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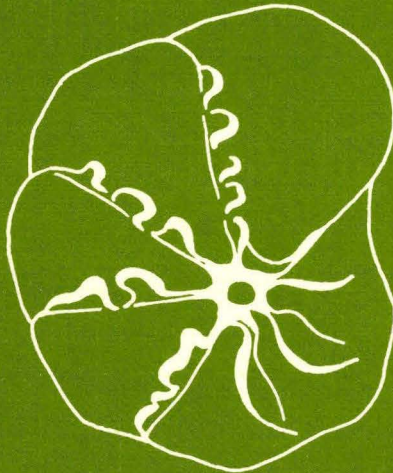
# **Middle and Late Weichselian marine deposits at Nørre Lyngby, northern Jutland, Denmark, and their foraminiferal faunas**

BY

*Karen Luise Knudsen*

DANSK SAMMENDRAG

*Midt og sen Weichselien marine aflejringer  
ved Nørre Lyngby, Nordjylland,  
Danmark, og deres foraminifer-faunaer*



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# Contents

Abstract .....	5
Introduction .....	6
Historical .....	6
Material and methods .....	7
Stratigraphic terms .....	9
Cliff section and borings .....	11
Profile 2 .....	11
Profile 4 .....	13
Profile 1 and boring III .....	14
Boring I .....	18
Profile 3 .....	18
Borings east of the cliff .....	20
Foraminiferal zones .....	23
Description, palaeoecology and distribution .....	23
The <i>Bulimina marginata</i> – <i>Buccella frigida</i> zone .....	23
The <i>Elphidium subarcticum</i> zone .....	23
The <i>Elphidium excavatum</i> zone .....	24
The <i>Elphidium albiumbilicatum</i> zone .....	25
Correlation .....	26
The <i>Bulimina marginata</i> – <i>Buccella frigida</i> zone .....	26
The <i>Elphidium subarcticum</i> zone .....	27
The <i>Elphidium excavatum</i> zone .....	29
The <i>Elphidium albiumbilicatum</i> zone .....	30
Foraminifera .....	33
Conclusions .....	36
Acknowledgements .....	38
Dansk sammendrag .....	39
References .....	42
Plates 1–7 .....	45

# Abstract

The marine Weichselian deposits at Nørre Lyngby are subdivided into four assemblage zones based on the content of benthonic foraminifera.

The lowermost zone, the *Bulimina marginata-Buccella frigida* zone, is correlated with the upper part of the Older *Yoldia* Clay of Vendsyssel and inferred to be of Middle Weichselian interstadial age.

The *Elphidium subarcticum* zone is correlated with the Lower *Saxicava* Sand and the *Elphidium excavatum* zone with the Younger *Yoldia* Clay of Vendsyssel. The *E. subarcticum* zone is found to be a sandy facies within the lower part of the *E. excavatum* zone at Nørre Lyngby. The foraminiferal faunas of these two zones indicate mainly arctic climatic conditions. Radiocarbon dates show that the *E. subarcticum* zone and also a major part of the *E. excavatum* zone belong to late Middle Weichselian.

The uppermost zone, the *Elphidium albumbilicatum* zone, is correlated with the Upper *Saxicava* Sand. The foraminiferal faunas in this zone seem to indicate an amelioration in climate, and the deposit might represent the Late Weichselian Bølling interstadial.

# Introduction

## Historical

Marine deposits in Vendsyssel containing arctic faunas were mentioned as early as 1828 by Pingel. Later Johnstrup (1882) described the molluscs in »undisturbed *Yoldia* Clay« at the locality of Nørre Lyngby (fig. 1), and Madsen (1895) mentioned a few foraminifera from that deposit. More detailed descriptions of the marine sediments at Nørre Lyngby were given by Jessen in 1899, 1918, 1931 and 1936. Jessen suggested that the deposits were of Late-glacial age, deposited in the *Yoldia* Sea, which transgressed the area during the Weichselian deglaciation. He found that the marine deposits in many parts of Vendsyssel consisted of three units, the *Yoldia* Clay itself and the two shallow water deposits, the Lower *Saxicava* Sand below and the Upper *Saxicava* Sand above the clay.

Because of isostatic adjustments of the area after the latest glaciation, these marine sediments now appear above sea level, and the surface of marine Late-glacial deposits forms the *Yoldia* plains. These plains surround the higher glacial highlands, which are composed mainly of glacial deposits but also of older marine sediments.

Jessen (1936) described two different types of the Younger *Yoldia* Clay in Vendsyssel. In the northern and eastern part the clay is rich in fossils, and its deposition presumably took place under normal marine conditions. In the southern and south-western part of Vendsyssel the clay is nearly unfossiliferous and is supposed to have been deposited in a brackish or even in a freshwater environment. He assumed these different ecological conditions to be caused by differences in meltwater supply from the melting ice cap to the areas of deposition.

The content of arctic molluscs led S. Hansen (1965) to place the Lower *Saxicava* Sand and the Younger *Yoldia* Clay of Vendsyssel in pollen zone I a (Oldest *Dryas*, according to Iversen 1942), and he also considered the Upper *Saxicava* Sand to be of Oldest *Dryas* age. Later Krog (1968) and Krog & Tauber (1974) correlated the Lower *Saxicava* Sand and the Younger *Yoldia* Clay chronologically with Daniglacial time and pollen zone I a, and they presented radiocarbon dates from these deposits (see also Tauber 1966 a, 1966 b). There are no radiocarbon dates, which can with certainty be refer-

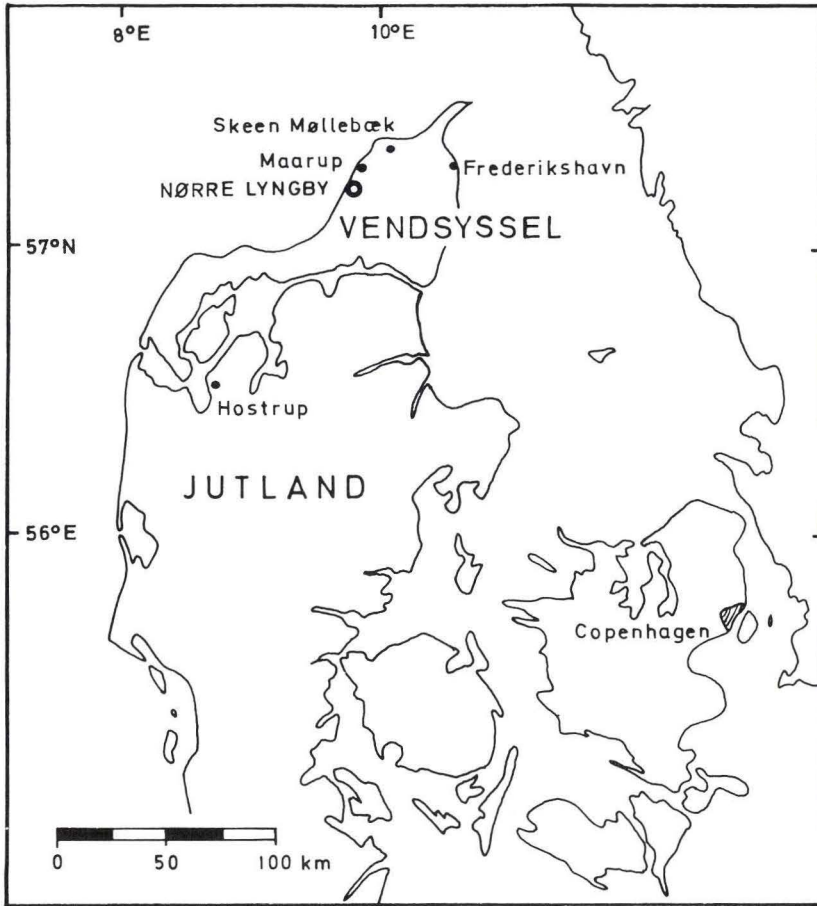


Fig. 1. Location map.

red to Upper *Saxicava* Sand, but this unit is usually considered to belong to Oldest *Dryas* time (Krog 1968, Krog & Tauber 1974).

Foraminiferal faunas from marine Late-glacial deposits of different localities in Vendsyssel were earlier described by Jørgensen (1971) and Knudsen (1971), and Michelsen (1967) described foraminiferal faunas from corresponding deposits on the island of Læsø east of Vendsyssel.

## Material and methods

Samples for the present investigation were collected partly from the coastal cliff at Nørre Lyngby and partly from borings on the beach at the foot of the cliff and in the adjacent area east of the cliff (figs. 2 and 3).

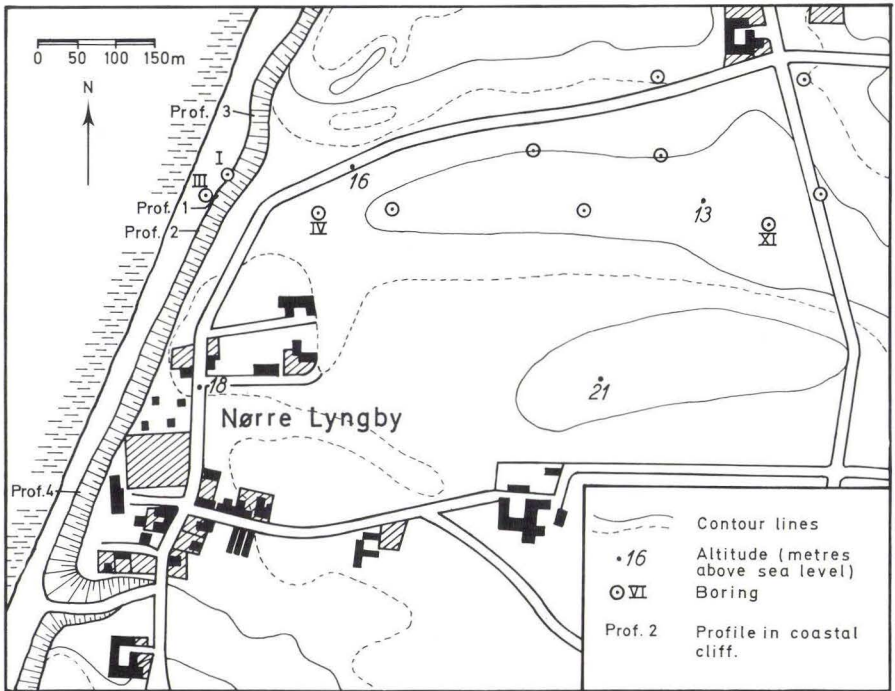


Fig. 2. Location of the borings and profiles in the Nørre Lyngby area. The numbered borings are described and the others just briefly mentioned in the present work. Map based on Geodetic Institute M 1217 I NØ Løkken.

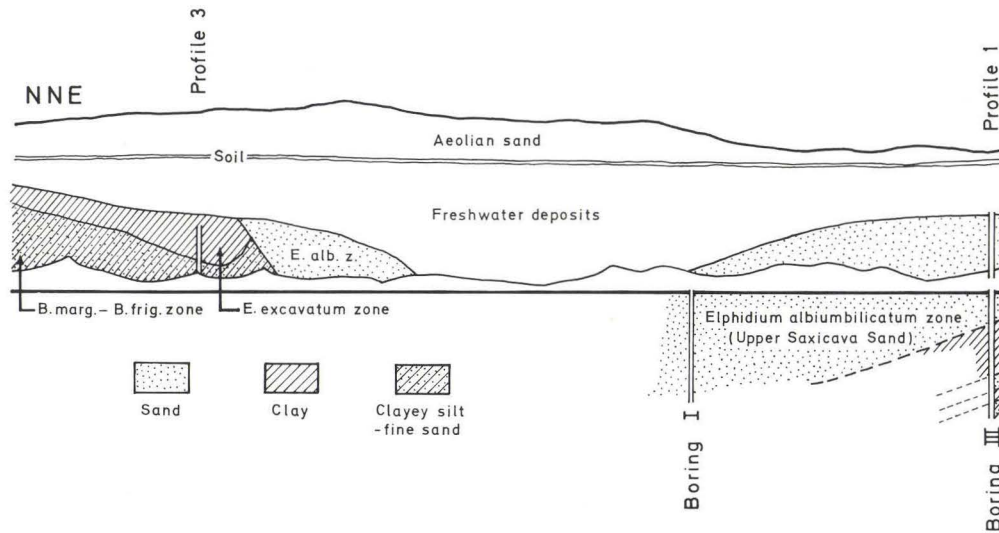


Fig. 3. Marine deposits in the cliff section at Nørre Lyngby and their continuation below the cliff. Locat



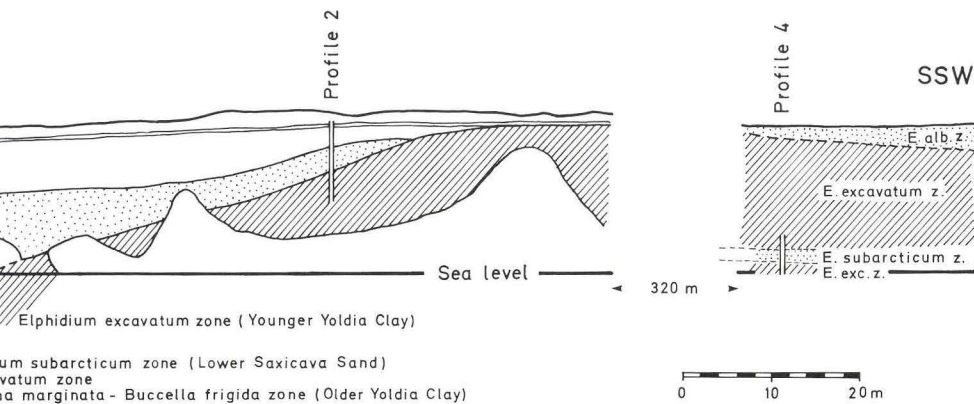
The borings were made with a 54 mm piston sampler (described by Knudsen 1973), by which almost continuous cores were obtained. The short intervals between the cores are indicated in the diagrams for each of the borings.

For foraminiferal analysis samples of about 100 g dry weight were treated in the laboratory, mainly as described by Feyling-Hanssen (1958) and by Feyling-Hanssen et al. (1971), using sieves with mesh diameters 1.0 and 0.1 mm. The foraminifera were concentrated by floatation with an ethylene bromide/absolute alcohol solution with specific gravity 1.75 g/ccm. It was attempted to count at least 300 specimens from each sample. The quantitative analyses of the faunas are summarized in range charts except for a few ones, which are only briefly described in the text. As an aid in interpreting the palaeoenvironment, a measure for the faunal diversity, as defined by Walton (1964), is given in the range charts. This measure indicates the number of ranked species in a counted assemblage, whose cumulative percentage accounts for 95% of the total fauna.

## Stratigraphic terms

The foraminiferal »zones« described in the present work are assemblage zones, according to the definition given by Hedberg (1976). The term »zone« is used for the purpose of brevity.

In discussions and correlations the generally used stratigraphic terms Older *Yoldia* Clay, Lower *Saxicava* Sand, Younger *Yoldia* Clay and Upper *Saxicava*



the profiles and borings are shown.

Sand (Jessen 1918, 1936) are maintained, in spite of the fact that they are combinations of biostratigraphical and lithostratigraphical terms. In the present work the term Late-glacial is not used synonymous with the chronostratigraphical term Late Weichselian, but as a local environmental term for the deglaciation period, as used by Jessen (1918, 1936).

# Cliff Section and Borings

The deposits of the coastal cliff at Nørre Lyngby consist partly of marine clay and sand, partly of freshwater sediments. In the cliff section (fig. 3) the surface of the marine deposits forms a depression, which is about 200 m wide and 15 m deep. This basin structure is filled up with a complex series of freshwater deposits, which have been described by i.a. Jessen & Nordmann (1915), Iversen (1942), Krog (1978) and M. R. Hansen (in prep.).

