# LATE QUATERNARY FORAMINIFERA FROM THE LØKKEN AREA

KAREN LUISE KNUDSEN

## Borings

Four borings at Løkken (see figs. 11 and 19) were carried out in 1965 by the Geotechnical Institute, Århus. They were situated along the highway east of Løkken and the exact positions are indicated on the map, fig. 19. The terrain surface at the bore sites lies between 5.1 m and 6.2 m above present-day sea level.

The sampling interval was mostly 0.5 m, sometimes smaller. 69 samples from the borings were analysed for foraminifera. The entire content of foraminifera was counted in the poor samples, but only part of it in the rich ones. Usually at least 300 specimens were counted in each sample, and the total population was estimated by extrapolation. For each of the borings investigated the statistical record of foraminifera was transferred to a range

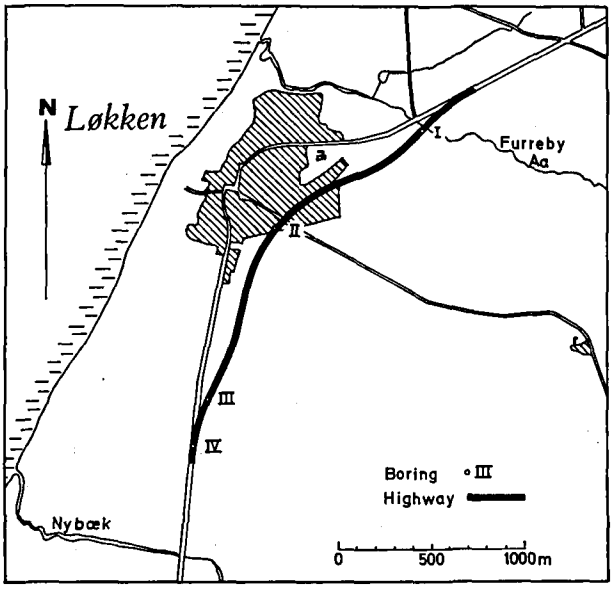


Fig. 19. Position of the four borings at Løkken.

chart showing the vertical distribution and abundance of different species throughout the boring. As a rule symbols indicating percentage frequency of each species were used in the charts. For samples containing less than 50 specimens, however, the number of specimens was entered directly on the chart. The selected foraminifera taxa in the range charts are mostly arranged according to their first appearance in the succession. In this way the faunal changes at different depths are very apparent. The same arrangement and number of taxa is used in the four range charts of the borings at Løkken, even if some of the species are not present in one or more of the borings. The zonation, indicated to the extreme left of the charts, was made on the basis of the distribution of foraminifera species in the borings. As shown in the range charts, the sampling was carried out in two different ways. For the undisturbed samples a coring tube was used, whereas an open auger was used for the disturbed samples. There may be some contamination with material from the upper part of the bore hole in the disturbed samples. Therefore the method of sampling must be considered when interpretation of the foraminiferal distribution is attempted.

## Boring no. I

Boring no. I is situated just south of Furreby Å (fig. 19). The terrain surface at the boring lies 5.1 m above sea level and the depth of this boring is 14.5 m. The uppermost sample is from 4.1 m above sea level and the lowest one from 9.4 m below sea level. 29 samples were analysed.

The distribution of 22 selected taxa is shown in the range chart, fig. 20. Two distinctly different assemblages were present in this boring. The lowermost samples (nos. 1–8) are dominated by the two species *Elphidium clavatum* and *Cassidulina crassa,* whereas *Ammonia batavus* and *Protelphidium anglicum* are the most frequent species in the upper part of the boring. The boundary between the two assemblages is situated at approximately 5.7 m below sea level.

In the lower samples the two dominant species *Elphidium clavatum* and *Cassidulina crassa* account for 79 %–97 % of the total fauna. In addition *Trifarina fluens, Virgulina loeblichi, Buccella frigida, Elphidium subarcticum, Bulimina marginata, Protelphidium orbiculare, Nonion labradoricum, Elphidium incertum,* and a few other species occur in a number of samples. It is, however, characteristic that these accessory species include only a small percentage of the total fauna. The faunal diversity is small, usually ranging between 1 and 8, with a maximum of 15, whereas the number of different species per sample ranges from 7 to 23. The number of specimens per 100 g sediment is generally less than 300; a single sample contained 1,770 specimens per 100 g sediment.

