolic soil developed. Finally the soil has been buried by another sand layer showing thin organic peaty horizons at different levels. All these post-E5 sediments are deposited in an open pine taiga-like landscape with alder, willow and sedges during the mire phase, and heath during the aeolian phase. Despite the open boreal character of the vegetation, the former Eemian tree species (*Corylus, Alnus, Carpinus, Picea* and *Quercus*) show too regular and general curves (1-5%) to be excluded (by a reworked pollen explanation) from the real vegetation composition.

In Beernem, the botanical sequence appears to be more continuous and complete. It ends with the E4-phase during which the vegetation composition is similar to this of St Amands. However, the stratigraphical and sedimentological sequence of both sites shows a strong variation between pure organic and more clastic deposition. It points to important palaeoecological and geomorphological changes. Climate deterioration and a falling sea level are definitely the basic causes for the profound change at the end of the Eemian period. The vegetation evolves to an open taiga with heath. Under a wet boreal climate, organic peat layers and soils were formed. River incision, surface erosion and aeolian activity are getting important. In quickly changing landscapes, sedimentation and redeposition of reworked older layers may take place. The recent study of Ferguson and Vanhoorne (1997) once more confirms this important geomorphological activity.

4.1.2. Early Weichselian interstadials

The above mentioned statement about the situation at the end of the Eemian period certainly has consequences on the stratigraphical positioning of all previously recognized late Eemian and specifically Early Weichselian layers in northern Belgium. In most cases, the complex Eemian sequences were subdivided in a lower (Eemian) and an upper (Early-Weichselian) part. Moreover, as all the layers have been positioned according to the Amersfoort-Brorup-Odderade tripartion, it is obvious that a complete reinvestigation is necessary. In consequence of this situation we only discuss the few deposits which have been palynologically investigated. De Groote (1977) mentions two sites: Beernem and Sint Jan in Eremo. In both diagrams, *Quercus* reaches nearly 10%, while *Alnus, Corylus, Carpinus* and *Ulmus* are also present. The geomorphological situation of these deposits may differ considerably. The Beernem deposit is underlain by an Eemian layer at about +5 m TAW, but in St Jan in Eremo the topographical position of the deposit is more than 3 m below 0 m TAW. At the latter site, the interstadial layer is formed on a post-Eemian erosion surface that was preserved and which has been covered by younger Weichselian coversands.

Fig. 3 shows the pollen diagram, made by this author, from a peaty layer at a depth of between 8 and 9 m of the bore hole Z276 Zemst (Belgian Geological Survey). The stratigraphical position of this organic layer is studied by Bogemans (1988) and is, according to this author, directly related to post-Eemian incision and sedimentation comparable to the situation of the Sint Jan in Eremo deposit. The pollen diagram shows a well pronounced interstadial evolution with consecutive maxima of *Artemisia, Salix, Betula* and *Quercus*, the latter becoming the dominant tree species for a short time. *Carpinus, Ulmus, Alnus* and *Corylus* belong to the AP. The maximum phase of the interstadial is followed by a remarkable expansion of *Picea*. Despite the lack of reference sequences, the Zemst diagram is regarded to represent the Brorup interstadial. The *Quercus* expansion and the restricted presence of *Carpinus,Ulmus* and *Corylus* reflect an intermittent situation in the strong forest gradient between northern Germany and middle Western Europe where La Grande Pile is situated (Behre and Lade,1986 and Behre,1989).

In the context of the proposed new interpretation of the Early Weichselian sediments, the Beernem and Sint Jan in Eremo layers must be positioned either in the Brorup, or in the Odderade interstadial.

4.2. Pleni-Weichselian

The discontinuity of the glacial sediment records in our regions does not allow the drawing up of a structured evolution scheme of the Weichselian palaeobotanical and palaeoecological evolution. A lot of organic deposits have been distinguished and situated in profiles of pleni-Weichselian sediments. Only in the case that ^{14}C datings are available, a correct chronostratigraphic situation has been possible. Some of these deposits have been palynologically analysed. The amount of reworked elements is almost directly proportional to the part of the clastic fraction of the sediments. Consequently, on palynological grounds vegetational recontruction and typifying of periods is not possible. The nearly absence of data from macroscopic investigations is the main factor of the incompleteness of the palaeobotanical record of the pleni-Weichselian.