Foraminiferal faunas from a series of vertical profiles through the marine deposits in the coastal cliff at Nørre Lyngby have been analysed. Four of these profiles and four of the eleven borings in the area are described below.

## Profile 2

Profile 2 is located about 100 m south of the centre of the freshwater basin (fig. 3). Lithology, grain size distribution and percentage distribution of selected species of foraminifera in profile 2 are shown in fig. 4. In the lower part of the profile, the sediments consist of clay and sandy clay with thin layers and lenses of sand. At about 11.0 m above sea level there is a sharp change to a sandy sequence above. The upper c. 2 cm of the clay is weathered and contains a few pebbles and shell fragments, suggesting a local break in sedimentation.

The foraminiferal faunas of the clayey sequence (samples no. 1–8) are characterized by very high dominance of *Elphidium excavatum*, forma *clavata*, which accounts for 78–95% of the total faunas. *Cassidulina crassa* varies from 2 to 6%, and *Elphidium albiumbilicatum* increases from less than 1% in the lower samples to 7% in samples 7 and 8. *Elphidium subarcticum* occurs in all the samples, but usually with frequencies not higher than 1%. Accessory species are *Bulimina marginata*, *Islandiella norcrossi*, *Elphidium asklundi*, *Buccella frigida* and a few others. The faunal diversities of these assemblages are usually only 2–4 with a maximum of 6. The foraminiferal faunas in these samples represent an assemblage zone, which is here called the *Elphidium excavatum* zone.

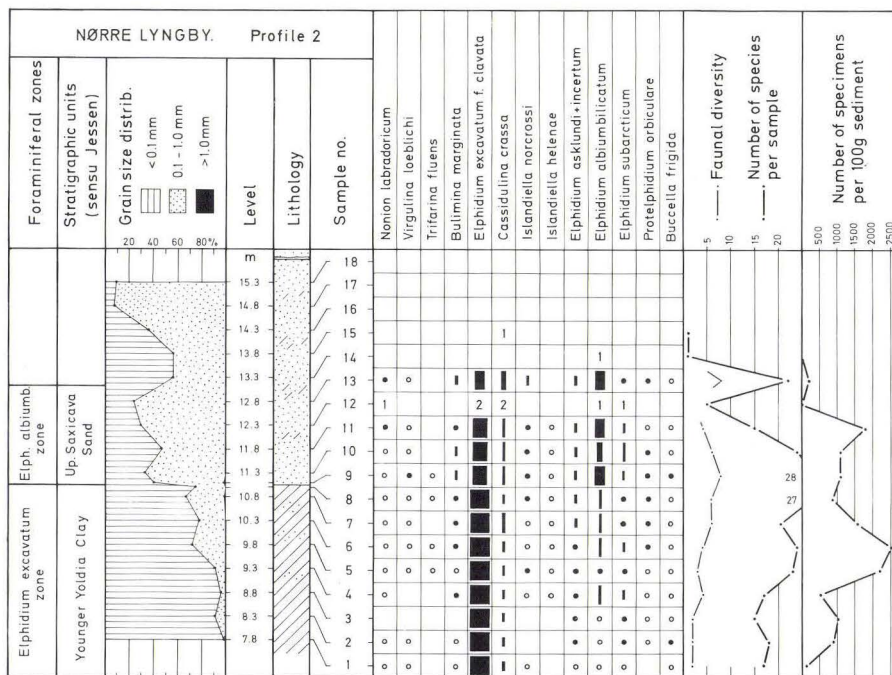


Fig. 4. Range chart for profile 2 from the cliff section. Legend for lithology in fig. 3 and for foraminiferal frequencies in fig. 6.

In the samples no. 9–13 from the sandy sequence of profile 2 *Elphidium excavatum*, forma *clavata* is still the dominant species, but the frequencies are lower (37–56 %) than in the samples of the underlying clay. *Elphidium albumbilicatum* is second in number with 20–31 % of the total faunas, and *Bulimina marginata*, *Cassidulina crassa*, *Elphidium asklundi* and *E. subarcticum* are common. These faunas are characterized by the high content of the species *E. albumbilicatum*, and also by higher faunal diversities than the *E. excavatum* zone faunas. The present assemblage zone is here called the *Elphidium albumbilicatum* zone.

The marine sequence of profile 2 is overlain by a non-marine sequence of sand covered by a thin humus layer (soil) at about 15.8 m above sea level. Aeolian sand occurs at the top.

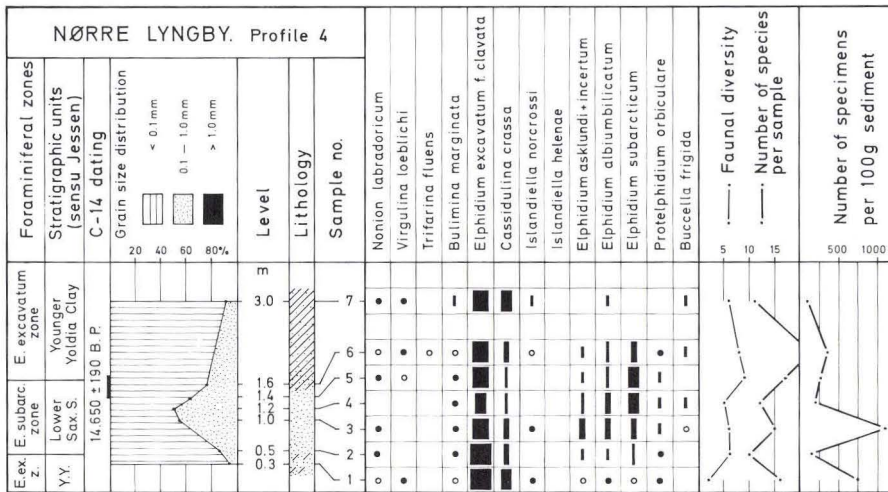


Fig. 5. Range chart for profile 4 from the cliff section. Legend for lithology in fig. 3 and for foraminiferal frequencies in fig. 6.

## Profile 4

South of profile 2 the coastal cliff mainly consists of horizontally stratified clay containing foraminiferal faunas as described from the lower part of profile 2. The deposit thus represents the *Elphidium excavatum* zone. At a distance of about 400 m south of the centre of the freshwater basin (fig. 3) the clay starts dipping to the south and is again covered by a sandy deposit of variable thickness. The foraminiferal faunas show that this sand represents the *Elphidium albiumbilicatum* zone, which was described from the upper part of profile 2. Contrary to profile 2 there is a gradual transition between clay and sand in this southern part of the cliff section. The upper part of the clay deposit contains an increasing number of sandy and silty layers of < 1 to 5 cm thickness, and the lower part of the sandy sequence usually contains a few layers of clay and sandy clay.

A series of samples for foraminiferal analysis (profile 4, fig. 3) was collected from the lowermost part of the coast cliff about 470 m south of the centre of the freshwater basin, and about 160 m north of a ramp leading to the beach from the village of Nørre Lyngby. The lithology and the distribution of selected species of foraminifera are shown in the range chart, fig. 5. The sediment is sandy clay in the lowermost part of the section, grading into a sand deposit of about 1 m thickness. At about 1.5 m above sea level there is a sharp change in sediment to clay containing a few thin sandy layers and lenses.

The foraminiferal faunas from the clayey parts of the profile, i.a. the lowermost and of the uppermost sample (no. 1 and no. 7) have high dominances of *Elphidium excavatum*, forma *clavata*, and *Cassidulina crassa* is second in number. Sample no. 1 contains few other species, and its faunal diversity is only 2. The uppermost sample (no. 7) has a higher content of accessory species, i.a. *Bulimina marginata*, *Islandiella norcrossi*, *Elphidium albiumbilicatum* and *Buccella frigida*, and its faunal diversity is 6. The faunas in this upper and lower part of the sequence are characteristic of the *Elphidium excavatum* zone, and this assemblage zone is found to continue in the upper part of the cliff section, above sample 7 in profile 4. The thickness of the *E. excavatum* zone is here about 8–10 m.

In the sand deposit, represented by samples 2–6, the frequency of *Elphidium excavatum*, forma *clavata* is lower (38–61 %). *Cassidulina crassa* gradually becomes less frequent than in the clayey deposits, whereas some other species are rather common in these samples, viz., *Elphidium asklundi* (2–12 %), *E. albiumbilicatum* (4–15 %), *E. subarcticum* (6–27 %) and *Protelphidium orbiculare* (1–3 %). The faunal diversity varies from 6 to 9. The assemblage zone represented by these five samples in profile 4 is here called the *Elphidium subarcticum* zone. This zone thus occurs within the lower part of the *Elphidium excavatum* zone in profile 4.

## Profile 1 and boring III

The samples of profile 1 were collected about 55 m south of the centre of the freshwater basin (fig. 3). The lithology and the distribution of selected species of foraminifera are shown in the range chart, fig. 6. The foraminiferal faunas of samples 1–10 in profile 1 are dominated by *Elphidium excavatum*, forma *clavata* (38–70 %). *Cassidulina crassa* and *Elphidium albiumbilicatum* are frequent, accounting for 11–25 % and 2–36 % of the faunas respectively. The most common accessory species are *Bulimina marginata*, *Islandiella norcrossi*, *Elphidium asklundi*, *E. albiumbilicatum*, *Protelphidium orbiculare* and *Buccella frigida*. The faunal diversity varies from 4–11 and the number of specimens is usually less than 500 per 100 g sediment. These faunas are characteristic of the *Elphidium albiumbilicatum* zone, and the deposit corresponds to that of the upper part of the marine sequence of profile 2, about 45 m farther south (fig. 3). The specimens of foraminifera in samples 11 and 12 of profile 1 are worn and etched, and are presumably reworked.

In order to investigate the continuation of the marine sequence at this locality, boring III was made on the beach just below profile 1, at the foot of the coastal cliff. The lithology and foraminiferal content of samples from the

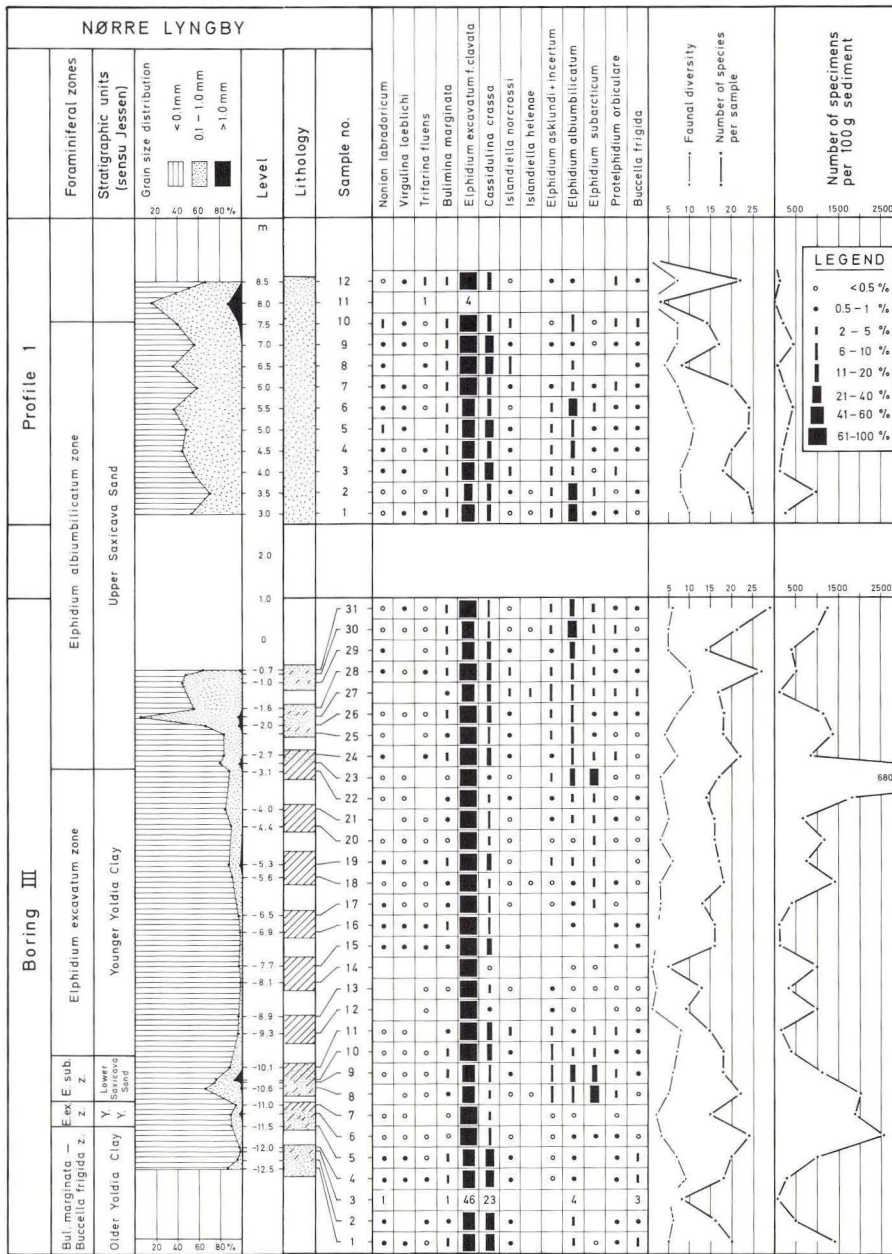


Fig. 6. Range chart for profile 1 from the cliff section and for boring III sited on the beach just below the profile. For poor foraminiferal faunas the entire number of specimens of each species is entered in the species columns instead of the percentages. Legend for lithology in fig. 3.

boring are given in a combined range chart for profile 1 and boring III (fig. 6). The upper part of boring III consists of sand with *Elphidium albiumbilicatum* zone faunas down to about 3 m below sea level, i.e. samples no. 23–31. There is a gradual change in sediment from this sand with a few thin layers of clay in the upper part of the boring through a series of alternating layers of sand and clay to clay with a few thin layers and lenses of sand. The clayey series, has a thickness of about 7 m (samples no. 12–22) and contains foraminiferal faunas similar to those characterizing the *Elphidium excavatum* zone of profile 2, with very high dominances of *Elphidium excavatum*, forma *clavata*.

Below the clay (the *Elphidium excavatum* zone) is a sandy layer with foraminiferal faunas characterized by relatively high frequencies of *Elphidium subarcticum*. In the four samples (no. 8–11) from that layer *E. subarcticum* accounts for 5–34 % of the total fauna, whereas *Elphidium excavatum*, forma *clavata* is still the dominant form comprising 45–63 % of the fauna. Other frequent species are *Cassidulina crassa* (4–18%), *Elphidium asklundi* (2–9 %), *E. albiumbilicatum* (1–11 %) and *Protelphidium orbiculare* (1–2 %). This is the characteristic composition of faunas in the *Elphidium subarcticum* zone as described from profile 4, about 400 m to the south. The succession of faunas in the present sandy sequence corresponds closely to that of samples 2–6 in profile 4. Below this sandy sequence of boring III there is another clayey layer (samples 6 and 7) containing foraminiferal faunas typical of the *E. excavatum* zone. The sandy sequence, the *E. subarcticum* zone, thus appears to be a sandy facies within the lowermost part of the clay, the *E. excavatum* zone, as in profile 4.