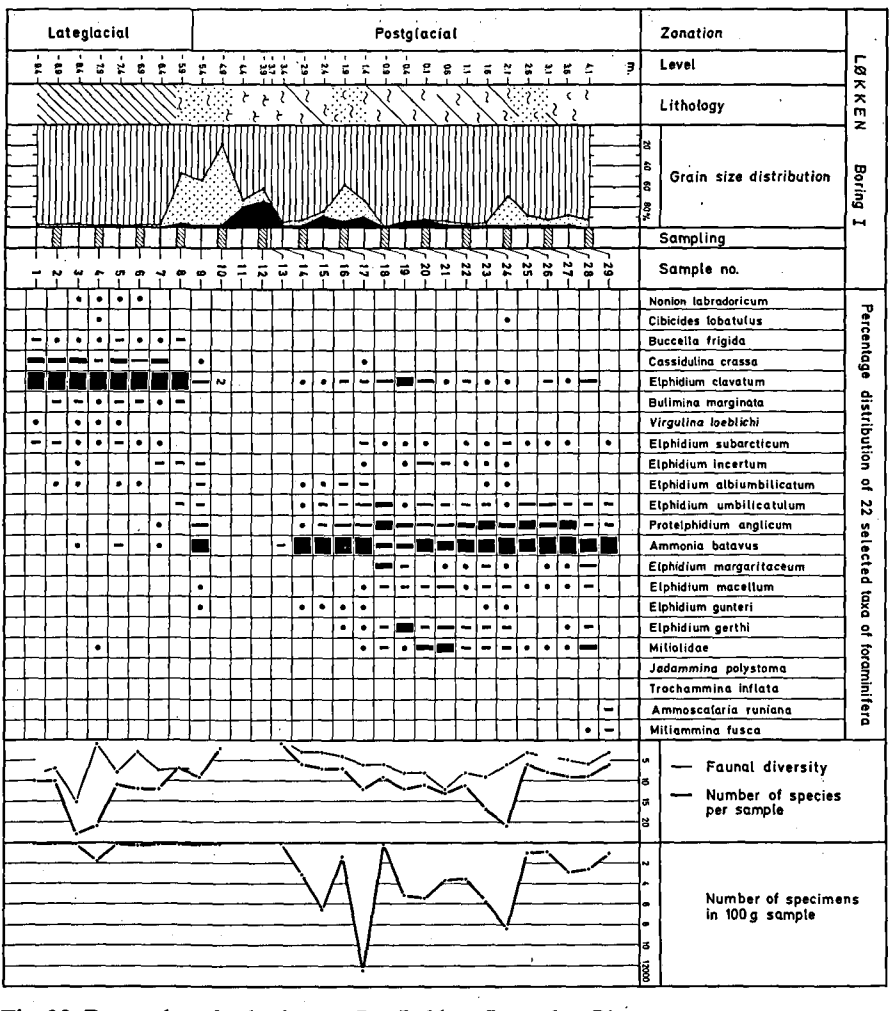


*Fig. 20.* Range chart for boring no. I at Løkken. Legend p. 71.

The assemblage in the lowermost samples of boring no. I indicates an arctic environment (Leslie, 1965; Nagy, 1965), and resembles those recorded from Lateglacial deposits on Læsø (Michelsen, 1967) and the Oslofjord region (Feyling-Hanssen, 1964a). This is one of the reasons for considering the deposits to be of Lateglacial age (Younger *Yoldia* Clay).

The low faunal diversity may indicate extreme ecological conditions. One of the reasons may be dilution of the sea water with cold freshwater from melting glaciers. The photosynthesis necessary for the phytoplankton production may have been reduced, for instance by low transparency of water

loaded with fine sediment from the glaciers. In this way unfavourable food conditions may be expected for the foraminifera (Feyling-Hanssen, 1964 a).

The low number of specimens in samples from these deposits is probably due to a high rate of sedimentation. The larger number of specimens in sample no. 4 is possibly a result of a lower rate of sedimentation at that time. A temporary improvement in the ecological conditions seems unlikely because of the extremely low faunal diversity in that sample.

The Lateglacial deposits in boring no. I consist of clay with thin layers of silt and fine sand. Only the uppermost sample (no. 8) is more sandy, as shown by the grain size distribution in fig. 20. The foraminifera assemblage is very poor in this sample, both in number of species and number of specimens per 100 g sediment. The absence of *Cassidulina crassa* and *Nonion labradoricum* linked with the presence of the species *Buccella frigida* and *Protelphidium orbiculare* indicates a shallow water environment. The sandy layer may represent littoral sediments, deposited during regression of the Lateglacial *Yoldia* Sea (the Upper *Saxicava* Sand, p. 119).