For the Lower Pleniglacial, pollen records of peaty sediments from Poperinge have been made by De Groote (1977). For the end of this period, the best known deposit is the one of Vijve-Kapelle, which has been analysed by De Groote (1977), Vandenberghe *et al.* (1974) and Vanhoorne (1987b). The deposit was roughly dated between 28.000 and 30.000 BP. Loamy organic sediments, dated 26.000-27.000 BP, and occurring at the southern border of the great Verrebroek-Gistel (cover) sand ridge have been sampled and analysed by this author and L. Denys (unpublished). These results prove the presence of the well-known tundra-like and arctic vegetation.

As already mentioned, much more elaborated multidisciplinary research is needed for the accomplishment of a valuable palaeontological data set that allows comparison with neighbouring countries.

5. The Post-glacial

Natural lakes no longer exist in Northern Belgium. Though the geomorphological features of the landscape are completely built up under periglacial conditions, lake forming elements such as moraines, palsa- and pingo remnants are lacking. Postpleniglacial organic sediments were formed under three main types of geomorphological and palaeoecological conditions:
- type 1: during the Lateglacial, when many natural depressions were filled with water and acted as shallow lakes;
-type 2: since the Atlantic period, when, due to the rising sea level and due to human influence (landnam activities), peaty deposits were formed;
- type 3: since the early beginning of the Lateglacial, when, due to intensive river incision deep channels were formed. Channels that bacame abandoned, acted as lakes until their complete infilling.

The sediments of types 1 and 3 are mostly subaquatic and produce excellent sequences for virtually all palaeontological disciplines. The type 2 sediments are well developed layers in the deposits of the coastal plain and the Lower Schelde area, but occur in the upstream zones as more heterogeneous peaty, organic loamy sediments. The former produce excellent samples for micro- and macrobotanical investigation; the latter are much variable for their conditions of palaeobotanical preservation. An important advantage of the sediments in northern Belgium is the strictly regional character of the deposits. As the rivers in the study area (IJzer, Leie, Schelde, Dender, Rupel, Nete, Mark) only have small and regional catchment basins, the river water can not be contaminated by allochtonous material. Moreover the infilling of the Belgian coastal plain was not affected by river sediments (see Baeteman, 1999).

A number of sequences from all these areas have been palynologically analysed (Munaut, 1967; Verbruggen, 1971; Beyens, 1982). Macrobotanical research has been produced often separated from the palynological investigations. This was the case in the coastal plain (Stockmans *et al.*, 1954; Allemeersch, 1991) and in some valleys (Diriken *et al.*, 1991). A number of archaeological sites in the western part of Flanders have been investigated palynologically by this author while the study of seeds and fruits, apart from scattered results, is in progress since the last years.

The most comprehensively studied period is definitely the Lateglacial. This may be explained by two reasons: the abundance and easy attainment of the sediments, and the existence of a temporary CEC palaeoclimatic research programme for northern Belgium.

This research yielded detailed information about the Bölling-Alleröd period for the first time. It was proved that the Older Dryas represents a short, but clearly pronounced palaeoecological event in our regions. The geographical area appears to be limited to (North) Western Europe, but is more than large enough to appoint it as an important regional climatological fact.

Another phase of great interest is the very beginning of the Lateglacial. A study for the British Isles, the Netherlands, Schlesweig-Holstein and northern Belgium (Walker *et al.*, 1994) resulted in various ideas about the estimation of the climatic conditions at the time. Despite of the presence of very interesting deposits from the beginning period of the Lateglacial, detailed palaeontological data are lacking until now. This represents an important gap in the knowledge of the transition period, specifically as the morphology of northern Belgium has so many obvious (unexplained) remnants of that period. The Younger Dryas was certainly the last cold period, but the forest vegetation resisted remarkbly better than in more northern regions.