The sediment of the lowermost 1.2 m of boring III consists of light olive-grey fine sand with some layers of clayey sand. The samples 1–5 from this deposit contain foraminiferal faunas characterized by very small but well preserved specimens, indicating a primary position and accordingly a marine formation. The foraminiferal faunas are dominated by the two species *Elphidium excavatum*, forma *clavata* (50–56 %) and *Cassidulina crassa* (32–38 %). Accessory species are *Bulimina marginata*, *Buccella frigida*, *Protelphidium orbiculare*, *Elphidium albiumbilicatum*, *Islandiella norcrossi*, *Nonion labradoricum* and *Virgulina loeblichii*. The faunal diversity varies from 5 to 9, and the number of specimens per 100 g sediment from 50 to 1400. These faunas represent an assemblage zone, which is here called the *Bulimina marginata*–*Buccella frigida* zone.



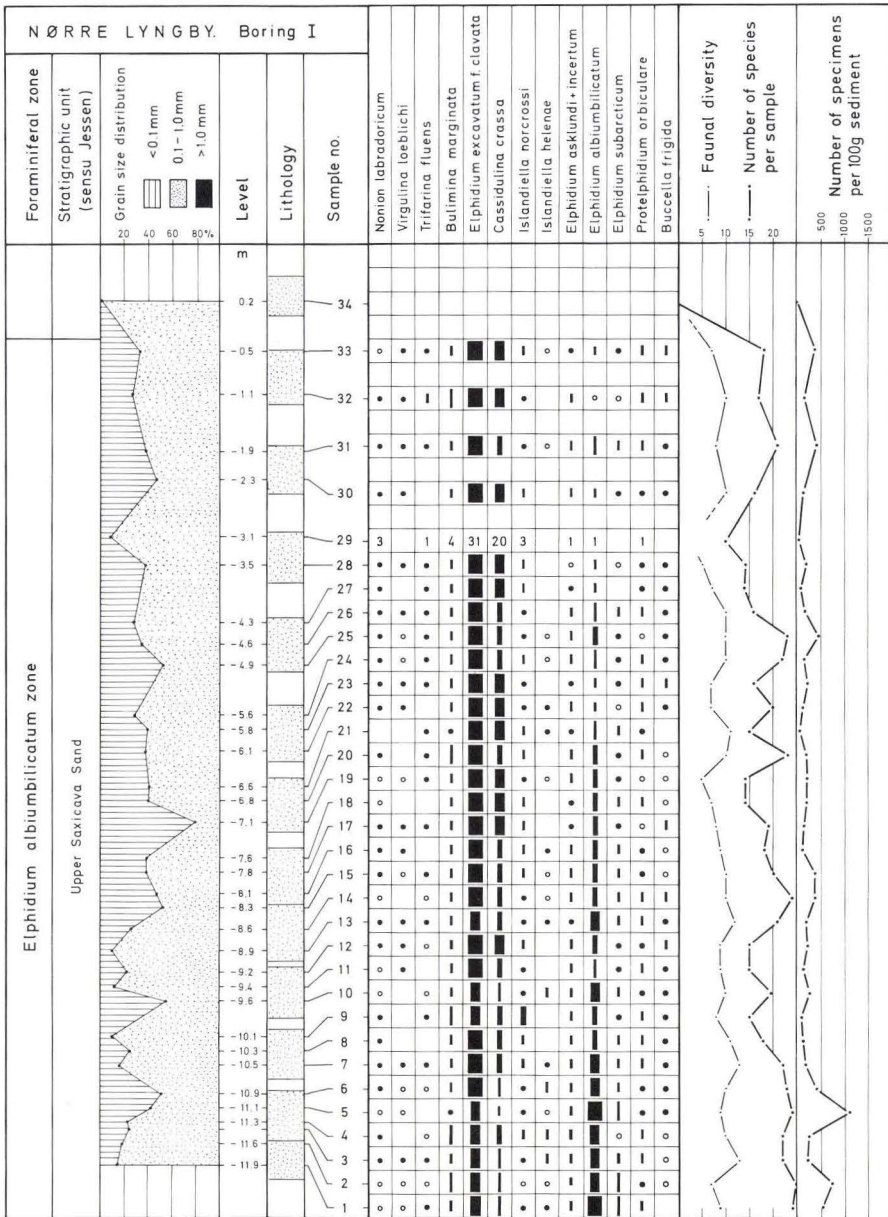


Fig. 7. Range chart for boring I at Nørre Lyngby. Legend for lithology in fig. 3 and for foraminiferal frequencies in fig. 6.

## Boring I

The site of boring I is about 20 m south of the centre of the freshwater basin (fig. 3). The boring was made on the beach just below the cliff section. It was 12.9 m deep and through the whole sequence the sediment consisted of light olive-grey fine sand with scattered thin layers of olive-grey clay. The lithology, the grain size distribution and the percentage distribution of selected species of foraminifera are shown in fig. 7.

The foraminiferal faunas of the 34 analysed samples from boring I were rather uniform with *Elphidium excavatum*, forma *clavata*, *E. albiumbilicatum* and *Cassidulina crassa* as the three dominant species. Common accessory species are *Bulimina marginata*, *Islandiella norcrossi*, *Elphidium asklundi*, *E. subarcticum*, *Protelphidium orbiculare* and *Buccella frigida*. This faunal composition indicates that the whole sequence of boring I belongs to the *Elphidium albiumbilicatum* zone. The lower boundary of the zone was not reached at 12.0 m below sea level at the locality. As the upper boundary was found in the cliff at about 2 m above sea level, the thickness of the *E. albiumbilicatum* zone at boring I is at least 14 m.

## Profile 3

The marine deposits, which mostly occur below sea level at boring I, are again found at a high level in the cliff section north of that boring (fig. 3). The marine deposits are considerably disturbed in this part of the cliff. A series of samples from profile 3 in the cliff section, about 55 m north of boring I, was analysed for the content of foraminifera. Three samples from the lower clayey sand and silt of profile 3 contained from 360 to 540 specimens of small but well preserved foraminiferal tests per 100 g sediment. One of these samples contained the fauna listed on p. 19 in 110 g sediment.

The faunal diversity is 7 and the number of specimens 440 per 100 g sediment. This composition of fauna is similar to those found in the lowermost part of boring III below the *E. excavatum* zone and the *E. subarcticum* zone, and the present deposit belongs to the *Bulimina marginata*-*Buccella frigida* zone.

Lying above the clayey sand and silt in profile 3 is an olive-grey clay with thin layers and lenses of fine sand. This clay contains foraminiferal faunas similar to those in the *E. excavatum* zone of the area. They have very high dominances of *Elphidium excavatum*, forma *clavata* (92–99 %). *Cassidulina crassa* is second in number, and the faunal diversities are 1–2. The *E. exca-*

Species	Frequency	Percentage
<i>Elphidium excavatum</i> , forma <i>clavata</i> .....	261	54
<i>Cassidulina crassa</i> .....	160	33
<i>Elphidium albiumblicatum</i> .....	12	3
<i>Bulimina marginata</i> .....	11	2
<i>Nonion labradoricum</i> .....	7	1
<i>Buccella frigida</i> .....	6	1
<i>Protelphidium orbiculare</i> .....	5	1
<i>Virgulina loeblichii</i> .....	4	1
<i>Fissurina</i> sp. ....	3	1
<i>Trifarina fluens</i> .....	3	1
<i>Islandiella norcrossi</i> .....	2	<1
<i>Epistominella takayanagii</i> .....	2	<1
<i>Buliminella elegantissima</i> .....	1	<1
<i>Elphidium magellanicum</i> .....	1	<1
<i>Ammonia batavus</i> .....	1	<1
Indeterminate specimens .....	1	<1
Total	480	

*vatum* zone is only up to 5 m thick in this northern part of the cliff, and as mentioned these layers are disturbed.

From about 10 m to about 30 m south of profile 3 in the cliff the *B. marginata*-*B. frigida* zone and the *E. excavatum* zone are overlain by a tilted unit of sand (fig. 3), in which the beds dip steeply southwards. Foraminiferal analysis of samples from this deposit show that it belongs to the *E. albiumblicatum* zone. The sedimentary structures of both the marine and the fresh-water deposits at the locality will be further discussed by M. R. Hansen (in prep.).

North of profile 3 the marine deposits overlie glaciofluvial sand and clay, and gradually these fluviatile sediments make up most of the cliff section (the diluvial sand and clay of Jessen 1931). The glaciofluvial deposits contain some foraminifera, but they are usually poorly preserved, and large robust forms seem to be overrepresented. These foraminiferal tests are therefore considered reworked.

## Borings east of the coastal cliff

Boring IV is located about 125 m ESE of boring I (fig. 2). The bore site lies c. 15.0 m above sea level, and the depth of the boring is 14.5 m. Lithology and distribution of selected species of foraminifera are shown in fig. 8. The foraminiferal analyses show that the lowermost 6 m of boring IV consist of marine deposits. There is a gradual change in sediment through the marine

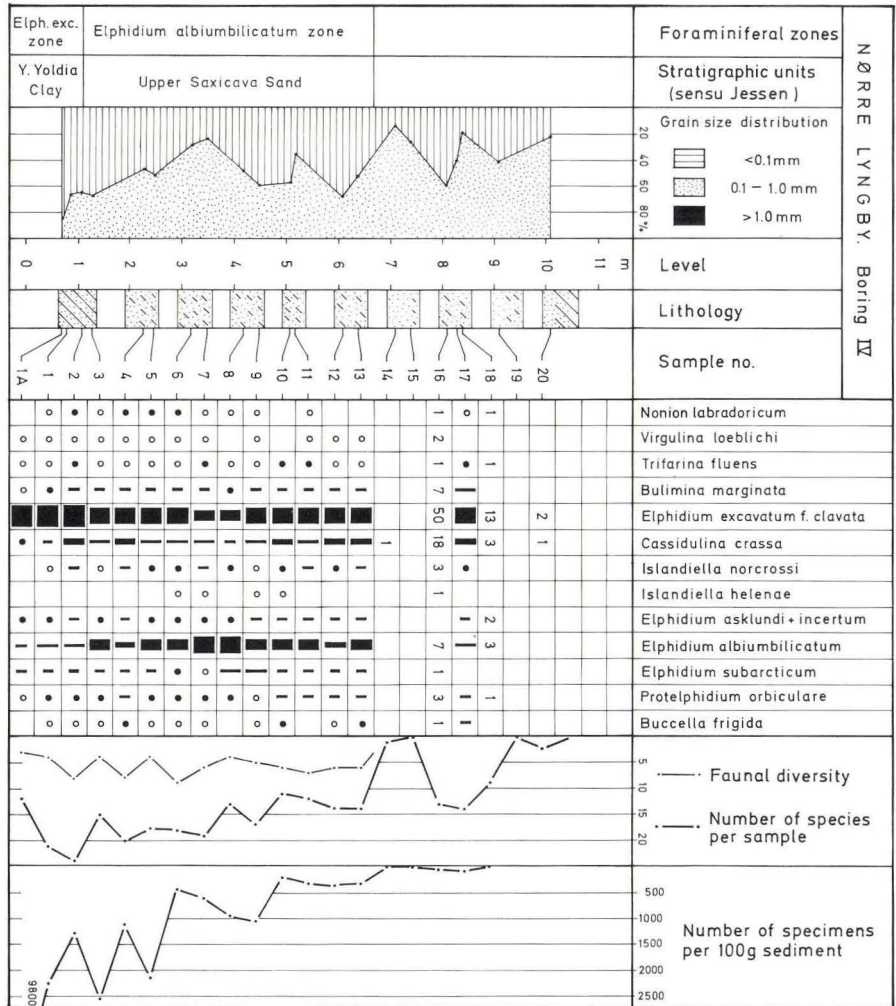


Fig. 8. Range chart for boring IV at Nørre Lyngby. Legend for lithology in fig. 3 and for foraminiferal frequencies in fig. 6.

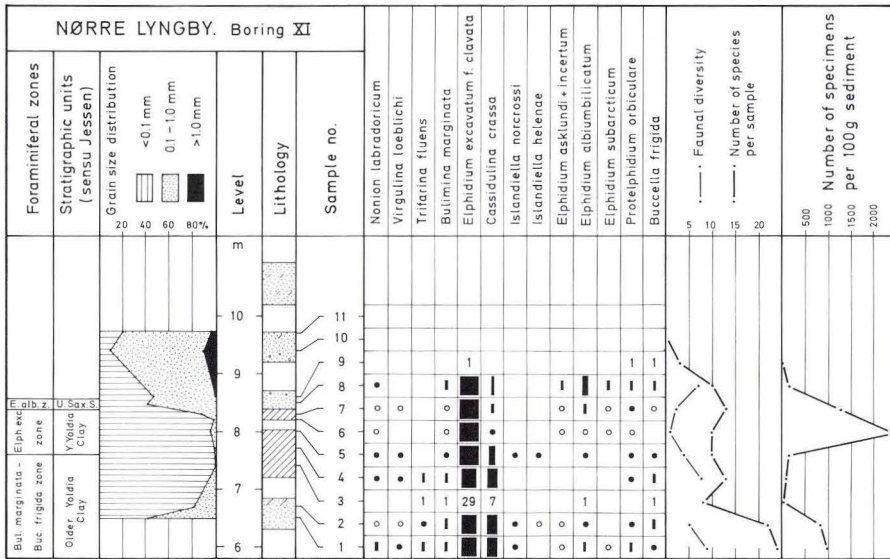


Fig. 9. Range chart for boring XI at Nørre Lyngby. Legend for lithology in fig. 3 and for foraminiferal frequencies in fig. 6.

sequence from a sandy clay in the lowermost part to a sandy deposit with scattered thin clay layers in the major part of the sequence. The lower sandy clay contains foraminiferal faunas, which are characteristic for the *E. excavatum* zone of the area. There is a very high dominance of *E. excavatum*, forma *clavata* in samples from this lower deposit. The content of *E. albiumbilicatum* in the faunas gradually increases from 4 % in the lowermost sample to 16–45 % in samples 3–13, indicating that these represent the *E. albiumbilicatum* zone of the area.

The marine sequence in boring IV is overlain by 8.5 m of freshwater sediments. There are a few foraminifera in the samples 14–20, but they are badly preserved and are considered to have been redeposited.

Boring XI is located about 700 m east of boring I (fig. 2). The bore site lies c. 14.5 m above sea level and the depth of the boring is 8.0 m. Lithology and distribution of selected species of foraminifera are shown in the range chart, fig. 9. The foraminiferal content in the lower 2.5 m of boring XI shows that these are marine deposits. The lower part is referred to the *B. marginata*-*B. frigida* zone, whereas the upper part represents the *E. excavatum* zone and the *E. albiumbilicatum* zone. The marine sequence in the boring is overlain by about 5 m freshwater sediments.

As shown on the location map, fig. 2, seven additional borings were carried

out north of borings IV and XI. Three of them only contained freshwater deposits, but the four borings in the northeastern part of the area contained glaciofluvial deposits and marine silt and sandy clay below the freshwater sediments. Only the *Bulimina marginata*-*Buccella frigida* zone was represented here.

# Foraminiferal zones

## Description, palaeoecology and distribution

### The *Bulimina marginata* – *Buccella frigida* zone

The foraminiferal assemblages of this zone are dominated by the two species *Elphidium excavatum*, forma *clavata* and *Cassidulina crassa*. The most common and characteristic accessory species are *Bulimina marginata*, *Buccella frigida*, *Nonion labradoricum*, *Islandiella norcrossi*, *Elphidium albiumbilicatum*, *Protelphidium orbiculare* and *Virgulina loeblichii*. The faunal diversity is usually 5–8 and the number of specimens only about 200–700 per 100 g sediment. The foraminiferal faunas of this assemblage zone are mainly arctic, but with a content of some boreal species.