The upper samples (nos. 9–29) in boring no. I are dominated by the two species *Ammonia batavus* and *Protelphidium anglicum* which account for 33–94 % of the total fauna. *Quinqueloculina seminulum, Elphidium umbilicatulum, E. clavatum, E. gerthi, E. macellum* and *E. margaritaceum* are quite frequent, and in addition *Elphidium subarcticum, E. incertum, E. albiumbilicatum, E. gunteri,* and some other species occur in a number of samples from this part of the boring. A few arenaceous species are found in the uppermost samples, viz. *Miliammina fusca* and *Ammoscalaria runiana.*

The faunal diversity is low, in general ranging from 3 to 9, whereas the number of species commonly ranges from 6 to 12 with a maximum of 21 species per sample. The total number of specimens is often rather high, ranging from 1,000 to 6,000 with a maximum of 13,000 per 100 g sediment.

The assemblage in the upper part of boring no. I is equivalent to Recent assemblages in boreal, brackish and shallow water. Consequently, it is believed that these deposits date from the Postglacial *Littorina* transgression in Vendsyssel. The low faunal diversity may indicate extreme ecological conditions during deposition of these sediments, the restricting factor probably being shallow and brackish water. The large number of specimens in the samples may be a result of favourable local food conditions.

The deposits between 4.9 m and 3.7 m below sea level (samples nos. 10–13) consist of sand and peat layers without foraminifera, whereas sample no. 9 (at 5.4 m below sea level) contains a boreal shallow water assemblage. This suggests a Postglacial age for the sediments. The unfossiliferous layers were probably deposited during a temporary regression of the *Littorina* Sea. However, sample no. 9 is disturbed and contamination from the overlying Postglacial deposits cannot be excluded.

The lithology and the grain size distribution of the Postglacial deposits in boring no. I are shown in fig. 20. The sediments are dominated by clay with a high content of plant remains and mollusc shells, but at certain levels more sandy layers are seen. There is no connection between occurrence of foraminifera species and grain size distribution in the Postglacial sediments, and, consequently, no indication of species affinity to bottom sediment.

## Boring no. II

Boring no. II is situated 950 m south of boring no. I at Løkken (see fig. 19). The terrain surface at the boring lies at 5.3 m above sea level, and the boring is 8.0 m deep. 14 samples between 3.8 m above sea level and 2.7 m below sea level were analysed.

The frequency distribution of 22 selected taxa from this boring is shown in the range chart, fig. 21. The assemblages are dominated by *Ammonia batavus* and *Protelphidium anglicum*. The two species account for 49–94 % of the total fauna. *Elphidium umbilicatulum, E. albiumbilicatum,* and *E. clavatum* are quite frequent and *E. subarcticum, E. margaritaceum, E. macellum, E. gunteri,* and *E. gerthi* occur in a number of samples from this boring. The arenaceous species *Jadammina polystoma* and *Trochammina inflata* are seen in some of the samples.

The faunal diversity is low, ranging from 3 to 5, whereas the number of species ranges from 6 to 12. Specimens are numerous in the upper part of the boring, ranging from 2,500 to 16,500 per 100 g sediment. The lower samples contain less than 100 specimens per 100 g.

The assemblage is equivalent to those recorded from the upper samples in boring no. I, and to faunas from shallow and brackish water in Recent boreal seas. Accordingly, Postglacial *Littorina* deposits are represented throughout boring no. II. As in boring no. I the low faunal diversity may indicate extreme ecological conditions, whereas the abundance of specimens may be attributed to a rich local food supply.

The samples between 1.7 m below sea level and 0.3 m above sea level (nos. 3–7) are almost unfossiliferous. The deposits comprise sandy sediments, with sandy peat in the upper part. Sample no. 1 and no. 2 contain typical Postglacial assemblages, and, accordingly, the unfossiliferous layers were deposited during a regression of the *Littorina* Sea. It should be added that sample no. 1 is undisturbed, and that contamination from the upper layers seems unlikely. The Postglacial *Littorina* transgression was probably interrupted by a regression, during which continental sand and peat layers were deposited.

