

Palynology of some Danish glacial sediments

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Samples of Danish glacial sediments have been analysed for palynomorphs. It is shown that the majority of dinoflagellates and acritarchs are reworked from the pre-Quaternary subground. On the basis of an approximate stratigraphic grouping of the palynomorphs, the microplankton content can be divided in a parautochthonous and an allochthonous group relative to the local pre-Quaternary subground. Thus, the matrix of the glacial deposits appears to have been transported considerably shorter than the clasts. This indicates that the majority of clasts in Danish tills has been transported during several cycles of reworking and deposition.

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The present study is a brief survey of the palynology of some till-sediments from the kineto-stratigraphical scheme of the Danish Weichselian (cf. Berthelsen, 1978 for references). Samples have been processed using standard palynological preparation techniques as modified by Hansen & Gudmundsson (in press). All samples yielded rich palyno-assemblages and were particularly rich in Upper Cretaceous and Cenozoic dinoflagellates, Mesozoic and Cenozoic spore-pollen, Lower Palaeozoic acritarchs and the green alga *Pediastrum*.

Palynological studies on Danish glacial material have previously been carried out by Andersen (1965) on the basis of material from Lindø. However, Andersen's study was based mainly on the spore-pollen content and led to the conclusion that palynological studies applied to glacial sediments would be of limited stratigraphic value. By contrast the present study emphasizes the plankton content, which in most preparations constitutes the major part of the palyno-assemblage.

Subdivision of the palyno-assemblages

Since the palyno-assemblages in Danish tills may cover a stratigraphic column from the Precambrian to the Quaternary it is mandatory to group the palynomorphs in operational groups. These groups must not be defined in such a way that

knowledge at specific level to all taxa from the Precambrian to the Quaternary is required. However, a meaningful grouping cannot be based on general morphological criteria only. Therefore, it is attempted to group the palynomorphs with reference to broadly defined stratigraphic levels, to especially characteristic taxa and to characteristic morphological groups. Using these 3 criteria 10 groups are distinguished:

- 1) Spore-pollen. All spore-pollen grains.
- 2) *Pediastrum*. This group contains exclusively the green alga *Pediastrum*.
- 3) Acritarchs. Mainly Lower Palaeozoic (Ordovician – Silurian) genera e.g. *Baltisphaeridium*, *Veryhachium*, *Orthosphaeridium*, *Michrhystridium*.
- 4) *Wetzeliiella*. This group is exclusively composed of the predominantly Eocene (Upper Paleocene – Oligocene) genus *Wetzeliiella* s.l.
- 5) Mesozoic – Cenozoic chorate dinoflagellates. All Mesozoic – Cenozoic spinose dinoflagellates, which cannot be placed in group 6 and 7.
- 6) Upper Cretaceous – Lower Danian chorate dinoflagellates. All spinose dinoflagellates, which in Denmark preferentially occur in Upper Cretaceous – Lower Danian sediments.
- 7) Upper Danian – Oligocene chorate dinoflagellates. All spinose dinoflagellates, which in Denmark preferentially occur in Upper Danian – Oligocene sediments.
- 8) Proximate dinoflagellates. Dinoflagellates with

no central body and without spines. Most specimens probably originate from Maastrichtian-Danian sediments.

9) Cavate dinoflagellates. Forms with clearly separated peri- and endophragma (excl. *Wetzeliiella*). Most specimens probably originate from Upper Cretaceous sediments.

10) Others. Various palynomorphs, which cannot be placed in groups 1–9, e.g. fossil fungi, algae, genera like *Tasmanites*, *Leiofusa* and severely damaged dinoflagellates.

Samples

Samples were kindly provided by Michael Houmark-Nielsen. The 12 samples were labeled:

Sample 1: Bluish grey till, Kulhuse, Northern Sjælland, MH 9.

Sample 2: Bluish grey till, Tulstrup, Northern Sjælland, MH 16.

Sample 3: Bluish grey till, Vesterløkke, Samsø, V 2.

Sample 4: Bluish grey till Ebbeløkke, Sjællands Odde, E 2.

Sample 5: Brown till, Orø, Isefjord, MH 15.

Sample 6: Brown till, Lyngerup, Isefjord, MH 14.

Sample 7: Brown till, Lyngerup, Isefjord, MH 13.

Sample 8: Brown till, Lyngerup, Isefjord, MH 12.

Sample 9: Brown till, Sejrbø, Sejro, MH 11.

Sample 10: Brown till, Als, MH 10.

Sample 11: Older Yoldia Clay, Frederikshavn.

Sample 12: Younger Yoldia Clay, Frederikshavn.

According to kineto-stratigraphical concepts as outlined in Berthelsen (1978) the samples 1–4 belong to the so-called »NE-ice«, samples 5–8 to a young Baltic ice (the so-called »SE-ice«), samples 9–10 to an older Baltic ice (Michael Houmark-Nielsen 1977: pers. comm.) while samples 11–12 belong to glacio-marine deposits from the middle and late Weichselian respectively.