The sediment of the *B. marginata*-*B. frigida* zone consists mainly of clayey silt or fine sand, but in some places also of sandy clay. This assemblage zone is found in the deeper parts of borings III and XI and also in some borings in the northeastern part of the area examined. The deposit occurs in the northern part of the cliff section below the *E. excavatum* zone. The thickness of the zone is not known.

### The *Elphidium subarcticum* zone

The foraminiferal faunas of this assemblage zone are dominated by *Elphidium excavatum*, forma *clavata*. Frequent species are *Cassidulina crassa*, *Elphidium subarcticum*, *E. albiumbilicatum*, *E. asklundi* and *Protelphidium orbiculare*. The high content of *E. subarcticum* is particularly characteristic of this zone. The faunal diversity varies from 5 to 8. An assemblage from the *E. subarcticum* zone is shown in plate 6, fig. 2. The faunas are shallow-water faunas indicating mainly arctic marine ecological conditions. However, the presence of *E. albiumbilicatum* in the faunas may indicate that the climate was not high-arctic.

The sediment of the present zone is mainly sand. It is found in boring III and in profile 4 of the Nørre Lyngby area, and the thickness is only about 1.5 m. In both localities the zone is clayey in its lower part, and it occurs within the *E. excavatum* zone.

The *Elphidium excavatum* zone

The foraminiferal faunas of the *E. excavatum* zone are characterized by very high dominance of the arctic form *Elphidium excavatum*, forma *clavata*, usually accounting for more than 85 % of the total fauna. *Cassidulina crassa* is second in number and in most of the faunas there are a few specimens of *Nonion labradoricum*, *Bulimina marginata*, *Elphidium asklundi*, *E. albiumbilicatum* and *E. subarcticum*. The faunal diversity is generally only 1–2, which is much lower than for the other assemblage zones of the area. An assemblage from the *E. excavatum* zone is shown in plate 6, fig. 1.

The faunas of the *E. excavatum* zone are arctic and the low faunal diversity indicates extreme marine ecological conditions. According to G. Vilks (pers. com.) the faunas are similar to recent foraminiferal faunas in stagnant basins of the arctic seas north of Canada, and according to J. Nagy (pers. com.) corresponding recent faunas are also recorded from sheltered lagoonal areas of Spitsbergen. During deposition of the *E. excavatum* zone at Nørre Lyngby the water was probably deeper than during deposition of the *E. subarcticum* zone, but more stagnant marine conditions might have been of greater importance for the difference in faunal composition.

The sediment of the *E. excavatum* zone consists of olive-grey clay usually with many thin sandy layers and lenses. The foraminiferal faunas in the thin sandy layers differ somewhat from those in the clay itself. In the lowermost part of the deposit the sand layers contain higher frequencies of the two species *Elphidium asklundi* and *E. subarcticum* and also some specimens of *E. albiumbilicatum* and *Protelphidium orbiculare*. The compositions of such faunas are similar to those of the *E. subarcticum* zone. Higher in the sequence of the *E. excavatum* zone, *E. asklundi* still occurs in the sandy layers, *E. subarcticum* is less common, whereas *E. albiumbilicatum* gradually becomes more common. All these species must in one way or another be connected with the deposition of sand instead of clay. They may either be dependent on sand directly as a substrate, or their occurrence may be caused by additional oxygen content or food supply during periods of better water circulation. The sand material and the foraminifera may also have been transported together into the present areas of clay deposition from more sandy shallow-water deposits by annual melting of inshore ice, or during periods of greater water circulation. The sand laminae perhaps reflect some kind of cyclic variation, although they do not resemble varves in the proper sense.

The faunal change in the sand laminae from *subarcticum* faunas in the lower part to *albiumbilicatum* faunas in the upper part of the *E. excavatum* zone is probably caused by a gradual amelioration in climate. It may also indicate a gradual lowering of the salinity, as the shallow-water species *E. albiumbilicatum* also tolerates lowered salinity.



*E. subarcticum* is a common species in arctic faunas. It was originally described from recent shallow-water faunas off the New England coast (Cushman 1944). *E. albiumbilicatum* was originally described from the interglacial Gardiners Clay, New York (Weiss 1954), and the species is common in recent boreal shallow and brackish water faunas (Lutze 1965). These two species are usually easily distinguishable, but in the present faunas from Nørre Lyngby there are often some difficulties in separating them. Some specimens clearly belong to *E. subarcticum*, others to *E. albiumbilicatum*, but transitional forms were found. Similar problems were also seen in faunas of the upper sandy part of the Hostrup Clay, which is inferred to represent the climatic amelioration near the end of the Elsterian Ice age (Knudsen 1977), and in the *Zirfaea* Beds of Bølling interstadial age (Jørgensen 1971 and Knudsen in prep.). Further investigations of the recent distributions of these two species and of living specimens in cultures might show that they are geographical variants of one species, *E. subarcticum* representing the arctic from the *E. albiumbilicatum* zone are shown in plate 7, figs. 1–2.

The *E. excavatum* zone is found as a nearly horizontally stratified deposit in the southern part of the cliff section at Nørre Lyngby. The thickness is from about 7 to more than 15 m. Close to the basin structure the layers dip to the north (fig. 3), and in boring I near the central part of the depression the present zone was not reached at 12.0 m below sea level. North of the depression the *E. excavatum* zone is again found in the cliff section, but here it is only from less than one to a few metres thick. According to the borings the succession of strata seems to be the same in the area east of the coastal cliff.

#### The *Elphidium albiumbilicatum* zone

The foraminiferal faunas of this assemblage zone are characterized by high frequencies of *Elphidium albiumbilicatum*. *Elphidium excavatum*, forma *clavata* is dominant, and common species are *Cassidulina crassa*, *Bulimina marginata*, *Elphidium asklundi* and *E. subarcticum*. The faunal diversities are higher than for the *E. excavatum* zone, usually about 5–10. Assemblages from the *E. albiumbilicatum* zone are shown in plate 7, figs. 1–2.

The sediment of the *E. albiumbilicatum* zone consists of sand with clayey layers in the lower part. The faunal composition together with the sandy sediment indicate changed environmental conditions compared to the conditions during deposition of the *E. excavatum* zone. The water was probably shallower, and a higher current velocity may have played an important role both for sediment and faunas. The increasing frequency of *E. albiumbilicatum* through the sand laminae in the uppermost part of the *E. excavatum* zone and in the *E. albiumbilicatum* zone are assumed to indicate rising temperatures, and perhaps also lowering salinities.

The *E. albiumbilicatum* zone is found above the *E. excavatum* zone at Nørre Lyngby. There is often a gradual transition from one zone to the other, both in sediment and fauna.

There is a remarkable increase in thickness of the *E. albiumbilicatum* zone towards the central part of the basin structure. The zone is only 2 m thick in profile 2, increasing to 10.5 m in the combined sequence of profile 1 and boring III and more than 14 m in boring I (fig. 3). The level of the upper boundary of this uppermost marine zone decreases from 13 m above sea level in profile 2 to 7.5 m a.s.l. in profile 1 and to about 2 m a.s.l. in boring I. The present foraminiferal zone is again found at a higher level in the cliff section north of boring I (fig. 3). This is believed to indicate a continuous sinking of the central part of this depression during deposition, as discussed later.

East of the coastal cliff the *E. albiumbilicatum* zone is only found in borings IV and XI in the southern part of the investigated area, also here beneath freshwater deposits.

## Correlation

### The *Bulimina marginata* – *Buccella frigida* zone

This zone, which is found in the northern part of the cliff section and in the lowermost part of several borings in the Nørre Lyngby area, is also described from a boring at Rubjerg about 2 km east of Nørre Lyngby (Abrahamsen & Knudsen in press). This assemblage zone may be correlated with part of the Older *Yoldia* Clay of Vendsyssel.

The composition of faunas are not exactly the same as in the Older *Yoldia* Clay, but they indicate marine ecological conditions corresponding to those indicated by the zone A faunas of the Older *Yoldia* Clay at Hirtshals (Andersen 1971) and the zone I faunas of the Skærumhede sequence (Konradi & Knudsen 1974, Knudsen 1976). These zones are correlated with the Middle Weichselian Sandnes interstadial, described by Feyling-Hanssen (1966, 1971, 1974). The foraminiferal faunas in all these deposits are mainly arctic, but with some boreal species. They thus indicate a milder period during the Middle Weichselian. Shell samples from the Sandnes Clay of the Sandnes-Jæren area have been radiocarbon dated at > 23,000 B.P. and 28,000–42,000 B.P. (Feyling-Hanssen 1974). These ages indicate that the Sandnes interstadial correlates with the Hengelo and Denekamp interstadials of the Netherlands (van der Hammen et al. 1971). A few specimens of *Hiatella arctica* have been found in the *B. marginata*-*B. frigida* zone at Nørre Lyngby, but not enough for radiocarbon dating.

The *Elphidium subarcticum* zone

The foraminiferal assemblage of the *Elphidium subarcticum* zone at Nørre Lyngby compares well with faunas from the Lower *Saxicava* Sand at Maarup about 6 km farther north in the cliff section (Jessen 1931, pl. II, post 26–36). A sample from this Lower *Saxicava* Sand contained the following foraminiferal species in 67 g sediment:

Lønstrup coast cliff, Maarup. Coll. Knudsen, 1969.

Species	Frequency	Percentage
<i>Elphidium excavatum</i> , f. <i>clavata</i> .....	189	57
<i>Elphidium subarcticum</i> .....	61	18
<i>Cassidulina crassa</i> .....	38	11
<i>Elphidium albiumbilicatum</i> .....	10	3
<i>Protelphidium orbiculare</i> .....	9	3
<i>Elphidium asklundi</i> .....	8	2
Polymorphinidae .....	3	1
<i>Bulimina marginata</i> .....	3	1
<i>Nonion labradoricum</i> .....	2	1
<i>Virgulina loeblichii</i> .....	1	<1
<i>Trifarina fluens</i> .....	1	<1
<i>Islandiella islandica</i> .....	1	<1
<i>Islandiella norcrossi</i> .....	1	<1
<i>Buccella frigida</i> .....	1	<1
<i>Epistominella takayanagii</i> .....	1	<1
<i>Elphidium bartletti</i> .....	1	<1
<i>Elphidium magellanicum</i> .....	1	<1
Total	331	

The faunal diversity of the sample is 7. The distribution of species is very close to those found in the *E. subarcticum* zone at Nørre Lyngby, and the present zone is inferred to correspond to the Lower *Saxicava* Sand of Vendsyssel. This deposit was described by Jessen in 1899 as the lower Late-glacial shore deposit and later, in 1918, 1931 and 1936 as the Lower *Saxicava* Sand.

At Nørre Lyngby this sandy facies occurs within the lower part of the clayey *E. excavatum* zone, whereas at Maarup the Lower *Saxicava* Sand rests directly upon a till, which is probably marine in its upper part. However, according to Jessen (1931) the Lower *Saxicava* Sand at Maarup, which is up to about 16–18 m thick, also contains some clayey layers in the lower part of the section.

A radiocarbon date of shells (*Hiatella arctica* (Linné)) from the Lower

*Saxicava* Sand at Maarup gave an age of 13,900 ± 220 B.P. (Tauber 1966 a, b, Krog & Tauber 1974). Radiocarbon dates from marine deposits at Nørre Lyngby and from other localities in Vendsyssel are summarized in table 1:

Table 1. Radiocarbon dates from marine Late-glacial deposits at Nørre Lyngby (this paper) and other localities in Vendsyssel (Krog & Tauber 1974).

	Nørre Lyngby	Other localities in Vendsyssel
Zirfaea Beds		11,950±190 – 12,770±190 B.P.
Upper <i>Saxicava</i> Sand	(?) 14,310±180 B.P.	
Younger <i>Yoldia</i> Clay	14,270±180 B.P.	12,650±180 – 14,280±240 B.P.
Boundary Y. <i>Yol.</i> C./L. <i>Sax.</i> S.	14,650±190 B.P.	
Lower <i>Saxicava</i> Sand		13,900±220 B.P.

A sediment layer of about 30 cm in profile 4 comprising the upper part of the *E. subarcticum* zone and the lower part of the overlying clay (the *E. excavatum* zone) was rich in mollusc shells, all belonging to one species, *Hiatella arctica*, and most of them in their living position in the sediment. Shells from that

STAGE	SUBSTAGE	CHRONO-ZONE	FORAMINIFERAL ZONES	STRATIGRAPHIC UNITS (sensu Jessen)	
Weichselian	Late Weichselian	Younger Dryas			
		Allerød			
		Older Dryas			
	Middle Weichselian	Bølling	Elphidium albiumbilicatum zone	Upper <i>Saxicava</i> Sand	
		Sandnes	Denekamp Hengelo	<i>E. excavatum</i> zone with <i>E. subarcticum</i> zone	Younger <i>Yoldia</i> Clay with Lower <i>Saxicava</i> Sand
				Bulimina marginata - <i>Buccella frigida</i> zone	Older <i>Yoldia</i> Clay

Fig. 10. Stratigraphic correlations of foraminiferal zones and stratigraphic units (sensu Jessen 1918, 1936) in the Nørre Lyngby area. Chronostratigraphic subdivisions after Mangerud et al. (1974).

level were collected for radiocarbon dating, and yielded the age of  $14,650 \pm 190$  B.P. (K-2670). The similarity of both foraminiferal faunas and radiocarbon ages justifies a correlation of the *E. subarcticum* zone at Nørre Lyngby with the Lower *Saxicava* Sand at Maarup. They may not be of exactly equal age, but corresponding marine ecological conditions must have prevailed during their deposition. Lower *Saxicava* Sand has not previously been recognized at Nørre Lyngby.

The Lower *Saxicava* Sand of Vendsyssel has earlier been correlated with pollen zone I a (Oldest *Dryas*) by S. Hansen (1965), Iversen (1967, 1973), Krog (1968) and Feyling-Hanssen et al. (1971). According to the chronostratigraphic subdivision of the Weichselian proposed by Mangerud et al. (1974), the present deposit belongs in the later part of the Middle Weichselian (fig. 10). Radiocarbon dates from the Lower *Saxicava* Sand infer that this shallow water facies may have been deposited during a lowering in sea level of about 10 m described by Mörner (1969, 1971). He suggested this to have taken place from about 15,000 B.P. until about 13,750 B.P. with minor oscillation, and correlated it with a temporary but distinct and worldwide climatic deterioration (Mörner 1973).

#### The *Elphidium excavatum* zone

The foraminiferal faunas of the *Elphidium excavatum* zone are similar to those described from the Younger *Yoldia* Clay elsewhere in Vendsyssel (Jørgensen 1971, Knudsen 1971) and the present assemblage zone is correlated with that deposit. Jessen (1899, 1918, 1931, 1936) and Jessen & Nordmann (1915) described this stratigraphic unit as the Late-glacial *Yoldia* Clay, but later it was called the Younger *Yoldia* Clay to distinguish it from the Weichselian interstadial and stadial Older *Yoldia* Clay of Vendsyssel (Feyling-Hanssen et al. 1971).

Two radiocarbon dates were obtained on shells from the *E. excavatum* zone at Nørre Lyngby. Besides the date mentioned above from the lowermost part of the clay and the underlying sand in profile 4 ( $14,650 \pm 190$  B.P.) shells of *Hiatella arctica* from a higher level in the zone about 200 m north of profile 4 (collected by N. Abrahamsen) were dated at  $14,270 \pm 180$  B.P. (K-2671) (see also table 1, p. 28). The Younger *Yoldia* Clay of Vendsyssel was earlier dated at  $12,650 \pm 180$  B.P. –  $14,280 \pm 240$  B.P. (Tauber 1966 a, b, Krog & Tauber 1974). Together with the Lower *Saxicava* Sand this deposit has also been correlated with pollen zone I a (Oldest *Dryas*) (S. Hansen 1965, Iversen 1967, 1973, Krog 1968, Feyling-Hanssen et al. 1971).