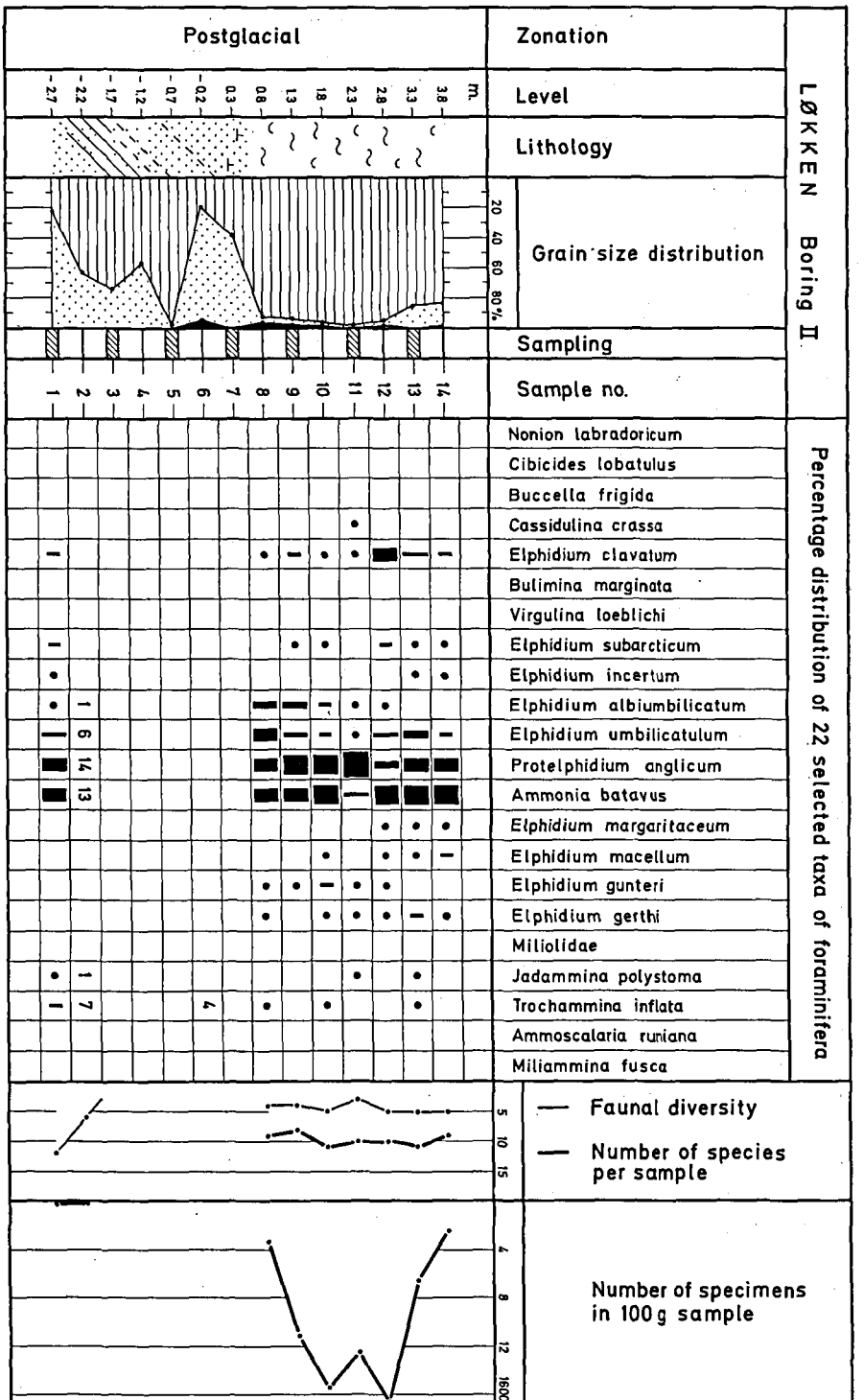


Fig. 21. Range chart for boring no. II at Løkken. Legend p. 71.

The lithology and the grain size distribution (fig. 21) shows that the lower part of the boring is dominated by sand and silt with some peat at approximately 0.3 m above sea level, whereas the upper part is composed of clay containing plant remains and mollusc shells.

Boring no. III

The position of boring no. III is shown in fig. 19. Boring no. III is 5 m deep, and the terrain surface lies at 5.7 m above sea level. 9 samples between 0.7 and 4.2 m above sea level were examined.

In the range chart, fig. 22, the distribution of 22 selected taxa is shown. Two distinctly different assemblages are represented in this shallow boring.