Results

On the basis of the palynological content the 12 samples can be placed in 4 different categories:

A) Samples: 1, 2, 3. Spore-pollen dominates, a large proportion seems to be Quaternary; small quantities of *Pediastrum*, acritarchs and *Wet-*

zeliella. Dinoflagellate groups 5 and 6 dominate the dinoflagellate content, while group 7 is represented in small quantities.

B) Samples: 4, 5, 6, 7, 8. Dinoflagellate group 7 (mainly Paleocene) dominates the palynoassemblage completely. The spore-pollen content is mainly of pre-Quaternary origin. Lower

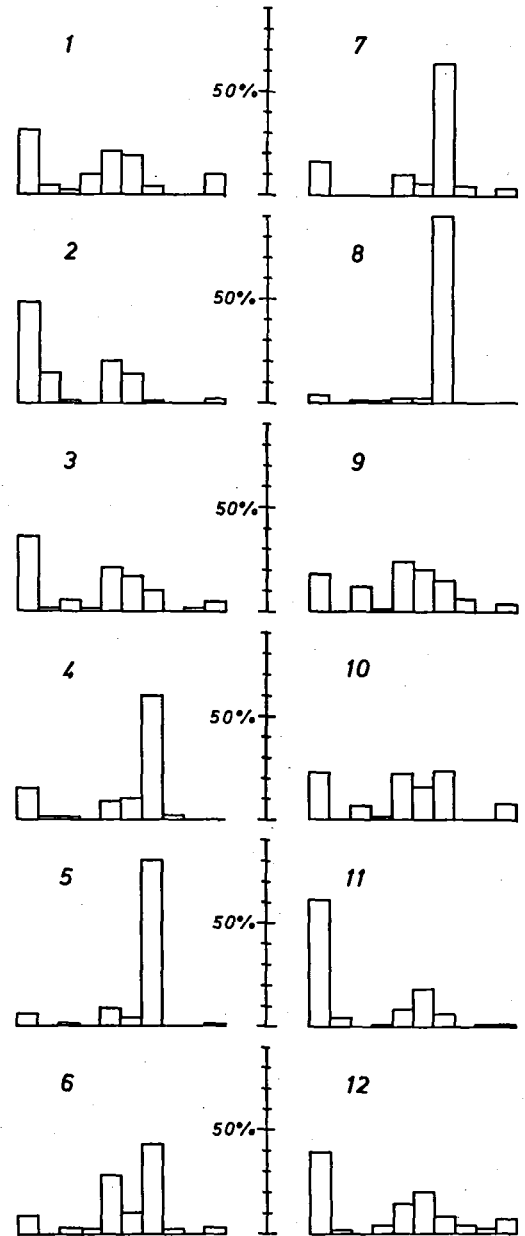


Fig. 1. The palynomorph content in samples 1–12. From the left to the right the columns represent groups 1–10.

Palaeozoic acritarchs may be present in very small quantities.

C) Samples: 9, 10. Dinoflagellate group 5, 6, 7 dominate. Lower Palaeozoic acritarchs present in relatively high quantities. *Wetzeliella* (Eocene) present. Spore-pollen content is mainly of pre-Quaternary age.

D) Samples: 11, 12. Almost like category A, but Lower Palaeozoic acritarchs are missing. A small proportion of the dinoflagellates are of Quaternary origin.

Between 100 and 400 palynomorphs per sample have been identified to generic level, and when necessary to specific level (fig. 1).

Discussion and conclusion

The high biostratigraphic resolution obtained through dinoflagellate zonations may to some

extend allow a determination of the age of the strata from which the dinoflagellate and acritarch content is derived. This determination, combined with the pre-Quaternary geological map of Denmark, offers the possibility of evaluating how far the glacial matrix material has been transported. For that purpose the plankton content has been subdivided into allochthonous microplankton, parautochthonous microplankton and stratigraphically insignificant microplankton (fig. 2).

The allochthonous group is defined as that part of the microplankton content that has been transported more than 10 km, i.e. the allochthonous microplankton species are not present in the pre-Quaternary subground of the area within a distance of 10 km. The parautochthonous group is defined as that part of the microplankton content that may have been transported less than 10 km, i.e. the parautochthonous microplankton content is probably present in the pre-Quaternary subground of the area within a distance of 10 km.