As the boundaries for pollen zone I a are difficult to define, van der Hammen (1957) and van der Hammen & Vogel (1966) suggested the Oldest *Dryas* to be included in the Bølling interstadial (sensu lato), which accord-

ingly represents the beginning of Late-glacial time. Its lower boundary was suggested to be about 13,300 B.P. (van der Hammen 1957). In 1974 Mangerud et al. followed that suggestion, proposing the lower boundary for Bølling s.l. to be defined at 13,000 B.P. According to this chronostratigraphic subdivision a major part of the Younger *Yoldia* Clay (*E. excavatum* zone) of Vendsyssel belongs in late Middle Weichselian time, but at least in some places the deposition of clay continued into the Late Weichselian Bølling interstadial (fig. 10).

#### The *Elphidium albiumbilicatum* zone

The sandy sequence, the *Elphidium albiumbilicatum* zone, which in many places overlies the *E. excavatum* zone (Younger *Yoldia* Clay) corresponds to the deposit described by Jessen in 1899 as the upper Late-glacial shore deposit, and later, in 1918, 1931 and 1936, as the Upper *Saxicava* Sand.

A radiocarbon date on shells (*Hiatella arctica*) from the *E. albiumbilicatum* zone (Upper *Saxicava* Sand) of profile 2 in the coastal cliff at Nørre Lyngby yielded an age of  $14,310 \pm 180$  B.P. (K-2413). The material was, however, rather unsuitable for dating as it consisted of weathered valves and fragments of *Hiatella arctica*, which may have been reworked from older deposits. This date thus gives only a maximum age for the deposit. Elsewhere in Vendsyssel shells from the Upper *Saxicava* Sand for radiocarbon dating were not found. Usually this deposit has earlier been correlated with the upper part of pollen zone I a (Oldest *Dryas*) (S. Hansen 1965, Iversen 1967, 1973, Krog 1968, Feyling-Hanssen et al. 1971).

Beach deposits with boreo-arctic mollusc faunas from Borgbakke and Raaholt at Frederikshavn have previously been referred to the Upper *Saxicava* Sand by Jessen (1936). Radiocarbon dates of three samples from these deposits ranged from  $12,020 \pm 180$  B.P. to  $12,400 \pm 180$  B.P. (Krog & Tauber 1974), which is within the age range of the Bølling interstadial (pollen zone I b). A correlation of these layers with the *Zirfaea* Beds of north-western Vendsyssel has also previously been proposed by Jessen (1899) and by Krog (1968). As mentioned above, Jessen later changed this interpretation.

Because of the rising temperature, which is indicated by the foraminiferal faunas in the *E. albiumbilicatum* zone (Upper *Saxicava* Sand) at Nørre Lyngby, it is suggested that this deposit may also belong in the Bølling interstadial. This might also be the case for other deposits of Upper *Saxicava* Sand in Vendsyssel. However, as the biostratigraphical boundary between the *E. excavatum* zone and the *E. albiumbilicatum* zone and the lithological change from clay to sand are presumably not synchronous, possibly only part of the Upper *Saxicava* Sand belongs in the Bølling interstadial (fig. 10). In connec-

tion with this it should be mentioned that a peat layer in the freshwater deposits above the *E. albiumbilicatum* zone at Nørre Lyngby has been dated to between late Bølling and early Allerød time (Krog 1978). This peat was inferred by Krog to consist of redeposited material.

In order to compare the foraminiferal faunas of the *E. albiumbilicatum* zone (Upper *Saxicava* Sand) at Nørre Lyngby with faunas from radiocarbon dated marine sediments of Bølling interstadial age, samples from the *Zirfaea* Beds in northwestern Vendsyssel have been analysed. Shells from this mostly sandy deposit have been dated at  $12,770 \pm 190$  B.P. to  $11,950 \pm 190$  B.P. (Krog & Tauber 1974) (see also table 1, p. 28). A sample from the *Zirfaea* Beds at Skeen Møllebæk contained the following foraminifera in one third of 100 g sediment (see also Knudsen 1977):

Skeen Møllebæk, *Zirfaea* Beds. Coll. Knudsen 1972.

Species	Frequency	Percentage
<i>Elphidium excavatum</i> , forma <i>clavata</i> .....	388	79
<i>Cassidulina crassa</i> .....	41	8
<i>Elphidium albiumbilicatum</i> .....	35	7
<i>Buccella frigida</i> .....	10	2
<i>Elphidium subarcticum</i> .....	8	2
<i>Protelphidium orbiculare</i> .....	2	<1
<i>Lagena semilineata</i> .....	1	<1
<i>Guttulina lactea</i> .....	1	<1
<i>Virgulina loeblichii</i> .....	1	<1
<i>Trifarina fluens</i> .....	1	<1
<i>Islandiella norcrossi</i> .....	1	<1
<i>Epistominella takayanagii</i> .....	1	<1
<i>Cibicides lobatulus</i> .....	1	<1
<i>Nonion depressula</i> .....	1	<1
<i>Elphidium asklundi</i> .....	1	<1
<i>Elphidium gerthi</i> .....	1	<1
Total .....	494	

Six other species were observed in the sample in addition to those listed above. The faunal diversity is 4, and the number of specimens per 100 g sediment is about 1500.

This foraminiferal fauna, which indicates increasing water temperature compared to the underlying arctic *E. excavatum* zone (Younger *Yoldia* Clay) faunas, is very much like those described above from the *E. albiumbilicatum* zone (Upper *Saxucava* Sand). The molluscan faunas are, however, different in the two deposits. The *Zirfaea* Beds contain a boreo-arctic mollusc fauna, whereas only a few specimens of one mollusc species, *Hiatella arctica*, were

found in the Upper *Saxicava* Sand. This may, however, have been caused by local ecological differences which did not affect the foraminiferal faunas.

According to Jessen (1936) there are indications of a break in sedimentation in the outcrops at Skeen Møllebæk between the Younger *Yoldia* Clay below and the *Zirfaea* Beds above.

Krog & Tauber (1974) demonstrated an age difference of 840 years between the uppermost part of the Younger *Yoldia* Clay and the lowermost part of the *Zirfaea* Beds. However, in a 31 m deep boring just south of Skeen Møllebæk (Knudsen in prep.) there seems to be a gradual transition from the Younger *Yoldia* Clay into a sandy deposit with foraminiferal faunas as found in the *Zirfaea* Beds. The change in faunal composition in this boring corresponds to that found in the sequences at Nørre Lyngby leading from the Younger *Yoldia* Clay into the Upper *Saxicava* Sand. Additional radiocarbon dates may contribute to solve these chronostratigraphical problems.



# Foraminifera

The foraminiferal species found in Middle and Late Weichselian deposits of the Nørre Lyngby area are arranged alphabetically in the following list, and selected species are illustrated in plates 1–5. For original references, synonymy lists, taxonomic remarks, and additional illustrations of the species mentioned in the present work, the reader is referred to the systematic section of Feyling-Hanssen et al., 1971. Only for later erected species, for additional species and when taxonomic problems makes it necessary, a few references have been added in the list.

In addition to the 72 listed species, there are some species belonging to the family Polymorphinidae, i.a. *Guttulina austriaca* d'Orbigny, 1846, *G. lactea* (Walker & Jacob, 1798) and *Pseudopolymorphina novangliae* (Cushman, 1923). As the Polymorphinidae usually account for less than 1 % of the fauna, they have been counted as a group in the present material, and the species are therefore not entered in the list.

The frequencies of the most common and characteristic species in the deposits are shown in range charts (figs. 4–9). Other species only occur scattered in the deposits, and usually they account for less than 1 % of the faunas.

The figured specimens and faunas, Catalogue No. 1976-KLK-1 to 1976-KLK-39 and 1976-KLK-F1 to 1976-KLK-F4, are kept in the Department of Micropalaeontology, Geological Institute, University of Aarhus, DK-8000 Aarhus C, Denmark.

- Ammonia batavus* (Hofker, 1951). Pl. 3, fig. 11  
*Astrononion gallowayi* Loeblich & Tappan, 1953  
*Bolivina pseudoplicata* Heron-Allen & Earland, 1930  
*Bolivina* cf. *robusta* Brady, 1884  
*Buccella frigida* (Cushman, 1922). Pl. 1, figs. 15–16  
*Buccella tenerrima* (Bandy, 1950)  
*Buccella wrightii* (Brady, 1881)  
1881: *Discorbina wrightii* Brady: *Quart. f. Micr. sci.* 21, p. 413, pl. 21, fig. 6.  
*Bulimina fossa* Cushman & Parker, 1938  
*Bulimina marginata* d'Orbigny, 1826. Pl. 1, figs. 2–3  
*Buliminella elegantissima* (d'Orbigny, 1839)  
*Cassidulina crassa* d'Orbigny, 1839. Pl. 1, figs. 7–8  
*Cassidulina laevigata* d'Orbigny, 1826  
*Cibicides lobatulus* (Walker & Jacob, 1798)  
*Cibicides pseudoungerianus* (Cushman, 1922)  
*Elphidium albiumbilicatum* (Weiss, 1954). Pl. 2, figs. 3–7; pl. 4, figs. 1–5  
*Elphidium articulatum* (d'Orbigny, 1839)

- 1839: *Polystomella articulata* d'Orbigny: *Voyage dans l'Amerique Méridionale – Foraminifères*. 5 (5). (Atlas 9, 1847). Paris, p. 30, pl. 3, figs. 9–10.
- 1971: *Elphidium umbilicatum* (Williamson) – Knudsen, in Feyling-Hanssen et al.: *Bull. geol. Soc. Denmark* 21, p. 281, pl. 13, figs. 8–11, pl. 23, figs. 1–4.
- 1977: *Elphidium williamsoni* Haynes – Hansen & Andersen: *Fossils and Strata* 10, p. 9–10, pl. 5, figs. 1–6.
- Elphidium asklundi* Brotzen, 1943. Pl. 2, figs. 8–9; pl. 3, fig. 1; pl. 4, figs. 6–8
- Elphidium bartletti* Cushman, 1933. Pl. 3, fig. 2
- Elphidium excavatum* (Terquem), forma *clavata* Cushman, 1930. Pl. 3, figs. 3–5; pl. 5, figs. 1–4
- 1930: *Elphidium incertum* (Williamson), var. *clavatum* Cushman: *U. S. nat. Mus., Bull.* 104, p. 20, pl. 7, fig. 10.
- 1972: *Elphidium excavatum* (Terquem) forma *clavata* Cushman – Feyling-Hanssen: *Micropaleontology* 18 (3), p. 339, pl. 1, figs. 1–9, pl. 2, figs. 1–9.
- Elphidium gerthi* van Voorthuysen, 1957
- Elphidium groenlandicum* Cushman, 1933
- Elphidium incertum* (Williamson, 1858)
- Elphidium macellum* (Fichtel & Moll, 1798)
- Elphidium magellanicum* Heron-Allen & Earland, 1932
- Elphidium margaritaceum* Cushman, 1930
- Elphidium subarcticum* Cushman, 1944. Pl. 3, figs. 6–8; pl. 5, figs. 5–8
- Elphidium ustulatum* Todd, 1957
- Eoeponidella laesoeensis* Michelsen, 1967
- Epistominella takayanagii* Iwasa, 1955
- Fissurina danica* (Madsen, 1895)
- Fissurina laevigata* Reuss, 1850
- Fissurina lucida* (Williamson, 1848)
- Fissurina marginata* (Montagu, 1803)
- Glandulina laevigata* d'Orbigny, 1826
- Hyalinea baltica* (Schroeter, 1783). Pl. 1, figs. 17–18
- Islandiella helenae* Feyling-Hanssen & Buzas, 1976. Pl. 1, figs. 9–10
- 1976: *Islandiella helenae* Feyling-Hanssen & Buzas: *Journ. of Foram. Res.* 6 (2), p. 156, figs. 1–4.
- Islandiella islandica* (Nørvang, 1945). Pl. 1, figs. 11–12
- Islandiella norcrossi* (Cushman, 1933). Pl. 1, figs. 13–14
- Lagena laevis* (Montagu, 1803)
- Lagena semilineata* Wright, 1886
- Lagena striata* (d'Orbigny, 1939), forma *typica*
- Laryngosigma hyalascidia* Loeblich & Tappan, 1953
- Laryngosigma williamsoni* (Terquem, 1878)
- Nonion barleeanum* (Williamson, 1858)
- Nonion depressula* (Walker & Jacob, 1798)
- 1978 *Nautilus depressulus* Walker & Jacob in Adams, G.: *Essays on the Microscope*. Kanmacher, Ed. 2, London, p. 641, fig. 33.
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- Nonion labradoricum* (Dawson, 1960). Pl. 2, figs. 1–2
- Oolina acuticosta* (Reuss, 1862)
- Oolina borealis* Loeblich & Tappan, 1954
- Oolina caudigera* (Wiesner, 1931)
- Oolina hexagona* (Williamson, 1848)
- Oolina lineata* (Williamson, 1848)
- Oolina melo* d'Orbigny, 1839
- Oolina williamsoni* (Alcock, 1865)
- Parafissurina lateralis* (Cushman), forma *simplex* (Buchner, 1940)
- Parafissurina tectulostoma* Loeblich & Tappan, 1953
- Patellina corrugata* Williamson, 1858
- Pateoris hauerinoides* (Rhumbler, 1936)
- Protelphidium anglicum* Murray, 1965
- Protelphidium orbiculare* (Brady, 1881). Pl. 3, figs. 9–10
- Pullenia bulloides* (d'Orbigny, 1826)
- Pullenia subcarinata* (d'Orbigny, 1839)
- Pyrgo williamsoni* (Silvestri, 1858)
- Quinqueloculina agglutinata* Cushman, 1917
- Quinqueloculina seminulum* (Linné, 1758). Pl. 1, fig. 1

*Quinqueloculina stalker* Loeblich & Tappan,  
1953

*Textularia sagitulla* DeFrance, 1824  
1824: *Textularia sagittula* DeFrance: *Dict.  
des Sci. Nat.* 32, p. 177.

*Trifarina angulosa* (Williamson, 1858)

*Trifarina fluens* (Todd, 1947). Pl. 1, fig. 6

*Uvigerina peregrina* Cushman, 1923. Pl. 1,  
fig. 5

*Virgulina fusiformis* (Williamson, 1858)

*Virgulina loeblich* Feyling-Hanssen, 1954.  
Pl. 1, fig. 4

*Virgulina schreibersiana* Czjzek, 1848

## Conclusions

After deglaciation of the Nørre Lyngby region in the later part of the Middle Weichselian the lower areas were transgressed by the so-called *Yoldia* Sea. The substratum of this Late-glacial marine transgression was partly glaciofluvial sand and clay and partly a marine deposit, which is here called the *Bulimina marginata-Buccella frigida* zone. Based on the foraminiferal content and the stratigraphic position in the cliff section and borings, this assemblage zone is inferred to represent the upper part of the Older *Yoldia* Clay of Vendsyssel, i.e. of Middle Weichselian interstadial age.