Only a limited number of early Holocene pollen sequences exists. These sequences always occur in deep abandoned river beds. In such conditions, contamination must be considered. Contradictions in literature concerning the zonation of Late-glacial / early Holocene sequences, as well as about the determination of the first appearance of (immigrating) plants such as *Alnus, Quercus, Corylus, Ulmus, Tilia* during that period, can be explained by contamination. We have to refer to Mullenders *et al.* (1966, 1972), Beyens (1982), Ntaganda and Munaut (1987). In the Preboreal, the presence of one or even two oscillations has been shown: Beyens (1984), Munaut and Paulissen (1973), Verbruggen (1976). The pollen diagrams show that the vegetation was rapidly evolving to a completely closed forest. The rapid forest expansion and the abundance of *Corylus* have to be considered as the striking facts of the Boreal vegetation. Despite a similar edaphic evolution there is an important difference in organic deposition in the valley bottoms between hilly loamy Flanders in the south on the one hand, and flat sandy Flanders in the north on the other hand. While the broad valley bottoms in the north remain dry, particular zones of the so-called palaeovalleys in the south (see Huybrechts, 1999) got infilled with predominantly terrestric peat and subaereal calcareous sediments. The expansion of *Alnus* is more or less synchronous with the onset of peat growth in the lower Schelde basin. The rising sea level is considered to be at the base of the latter phenomenon.

Within the climax vegetation of the Atlantic, *Tilia* definitely had a major role, even on pure sandy soils such as in the Kempen. The presence of *Viscum* has to be a prove of higher temperatures than the present-day ones. These conditions seem to have lasted until about 4000 BP. Due to this "belated" end of Atlantic conditions compared to Scandinavia, the Subboreal chronozone (5000-2800 BP) is subdivided in an A part (5000-4000 BP) and a B part (4000-2800 BP). The *Ulmus* decrease, deforestation and gradual expansion of heath, also in the loamy regions of middle Belgium, are the main generally known results of human impact. *Fagus*, a tree species that never returned in the interglacial vegetations since the early Quaternary, comes back this time, while *Carpinus*, a typical telocratic species, hardly gains back its place, particularly in the sandy northern part of Belgium. To "complete" the incompleteness of this telocratic list, the fully absence of *Picea* must be mentioned. A period of maximum peat growth can be situated roughly between 5000 BP and 2500 BP. Favourable local edaphic conditions (a prograded coastal plain and deforestation in the inland) as well as a more humid climate were at the base of this evolution. The question whether the oligotrophic phase of this peat growth ever developed into a raised bog situation, particularly in the coastal plain (see Denys, 1999), the lower Schelde alluvial plain and in some areas of the northern Kempen is still animatedly discussed between palaeoecologists and historians. According to the latter, the area where peat was excavated in northern Belgium is much more extended than the area based on palaeoecological and geomorphological evidence proposed by this author. Moreover, the palaeobotanical studies clearly prove that northern Belgium is at the southern border of the northwestern European raised bog area (Verbruggen, 1979).

The "prehistoric" human influence reaches its last maximum in the second century AD. Import of *Juglans, Castanea, Vitis(?)*, other fruit-tree species and a lot of (kitchen)herbs represent the first wave of allochtonous plants. A second wave, more gradually, may be situated after the great discoveries of the 16th century. During the so-called Dark Ages or the Migration period roughly between 350 and 500 AD, the "natural" vegetation shows its last short revival. Hereafter, the landscape evolved within a few centuries to its definite state of complete human impact.

6. Conclusion

Overview-scheme Fig. 3 can be seen as a synthetic conclusion of this paper. It shows the two "phases" of organic sedimentation in northern Belgium: an early Quaternary one and a post-Elsterian one. The scheme is assumed to be complete until the Early Weichselian.

The dataset is restricted and for several sites the palaeobotanical evidence is incomplete and debatable. Also the major part of the investigations are more than 20 years old. This paper offered the opportunity to publish a lot of results that were left in drawers. The repositioning of this data in the actual West European context confirmed the existence of interesting deposits in the Quaternary of northern Belgium. Discussions on the stratigraphical positioning of the above mentioned and other organic layers of the Pleistocene of northern Belgium have intentionally been omitted from the scope of this paper.

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