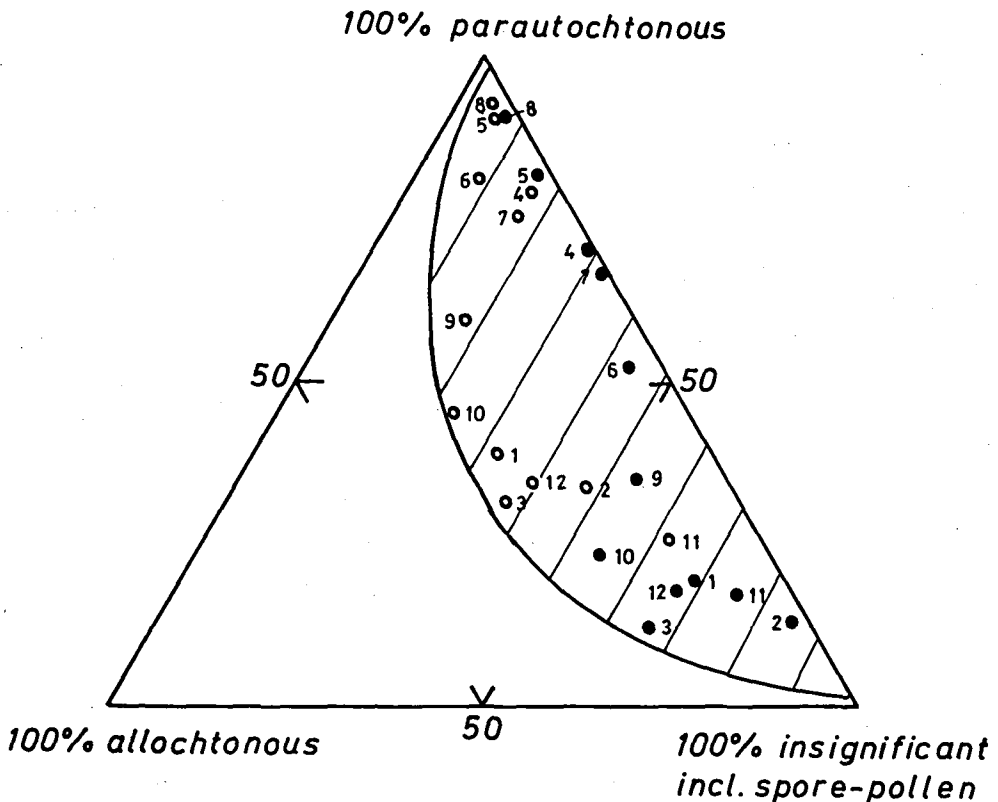


Fig. 2. Triangle-diagram showing the distribution of 1) allochthonous microplankton, 2) parautochthonous microplankton and 3) insignificant microplankton plus spore-pollen. Dots indicate the distribution before division of the insignificant group, circles after division of the insignificant group into the allochthonous and parautochthonous groups. Numbers refer to sample numbers.

The insignificant group comprises long-ranging species, which cannot be assigned to any stratigraphic level mapped as one unit in the geological map of Denmark.

The present work is not sufficient for a statistically significant evaluation of the amount of allochthonous/parautochthonous matrix content in Danish glacial deposits. However, it appears from fig. 2 that a decrease in the parautochthonous microplankton content is related to an increase in spore-pollen content rather than to an increase in allochthonous microplankton.

Therefore, comparing the source-areas of the matrix with the source-areas of the clasts of Danish tills and tilloid deposits a discrepancy exists suggesting a more complex transportation of the clasts than of the matrix. It is well-known that the main part of clasts present in Danish tills are derived from the Fennoscandian Precambrian Shield, although Maastrichtian and Danian flints in some areas may dominate. The transportation ability of the inland-ice during the Quaternary has hardly been significantly different with reference to fine-grained and coarse-grained material, since both fine-grained and coarse-grained materials in Danish lodgement-tills are generally found to be an almost homogenous mixture (moraine-clay, boulder-clay, etc.). Consequently, it may be concluded that the clasts have been picked up together with the matrix-material by the ice far from the original source-area of the clasts. The clasts therefore must have been in the area from which the matrix originates before clasts and matrix were picked up and mixed together by the ice.

Thus, taking into account that the major part of the matrix-material could originate from the pre-Quaternary subground within a distance of less than 10 km, it can be claimed that the coarser

material has been transported during several cycles of reworking and deposition before the last deposition. This hypothesis is supported by studies of the stone-content in Danish tills (cf. Marcussen 1974 & 1978, for references) and by studies on trace elements in the fine fraction ($< 32 \mu\text{m}$) from Danish tills. These trace elements show a clear affinity to the local pre-Quaternary subground (Binzer 1974).

Dansk sammendrag

12 prøver af danske istidsaflejringer er undersøgt for dinoflagellater, acritarcher, sporer og pollen. Det vises, at hovedparten af dinoflagellaterne er oparbejdet fra den lokale undergrund. På basis af en tilnærmet stratigrafisk inddeling af mikroplankton-indholdet kan dette inddeles i bl.a. to grupper, hvoraf den ene og mest dominerende kan stamme fra undergrundslag inden for en afstand på mindre end 10 km, mens den anden og mindste gruppe stammer fra undergrundslag mere end 10 km borte. Da hovedparten af sten i danske istidsaflejringer stammer fra det skandinaviske grundfjeld, kan der således påvises en betydelig forskel i transportafstanden for istidsaflejringerne finkornede og grovkornede dele. Dette tages som udtryk for, at hovedparten af de grovkornede dele er transporteret i flere omgange, inden de nåede frem til stedet, hvor de ligger idag.

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