The marine Late-glacial deposits in the Nørre Lyngby area are divided in three foraminiferal assemblage zones, the *Elphidium subarcticum* zone, which is correlated with the Lower *Saxicava* Sand, the *E. excavatum* zone, which is correlated with the Younger *Yoldia* Clay and the *E. albiumbilicatum* zone, which is correlated with the Upper *Saxicava* Sand of Vendsyssel. *Elphidium excavatum*, forma *clavata* is the dominant form in all three zones, but in the *E. excavatum* zone, there are especially high frequencies of this form. The *E. subarcticum* zone is characterised by high frequencies of *E. subarcticum* together with other species of *Elphidium*, whereas the *E. albiumbilicatum* zone is characterized by a high content of *E. albiumbilicatum* in addition to increases of other species. The foraminiferal faunas of the *E. subarcticum* zone (Lower *Saxicava* Sand) and the *E. excavatum* zone (Younger *Yoldia* Clay) are mainly arctic, whereas the *E. albiumbilicatum* zone (Upper *Saxicava* Sand) faunas are considered to be boreo-arctic.

Based on radiocarbon dates (table 1, p. 28) the *E. subarcticum* zone and a major part of the *E. excavatum* zone are suggested to belong in late Middle Weichselian. The influence of boreal foraminiferal species in the *E. albiumbilicatum* zone infers that this zone might be of Late Weichselian Bølling interstadial age (fig. 10).

In the Nørre Lyngby area the *E. subarcticum* zone, or the Lower *Saxicava* Sand, occurs as an only 1.5 m thick sandy facies within the lower part of the *E. excavatum* zone (Younger *Yoldia* Clay).

The *E. excavatum* zone, or the Younger *Yoldia* Clay, has a thickness of up to more than 15 m and is found as nearly horizontally stratified deposits in the southern part of the cliff section. In some places this clay is overlain by a

sandy deposit of variable thickness, the *E. albiumbilicatum* zone, or the Upper *Saxicava* Sand. The foraminiferal faunas indicate decreasing water depth during deposition of this uppermost marine zone. Isostatic adjustments after deglaciation caused the present areas to emerge above sea level.

Farther north in the cliff section the surface of the marine deposits forms a depression, which is filled with Late-glacial freshwater deposits. Beneath the central part of this basin the *E. albiumbilicatum* zone has a thickness of at least 14 m, whereas about 100 m south of the centre it is only 2 m thick. Borings show that this depression can be followed from the cliff section inland towards east, and that about a similar succession of strata in the marine deposits is found in that direction.

This east-west trending depression may represent a deep valley formed prior to the Late-glacial transgression, either by the ice itself, or by meltwater streams during deglaciation, or a combination of these factors. However, the dip of the layers and the rapid increase in thickness of the *E. albiumbilicatum* zone towards the central part of the depression indicate continuous sinking of the basin during deposition. According to H. Lykke Andersen (pers. com.) seismic measurements in the area show a fault line in the chalk below the Nørre Lyngby depression. This fault might well have been active during the Quaternary, and may be the reason for continuous sinking of the basin during deposition of the present Middle and Late Weichselian (Bølling interstadial) deposits, and thus probably also for the slidings of the marine layers in the northern part of the basin. Another possible reason might have been gradual melting of buried ice in the area.

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# Dansk sammendrag

Midt og sen Weichselien marine aflejringer ved Nørre Lyngby, Nordjylland, Danmark, og deres foraminifer-faunaer.

I kystklinten ved Nørre Lyngby i Vendsyssel ses et snit gennem marine, glaciofluviale og limniske Pleistocæne aflejringer. Der er foretaget kvantitative analyser af fossile benthoniske foraminiferfaunaer i de marine sedimenter dels fra kystklinten og boreriger i stranden ved klintens fod og dels fra en serie boreriger i området øst for klinten. De undersøgte marine aflejringer er på grundlag af foraminiferindholdet inddelt i fire faunazoner.

Den nederste zone indeholder en fauna, som domineres af de to arter *Elphidium excavatum*, forma *clavata* og *Cassidulina crassa*. Andre karakteristiske arter er *Bulimina marginata*, *Islandiella norcrossi*, *Elphidium albiumbilicatum* og *Buccella frigida*, og zonen er her kaldt *Bulimina marginata-Buccella frigida* zonen. Faunaen er arktisk med et indhold af enkelte mere varme-krævende arter, og zonen synes at kunne korreleres med den øvre del af det Ældre *Yoldia* Ler i Vendsyssel, som er henført til Sandnes interstadialen af midt Weichselien alder. *B. marginata-B. frigida* zonen sedimenter består hovedsagelig af leret silt eller finsand. Aflejringen forekommer dels i den nordlige del af kystklinten ved Nørre Lyngby, dels i den dybeste del af boring III samt i flere boreriger i den nordlige og østlige del af det undersøgte område (fig. 2 og 3).

I store dele af Nørre Lyngby området er *B. marginata-B. frigida* zonen aflejringer, og visse steder også de glaciofluviale aflejringer, overlejret af marine Sen-glaciale aflejringer. Denne marine serie er inddelt i tre faunazoner på grundlag af foraminiferer, *Elphidium subarcticum* zonen, *E. excavatum* zonen og øverst *E. albiumbilicatum* zonen. *Elphidium excavatum*, forma *clavata* er en dominerende form i alle disse zoner, men faunaen i *E. excavatum* zonen er specielt karakteriseret af en meget høj dominans af denne form. *E. subarcticum* zonen er karakteriseret af en ret stor hyppighed af *E. subarcticum* sammen med *E. asklundi*, *E. albiumbilicatum* og *Protelphidium orbiculare*. *E. albiumbilicatum* zonen er karakteriseret dels af *E. albiumbilicatum*, dels af stigende frekvens af *Cassidulina crassa*, *Bulimina marginata* og en del andre arter, som ikke er almindelige i *E. excavatum* zonen.

Faunaerne i *E. subarcticum* zonen og i *E. excavatum* zonen er hovedsagelig arktiske, og disse zoner er korreleret med henholdsvis Nedre *Saxicava* Sand og Yngre *Yoldia* Ler i Vendsyssel. Faunaen i *E. albiumbilicatum* zonen er

tolket som boreo-arktisk, og denne zone er korreleret med Øvre *Saxicava* Sand. Det skal nævnes, at en detaljeret undersøgelse af foraminiferfaunaerne gennem *E. excavatum* zonen sedimenter synes at afspejle en gradvis stigende temperatur og måske samtidig en lavere saltholdighed allerede under aflejringen af disse.

*E. subarcticum* zonen (Nedre *Saxicava* Sand) er kun fundet på to lokaliteter ved Nørre Lyngby. Den forekommer som en 1,5 m tyk, sandet facies inden for den allernederste del af *E. excavatum* zonen (Yngre *Yoldia* Ler). *E. excavatum* zonen forekommer i næsten hele klintens udstrækning ved Nørre Lyngby, i den sydlige del som en nogenlunde horisontalt lagdelt ler af op til mere end 15 m tykkelse. Visse steder overlejres den konkordant af en sandet lagserie, *E. albiumbilicatum* zonen (Øvre *Saxicava* Sand). Overfladen af den marine lagserie danner i den nordlige del af klinten en bassinformet depression af omkring 200 m udstrækning og indtil ca. 15 m dybde. Denne depression er fyldt med en Sen-glacial ferskvands-lagserie. I kystklinten nord for bassinet forekommer *E. excavatum* zonen og *E. albiumbilicatum* zonen atter i et højt niveau. De overlejrer her dels glaciofluviale sedimente og dels *B. marginata*-*B. frigida* zonen aflejringer. Langs nordflanken af bassinstrukturen er de marine aflejringer forstyrrede på grund af senere udskridninger i bassinet.

Der er en stærkt tiltagende tykkelse af den øverste marine zone, *Elphidium albiumbilicatum* zonen (Øvre *Saxicava* Sand), mod den centrale del af bassinet. Zonen er omkring 2 m tyk ved bassinets sydlige begrænsning (profil 2) og tiltager til mere end 14 m under den centrale del (boring I). Boringerne øst for klinten viser, at nogenlunde det samme aflejningsmønster kan følges gennem en depression, som strækker sig i øst-vestlig retning.

Selve bassinstrukturen og den stærkt tiltagende lagtykkelse af den øverste marine zone mod den centrale del, synes at pege i retning af en kontinuerlig indsykning af bassinet samtidig med aflejringen af *E. albiumbilicatum* zonen sedimente. Dannelsen af dette bassin samt forstyrrelserne i lagene langs nordflanken kan muligvis knyttes sammen med Kvartære bevægelser langs en forkastning, som ved hjælp af seismiske målinger er registreret i kalken under Nørre Lyngby. En anden mulig årsag til bassindannelsen kan have været langsom bortsmeltning af dødis i området.

Der er foretaget én C-14 datering fra grænsen mellem *E. subarcticum* zonen (Nedre *Saxicava* Sand) og *E. excavatum* zonen (Yngre *Yoldia* Ler) og én fra et højere niveau i *E. excavatum* zonen aflejringer ved Nørre Lyngby. Disse dateringer gav aldre på henholdsvis  $14.650 \pm 190$  B.P. og  $14.270 \pm 180$  B.P. Andre steder i Vendsyssel er Yngre *Yoldia* Ler dateret til mellem  $14.280 \pm 240$  B.P. og  $12.650 \pm 180$  B.P. Ifølge den kronostratigrafiske inddeling, som er foreslået af Mangerud et al. (1974), synes således i hvert



fald størstedelen af det Yngre *Yoldia* Ler i Vendsyssel at være af sen midt Weichselien alder (fig. 10).

Foruden ovennævnte datering fra grænsen mellem Nedre *Saxicava* Sand og Yngre *Yoldia* Ler, foreligger en enkelt datering af skaller fra Nedre *Saxicava* Sand (ved Maarup), som gav en alder på  $13.900 \pm 220$  B. P. Dannelsen af denne sandede facies i den nedre del af *E. excavatum* zonen ved Nørre Lyngby kan muligvis sættes i forbindelse med en sænkning af havspejlet på omkring 10 m, som menes at have fundet sted under en koldere periode fra omkring 15.000 B.P. frem til omkring 13.700 B.P.

Der foreligger kun en enkelt datering fra *E. albiumbilicatum* zonen (Øvre *Saxicava* Sand) ved Nørre Lyngby. Da skallerne muligvis kan være omlejrrede er dateringen ret usikker. Den gav en alder på  $14.310 \pm 180$  B.P. Der findes ingen C-14 dateringer fra sikkert Øvre *Saxicava* Sand andre steder i Vendsyssel. En sammenligning af foraminiferfaunaerne i *E. albiumbilicatum* zonen (Øvre *Saxicava* Sand) ved Nørre Lyngby med faunaer fra *Zirfaea* lagene ved Skee Møllebæk, som er dateret til Bølling interstadial tid, viser, at der er meget stor lighed mellem disse. Bedre dateringer af det Øvre *Saxicava* Sand ville sandsynligvis vise, at denne aflejring, eller i hvert fald en del af den, også kan henregnes til Bølling interstadial tid. Da de lithologiske grænser mellem de marine Sen-glaciale zoner i Vendsyssel imidlertid må formodes at være diakrone, kan kun yderligere biostratigrafiske undersøgelser kombineret med en serie C-14 dateringer løse disse mere detaljerede stratigrafiske problemer.

På grund af samspillet mellem isostatisk og eustatisk bevægelser efter Weichseliens afsmeltning blev Nørre Lyngby området efter dannelsen af Øvre *Saxicava* Sand omdannet til et landområde.

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# Plates

Plate 1

Miliolidae, Buliminidae, Cassidulinidae, Discorbidae, Anomalinidae	Catalogue No.	Text page
Fig. 1. <i>Quinqueloculina seminulum</i> (Linné, 1758) . . . . .		34
Specimen from the <i>E. subarcticum</i> zone (Lower <i>Saxicava</i> Sand) of bor. III, spl. no. 8, Nørre Lyngby; × 75 . . . . .	1976-KLK-1	
Figs. 2–3. <i>Bulimina marginata</i> d’Orbigny, 1826 . . . . .		33
Fig. 2. Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxicava</i> Sand) of bor. III, spl. no. 27, Nørre Lyngby; × 75 . . . . .	1976-KLK-2	
Fig. 3. Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxicava</i> Sand) of bor. III, spl. no. 26, Nørre Lyngby; × 75 . . . . .	1976-KLK-3	
Fig. 4. <i>Virgulina loeblichii</i> Feyling-Hanssen, 1954 . . . . .		35
Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxicava</i> Sand) of bor. IV, spl. no. 4, Nørre Lyngby; × 75 . . . . .	1976-KLK-4	
Fig. 5. <i>Uvigerina peregrina</i> Cushman, 1923 . . . . .		35
Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxicava</i> Sand) of profile 1, spl. no. 5, Nørre Lyngby; × 75 . . . . .	1976-KLK-5	
Fig. 6. <i>Trifarina fluens</i> (Todd, 1947) . . . . .		35
Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxicava</i> Sand) of bor. I, spl. no. 25, Nørre Lyngby; × 75 . . . . .	1976-KLK-6	
Figs. 7–8. <i>Cassidulina crassa</i> d’Orbigny, 1839 . . . . .		33
Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxicava</i> Sand) of bor. III, spl. no. 25, Nørre Lyngby; × 75 . . . . .	1976-KLK-7	
Figs. 9–10. <i>Islandiella helenae</i> Feyling-Hanssen & Buzas, 1976 . . . . .		34
Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxicava</i> Sand) of profile 2, Nørre Lyngby; × 75 . . . . .	1976-KLK-8	
Figs. 11–12. <i>Islandiella islandica</i> (Nørvang, 1945) . . . . .		34
Specimen from <i>E. excavatum</i> zone (Younger <i>Yoldia</i> Clay) of bor. III, spl. no. 18, Nørre Lyngby; × 75 . . . . .	1976-KLK-9	
Figs. 13–14. <i>Islandiella norcrossi</i> (Cushman, 1933) . . . . .		34
Specimen from the <i>E. subarcticum</i> zone (Lower <i>Saxicava</i> Sand) of bor. III, spl. no. 8, Nørre Lyngby; × 75 . . . . .	1976-KLK-10	
Figs. 15–16. <i>Buccella frigida</i> (Cushman, 1922) . . . . .		33
Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxicava</i> Sand) of bor. IV, spl. no. 1, Nørre Lyngby; × 75 . . . . .	1976-KLK-11	
Figs. 17–18. <i>Hyalinea baltica</i> (Schroeter, 1783) . . . . .		34
Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxicava</i> Sand) of bor. I, spl. no. 1, Nørre Lyngby; × 75 . . . . .	1976-KLK-12	