The lowermost 5 samples are dominated by *Elphidium clavatum* and *Cassidulina crassa* which account for 62–86 % of the total fauna. *Nonion labradoricum, Buccella frigida, Bulimina marginata, Elphidium incertum, E. subarcticum,* and *E. umbilicatulum* are common species, but they only constitute a small percentage of the total fauna. The large number of *Ammonia batavus* in the disturbed sample no. 4 is probably caused by contamination from overlying layers.

The faunal diversity in this part of the boring is low, ranging between 8 and 10. The number of species varies from 18 to 34, and the number of specimens from 200 to 3,500 per 100 g sediment. The assemblage of the lowermost 5 samples is comparable to those recorded from the lower part of boring no. I at Løkken, as well as those from Recent arctic regions and from Lateglacial deposits. The assemblage is therefore considered to be of Lateglacial age (Younger *Yoldia* Clay). The number of species in the samples is rather high, but the low faunal diversity may nevertheless indicate rather extreme ecological conditions. Specimens are comparatively abundant in two of the samples. As, however, the faunal diversity is about the same in all samples, this is believed to be due to a temporary lower rate of sedimentation rather than to improved ecological conditions. The Lateglacial sediments consist of well stratified clay with some silty and sandy layers.

In the upper part of boring no. III *Ammonia batavus* and *Protelphidium anglicum* are the dominant species, accounting for 85–89 % of the total fauna. *Elphidium clavatum, E. subarcticum, E. albiumbilicatum,* and *E. umbilicatulum* occur frequently, and *E. incertum, E. margaritaceum, E. macellum, E. gunteri,* and *E. gerthi* are also common species, but all these accessory species only constitute a small percentage of the total fauna. The arenaceous species *Jadammina polystoma, Trochammina inflata,* and *Miliammina fusca* are seen in the uppermost samples from this boring.

The assemblages are equivalent to those recorded from the Postglacial deposits in borings nos. I and II at Løkken. The number of species varies