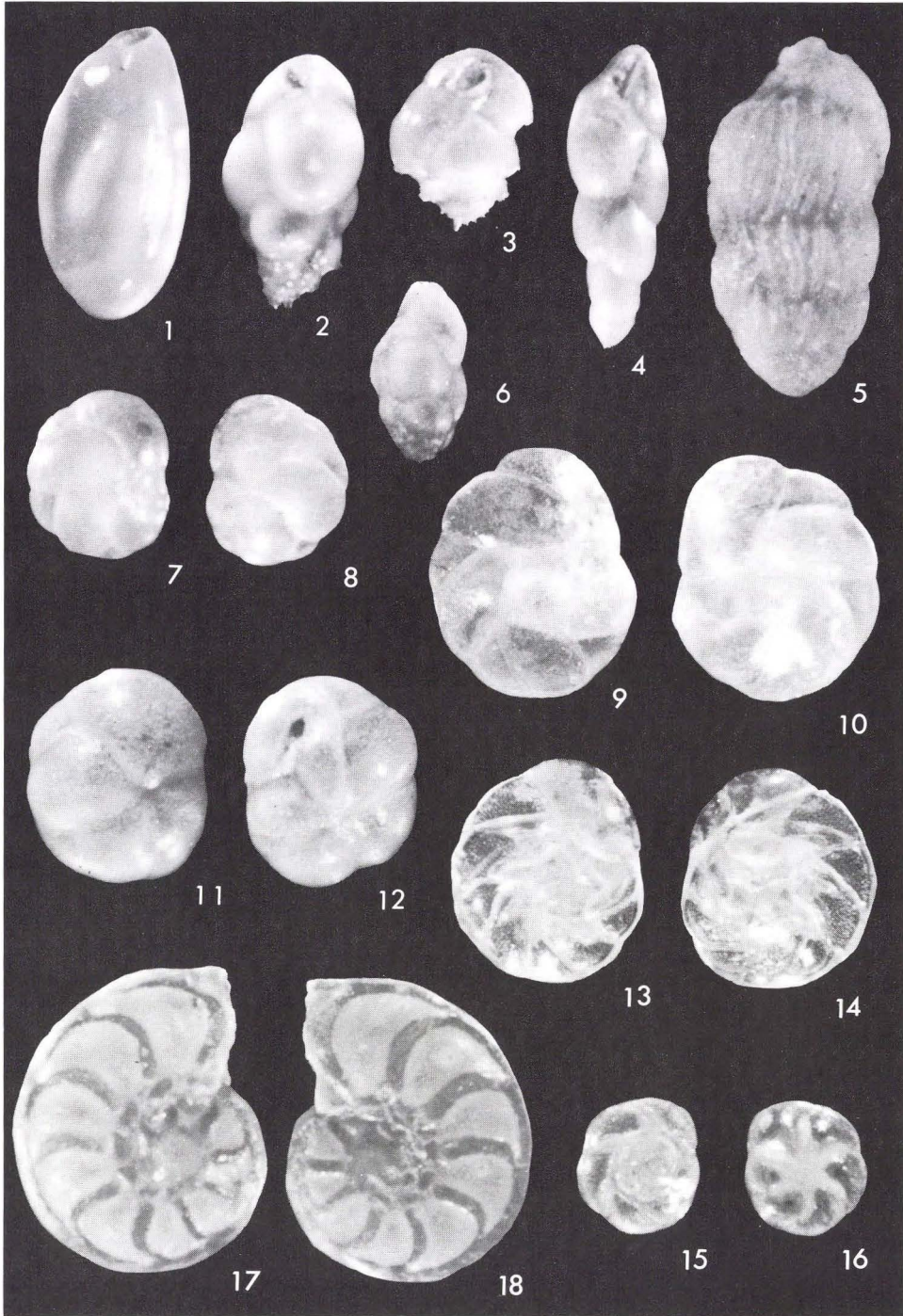


Plate 2

Nonionidae, Elphidiidae	Catalogue No.	Text page
Figs. 1–2. <i>Nonion Labradoricum</i> (Dawson, 1960) .....		34
Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxicava</i> Sand) of bor. III, spl. no. 31, Nørre Lyngby; × 75 .....	1976-KLK-13	
Figs. 3–7. <i>Elphidium albiumbilicatum</i> (Weiss, 1954) .....		33
Figs. 3–4. Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxicava</i> Sand) of profile 2, Nørre Lyngby; × 75 .....	1976-KLK-14	
Fig. 5. Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxica-</i> <i>va</i> Sand) of bor. IV, spl. no. 3, Nørre Lyngby; × 75 .....	1976-KLK-15	
Fig. 6. Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxica-</i> <i>va</i> Sand) of profile 2, Nørre Lyngby; × 75 .....	1976-KLK-16	
Fig. 7. Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxica-</i> <i>va</i> Sand) of bor. IV, spl. no. 3, Nørre Lyngby; × 75 .....	1976-KLK-17	
Figs. 8–9. <i>Elphidium asklundi</i> Brotzen, 1943 .....		34
Fig. 8. Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxica-</i> <i>va</i> Sand) of profile 2, Nørre Lyngby; × 75 .....	1976-KLK-18	
Fig. 9. Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxica-</i> <i>va</i> Sand) of profile 1, spl. no. 3, Nørre Lyngby; × 75 .....	1976-KLK-19	



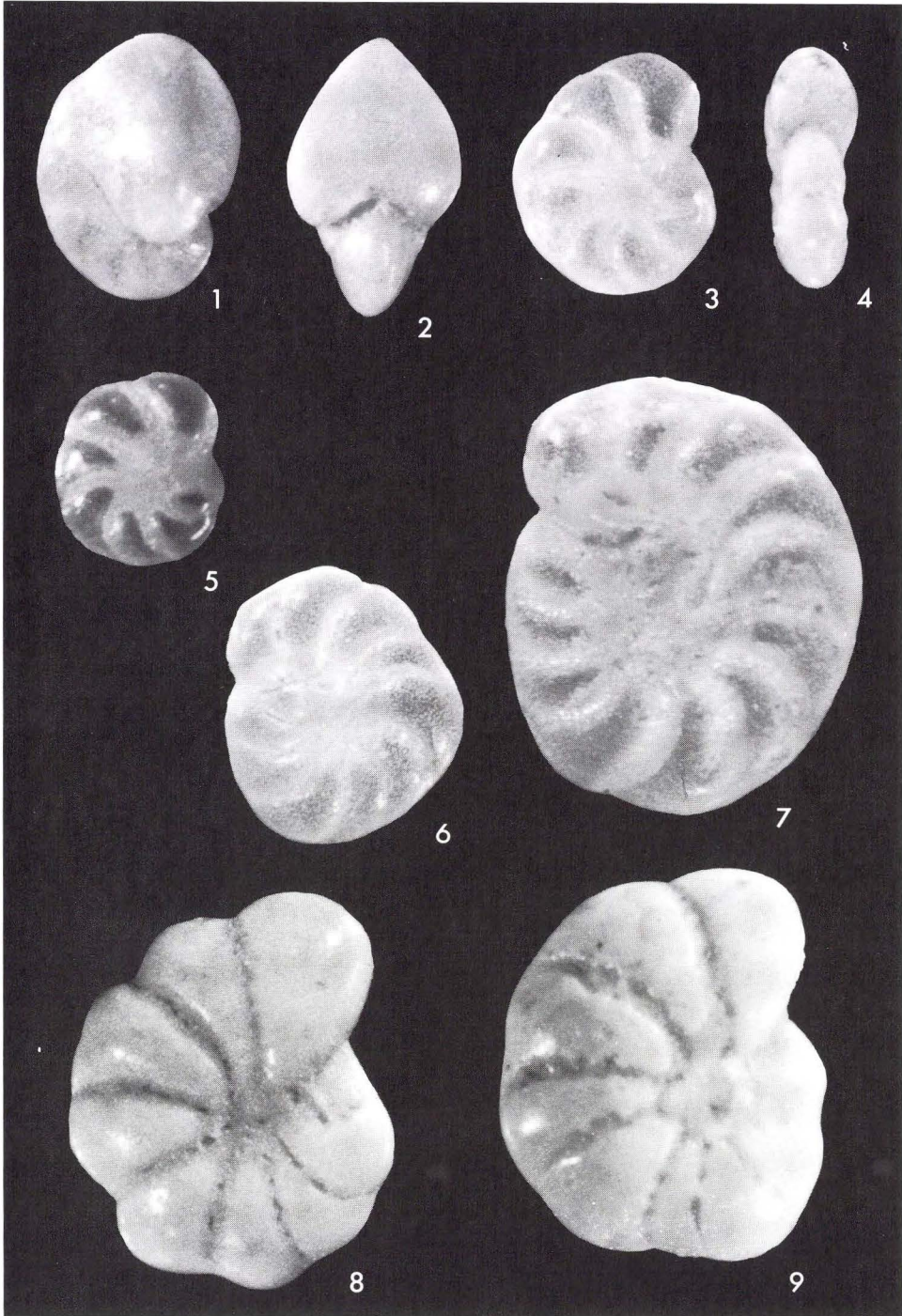


Plate 3

Elphidiidae, Rotaliidae	Catalogue No.	Text page
Fig. 1. <i>Elphidium asklundi</i> Brotzen, 1943 .....		34
Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxicava</i> Sand) of bor. IV, spl. no. 3, Nørre Lyngby; × 75 .....	1976-KLK-20	
Fig. 2. <i>Elphidium bariletti</i> Cushman, 1933 .....		34
Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxicava</i> Sand) of bor. I, spl. no. 24, Nørre Lyngby; × 75 .....	1976-KLK-21	
Figs. 3–5. <i>Elphidium excavatum</i> (Terquem), forma <i>clavata</i> Cushman, 1930 .....		34
Fig. 3. Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxica-</i> <i>va</i> Sand) of bor. IV, spl. no. 5, Nørre Lyngby; × 75 .....	1976-KLK-22	
Fig. 4. Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxica-</i> <i>va</i> Sand) of bor. IV, spl. no. 5, Nørre Lyngby; × 75 .....	1976-KLK-23	
Fig. 5. Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxica-</i> <i>va</i> Sand) of bor. IV, spl. no. 5, Nørre Lyngby; × 75 .....	1976-KLK-24	
Figs. 6–8. <i>Elphidium subarcticum</i> Cushman, 1944 .....		34
Fig. 6. Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxica-</i> <i>va</i> Sand) of bor. IV, spl. no. 3, Nørre Lyngby; × 75 .....	1976-KLK-25	
Fig. 7. Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxica-</i> <i>va</i> Sand) c. 10 m north of profile 2, Nørre Lyngby; × 75 .....	1976-KLK-26	
Fig. 8. Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxica-</i> <i>va</i> Sand) of bor. IV, spl. no. 5, Nørre Lyngby; × 75 .....	1976-KLK-27	
Figs. 9–10. <i>Protelphidium orbiculare</i> (Brady, 1881) .....		34
Specimen from the <i>E. subarcticum</i> zone (Lower <i>Saxicava</i> Sand) of bor. III, spl. no. 8, Nørre Lyngby; × 75 .....	1976-KLK-28	
Fig. 11. <i>Ammonia batavus</i> (Hofker, 1951) .....		33
Spiral side of specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxicava</i> Sand) of bor. I, spl. no. 7, Nørre Lyngby; × 75 .....	1976-KLK-29	

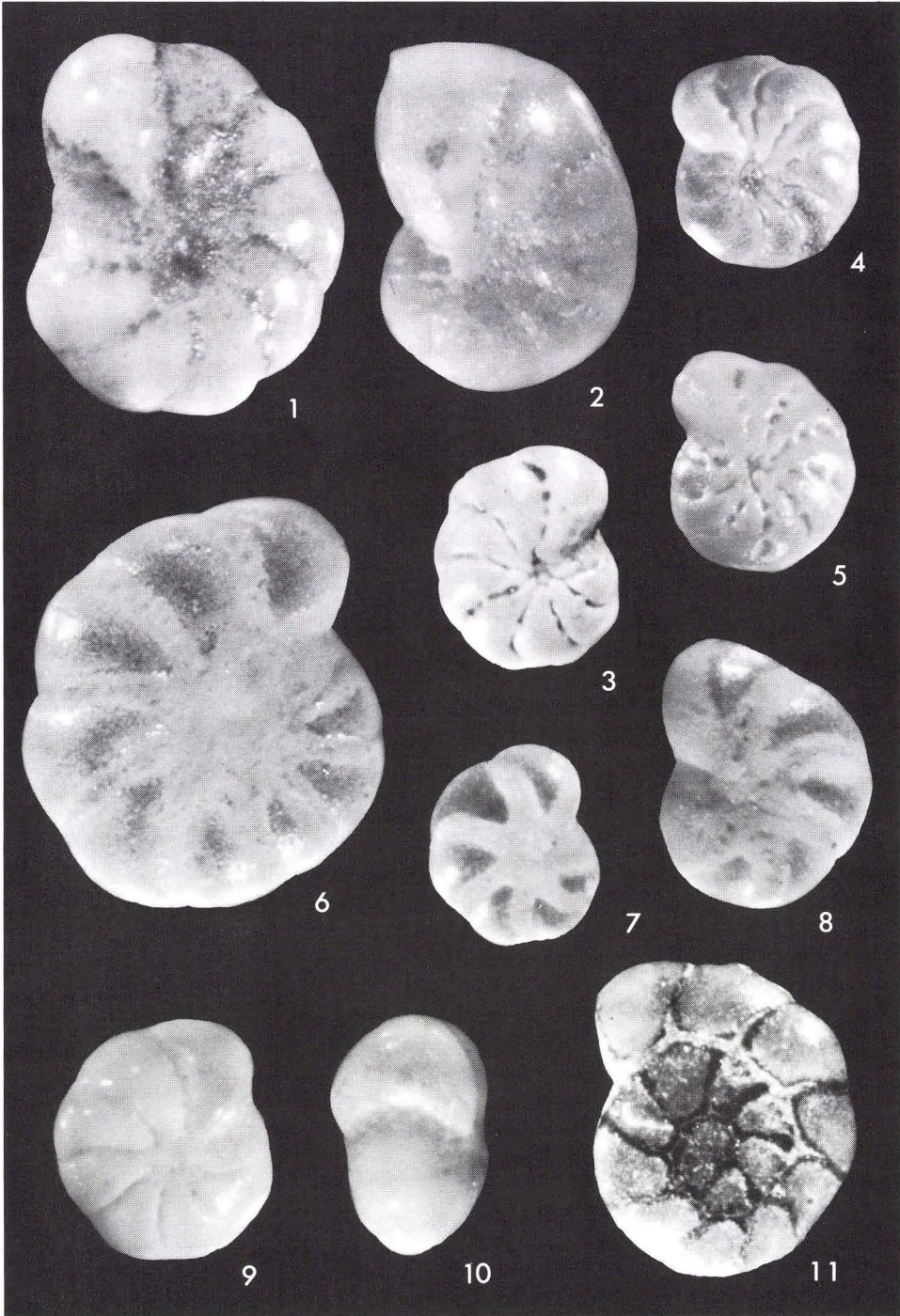


Plate 4

	Catalogue No.	Text page
Elphidiidae		
Figs. 1–5. <i>Elphidium albiumbilicatum</i> (Weiss, 1954) .....		33
Figs. 1–2. Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxicava</i> Sand) of bor. IV, spl. no. 2, Nørre Lyngby; × 160 .....	1976-KLK-30	
Fig. 3. Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxicava</i> Sand) of profile 2, Nørre Lyngby; × 100 .....	1976-KLK-31	
Figs. 4–5. Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxicava</i> Sand) of profile 2, Nørre Lyngby; Fig. 4, × 100; Fig. 5, × 370 .....	1976-KLK-32	
Figs. 6–8. <i>Elphidium asklundi</i> Brotzen, 1943 .....		34
Fig. 6. Specimen from the <i>E. excavatum</i> zone (Younger <i>Yoldia</i> Clay) of bor. III, spl. no. 12, Nørre Lyngby; × 70 .....	1976-KLK-33	
Figs. 7–8. Specimen from the <i>E. excavatum</i> zone (Younger <i>Yoldia</i> Clay) of bor. IV, spl. no. 1 A, Nørre Lyngby; × 75 .....	1976-KLK-34	
Scanning electron micrographs.		

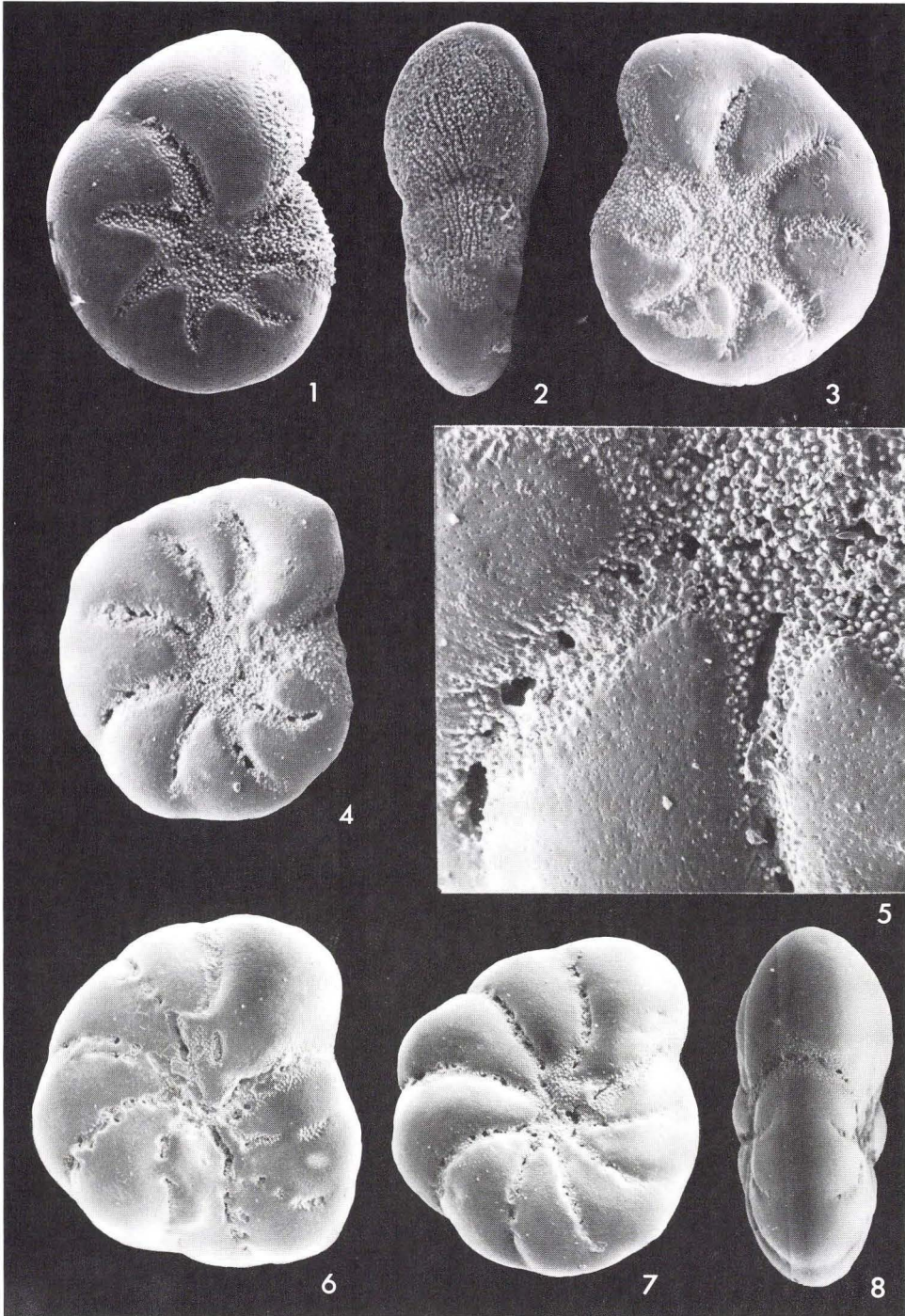


Plate 5

Elphidiidae	Catalogue No.	Text page
Figs. 1–4. <i>Elphidium excavatum</i> (Terquem), forma <i>clavata</i> Cushman, 1930 .....		34
Fig. 1. Specimen from the <i>E. excavatum</i> zone (Younger <i>Yoldia</i> Clay) of the coastal cliff at Nørre Lyngby; × 110 .....	1976–KLLK–35	
Fig. 2. Edge view of specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxicava</i> Sand) of bor. IV, spl. no. 4, Nørre Lyngby; × 135 .....	1976–KLLK–36	
Fig. 3. Side view of the same specimen as Fig. 2; × 120 .....		
Fig. 4. Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxicava</i> Sand) of bor. IV, spl. no. 2, Nørre Lyngby; × 140 .....	1976–KLLK–37	
Figs. 5–8. <i>Elphidium subarcticum</i> Cushman, 1944 .....		34
Figs. 5–6. Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxicava</i> Sand) of bor. IV, spl. no. 2, Nørre Lyngby; × 80 .....	1976–KLLK–38	
Figs. 7–8. Specimen from the <i>E. albiumbilicatum</i> zone (Upper <i>Saxicava</i> Sand) of bor. IV, spl. no. 2, Nørre Lyngby; Fig. 7, × 70; Fig. 8, × 180 .....	1976–KLLK–39	
Scanning electron micrographs.		

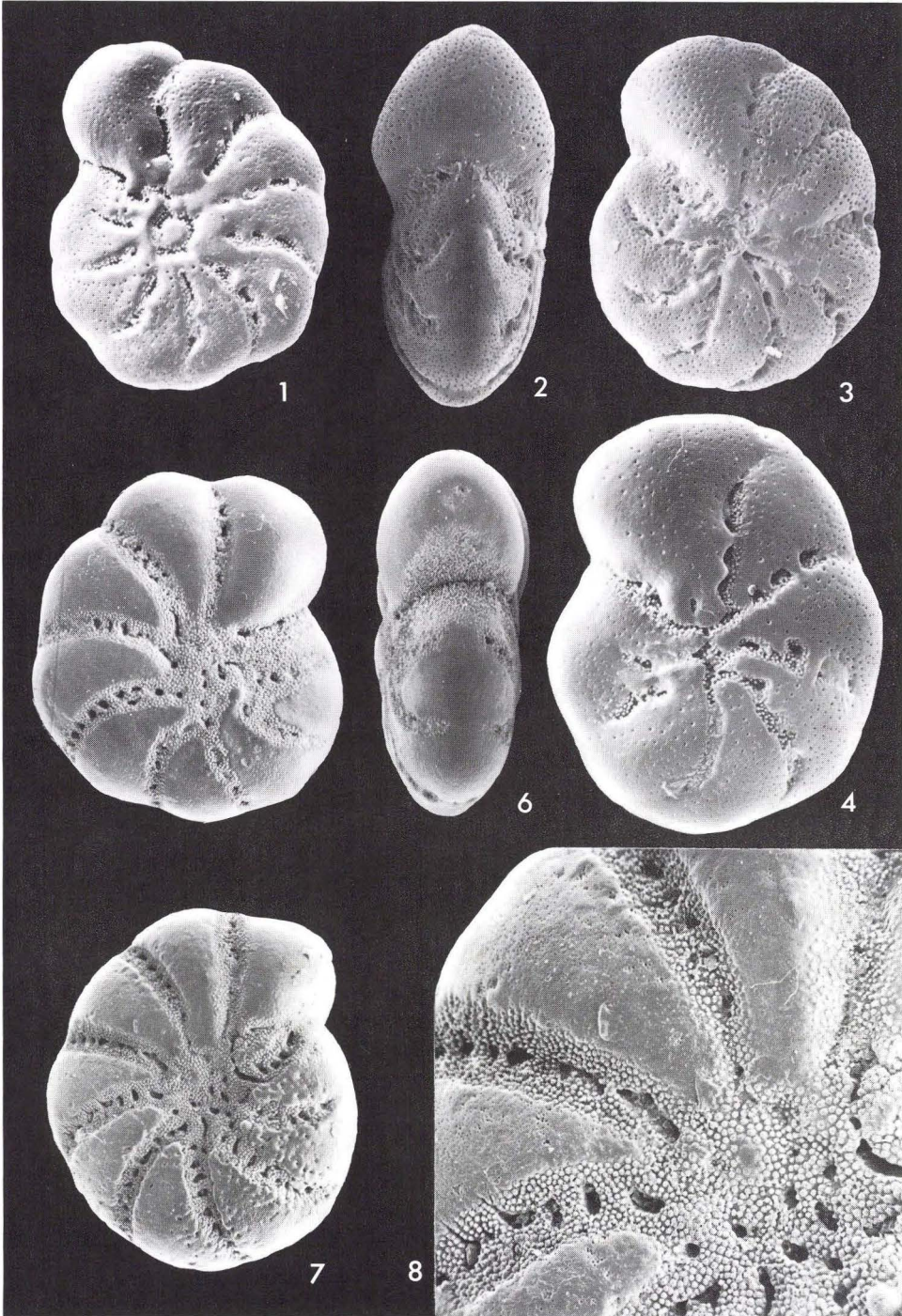
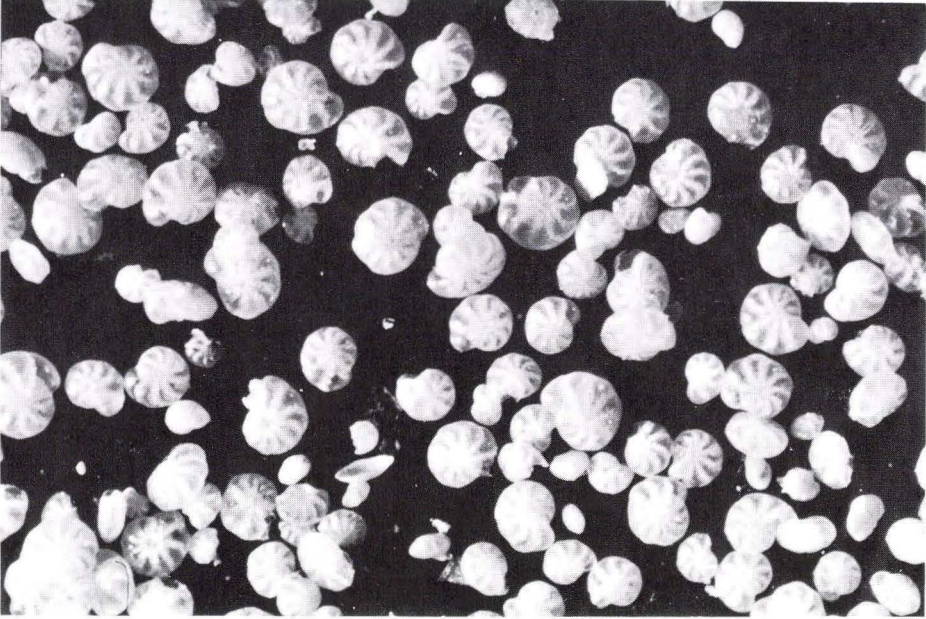


Plate 6

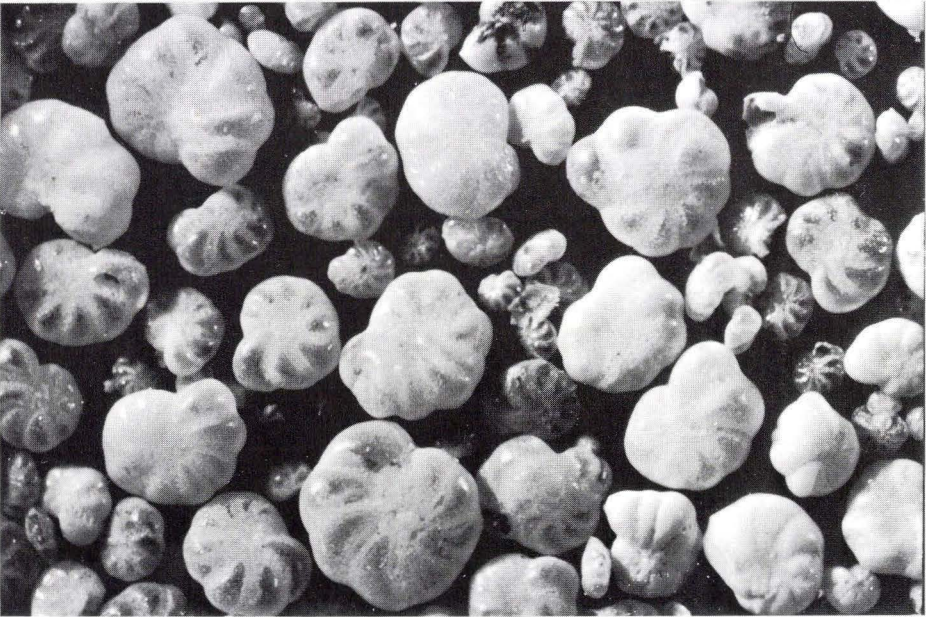
Catalogue No.

- Fig. 1. Foraminiferal assemblage from the *E. excavatum* zone (Younger *Yoldia* Clay) of bor. III, spl. no. 18, Nørre Lyngby. The fauna is characterized by the very high dominance of *Elphidium excavatum* (Terquem), forma *clavata* Cushman; × 25 ..... 1976-KLK-F1
- Fig. 2. Foraminiferal assemblage from the *E. subarcticum* zone (Lower *Saxicava* Sand) of bor. III, spl. no. 8, Nørre Lyngby. *Elphidium excavatum* (Terquem), forma *clavata* Cushman is the dominant species, but the faunas in this sandy facies are characterized by the rather high frequencies of *Elphidium subarcticum* Cushman; × 25 ..... 1976-KLK-F2





1



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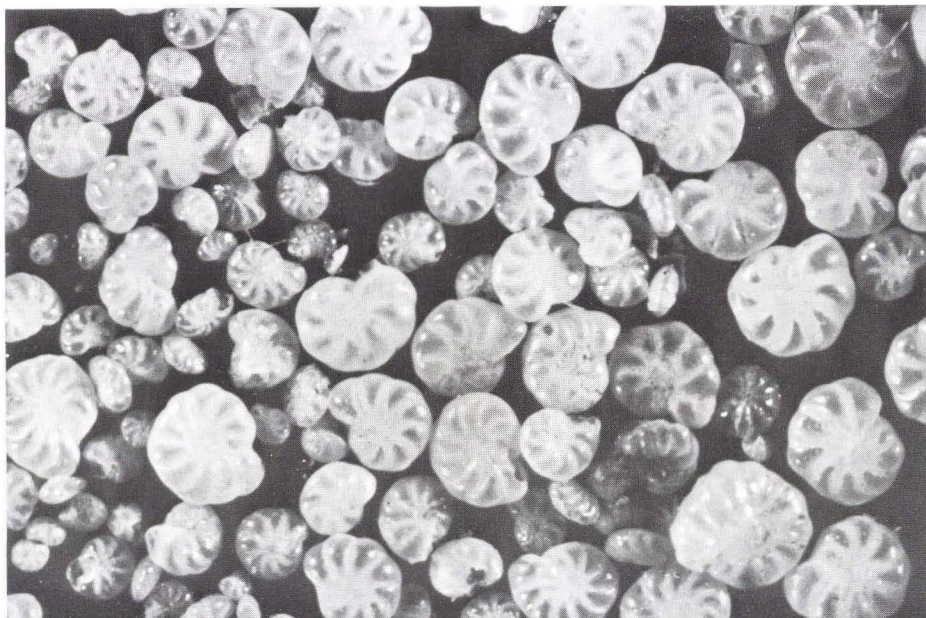
Plate 7

Catalogue No.

- Fig. 1. Foraminiferal assemblage from the *E. albiumbilicatum* zone (Upper *Saxicava* Sand) of profile 2 in the coast cliff at Nørre Lyngby. *Elphidium excavatum* (Terquem), forma *clavata* Cushman is the dominant species, but the fauna is characterized by the high frequency of *Elphidium albiumbilicatum* (Weiss); × 25 ..... 1976-KLK-F3
- Fig. 2. Foraminiferal assemblage from the *E. albiumbilicatum* zone (Upper *Saxicava* Sand) of bor. IV, spl. no. 3, Nørre Lyngby. The composition of species is very close to that of fig. 1; × 25 ..... 1976-KLK-F4



1



2