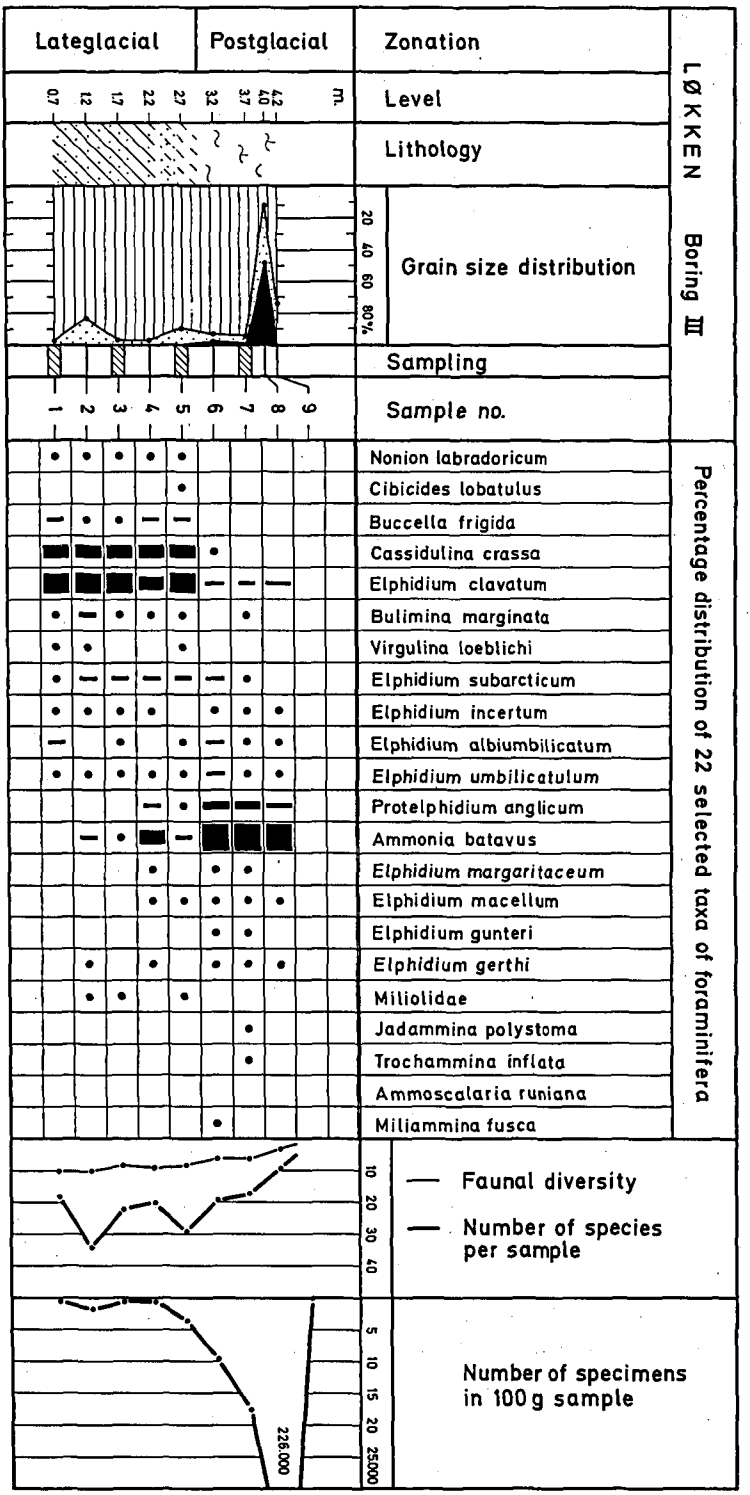


Fig. 22. Range chart for boring no. III at Løkken. Legend p. 71.

from 9 to 19, whereas the faunal diversity ranges between 3 and 6, probably indicating extreme ecological conditions. Specimens are abundant, with a maximum of 226,000 per 100 g sediment. As mentioned above, this may possible be caused by favourable food conditions.

The *Littorina* deposits consist of clay with a high content of plant remains and mollusc shells. Sample no. 8 is particularly rich in mollusc shells. This explains the sudden change in the grain size distribution at that level (fig. 22).

Boring no. IV

The position of boring no. IV is shown on the map, fig. 19. The terrain surface at the boring is 6.2 m above sea level and the boring is 10 m deep. 17 samples from the interval 3.2 m above to 3.8 m below sea level have been examined.

The distribution of 22 selected taxa is shown in the range chart, fig. 23. As in the borings nos. I and III, two different types of assemblages are represented. In the lower 6 samples *Elphidium clavatum* and *Cassidulina crassa* are the most frequent species, accounting for 51–73 % of the total fauna. The assemblage is comparable to those recorded from the deepest part of borings nos. I and III, and the deposits are therefore considered to be of Lateglacial age. The number of species ranges from 10 to 24, the number of specimens is less than 600. These Lateglacial sediments in boring no. IV consist of clay with thin layers of silt and sand. As shown in fig. 23 the uppermost Lateglacial sample is more sandy. This layer was probably deposited during a regression of the *Yoldia* Sea (Upper *Saxicava* Sand), as also suggested for a corresponding sample from boring no. I (p. 133).

The upper samples of boring no. IV contain an assemblage dominated by the two species *Ammonia batavus* and *Protelphidium anglicum* which account for 43–93 % of the total fauna. *Elphidium subarcticum, E. albiumbilicatum, E. umbilicatulum, E. gunteri,* and *E. gerthi* are common species, but amount only to a small percentage of the total fauna. The faunal diversity is low, ranging between 3 and 9, whereas the number of species varies from 9 to 26, and the number of specimens from 3,000 to 15,000 per 100 g sediment.

The deposits, being equivalent to those in the upper part of the borings nos. I, II, and III, are regarded as being of Postglacial age. The Postglacial samples are sandy at the bottom, whereas they consist of clay with a high content of plant remains and mollusc shells at the top.

Fig. 24 shows the stratigraphy, based upon the content of foraminifera in the four borings at Løkken. In the basal sequence in three of the borings Lateglacial deposits are represented. Postglacial deposits are present through-

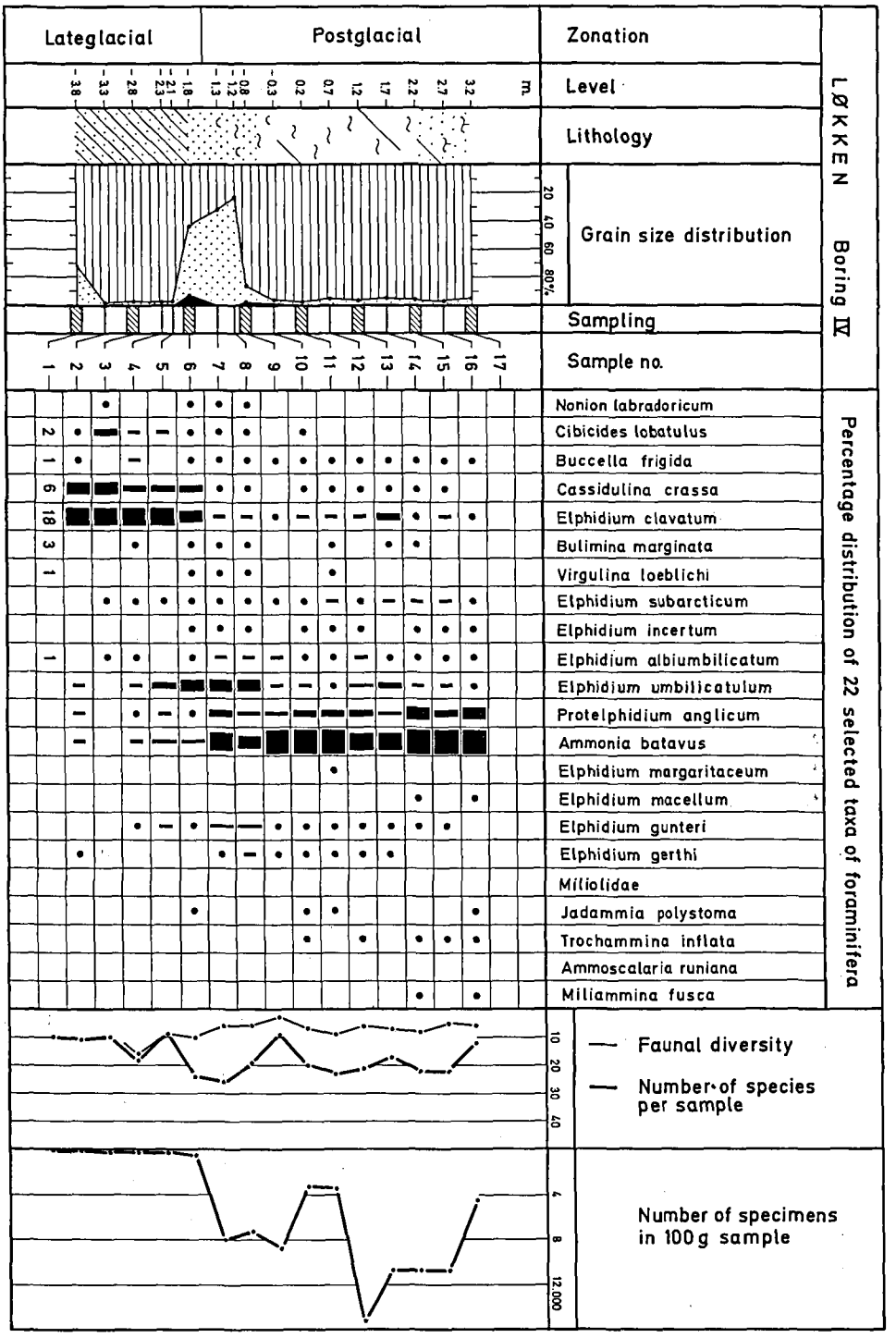


Fig. 23. Range chart for boring no. IV at Løkken. Legend p. 71.

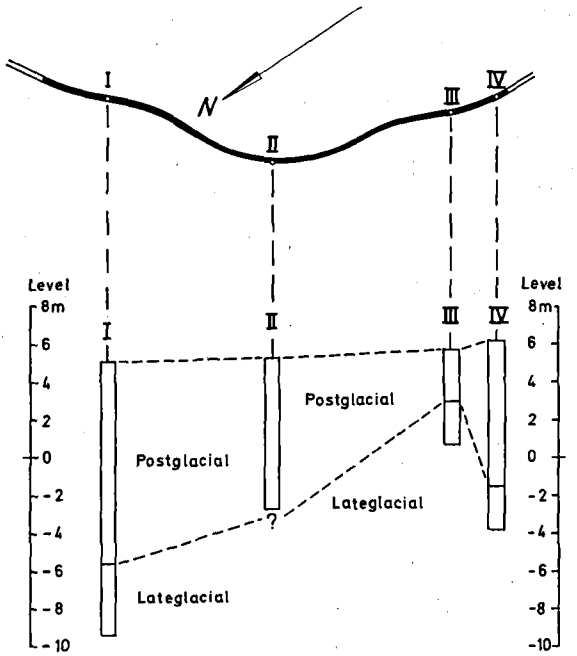


Fig. 24. Profile through the four borings at Løkken (cf. fig. 19).

out boring no. II and occur in the upper part of the other borings. The boundary between Lateglacial and Postglacial deposits may be placed at approximately 5.7 m below sea level in boring no. I, 3.0 m above sea level in boring no. III, and 1.5 m below sea level in boring no. IV.

## The coast cliff north of Løkken

### Løkkens Blånæse

In addition to the investigation of the samples from the borings at Løkken, the foraminiferal content of samples from the coastal cliff north of Løkken has been examined. The upper samples from the profiles B – F (fig. 25) contain assemblages equivalent to those from the Postglacial deposits of the borings. The dominant species are *Ammonia batavus* and *Protelphidium anglicum* (26–82 % of the total fauna). *Elphidium clavatum, E. albiumbilicatum, E. umbilicatulum, E. gerthi, Jadammina polystoma* and *Trochammina inflata* are frequent species. The faunal diversity is generally low, ranging from 3 to 7, but the number of specimens per 100 g sediment is often very large.

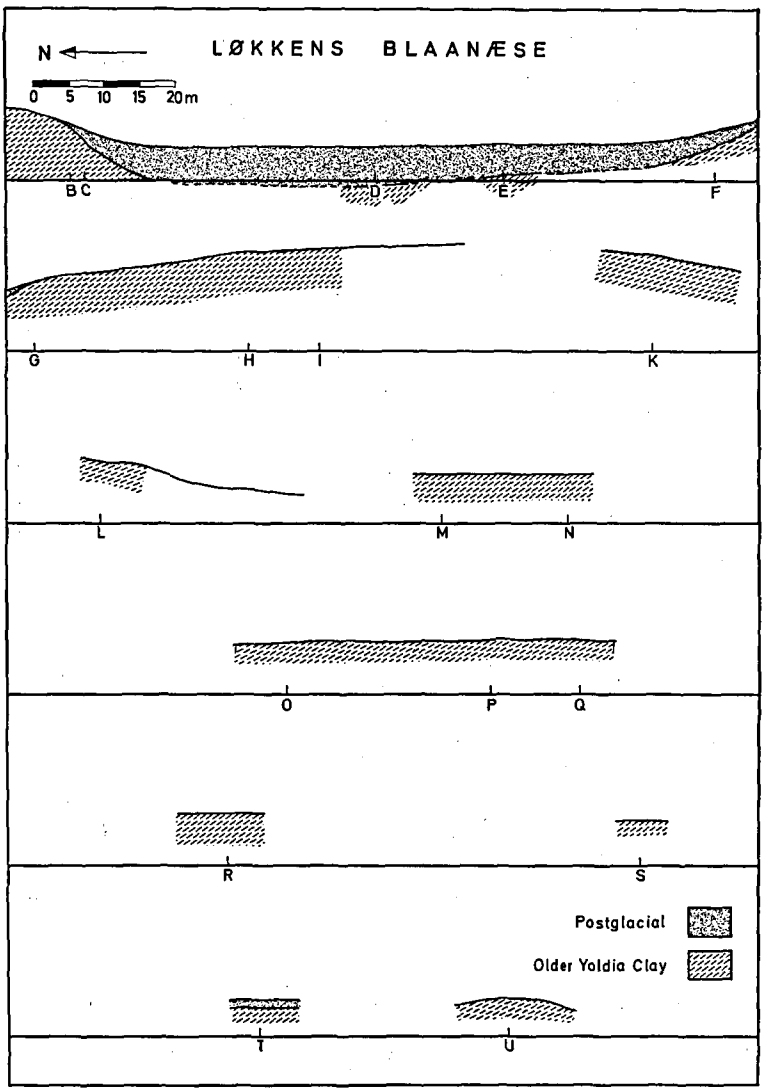


Fig. 25. Section of the coast cliff from Løkkens Blånæse in the north to Løkken in the south. The letters indicate the location of investigated profiles.

The upper part of the range chart, fig. 26, shows the frequency of selected taxa from profile C. The assemblages in the upper samples are equivalent to the Postglacial assemblages of the borings at Løkken, and are therefore considered to be of Postglacial age. The lower samples from this Postglacial deposit consist of sand with pebbles and fragments of wood, whereas the upper ones consist of clay with a high content of organic material.

The most frequent species in the lower, sandy layer are *Jadammina polystoma, Trochammina inflata, Protelphidium anglicum,* and *Ammonia batavus,* indicating brackish, shallow water. A similar sandy bottom layer is seen in the Postglacial part of the profiles D, F and T (fig. 25). Many of the foraminifera from this sandy layer have only their tectinous wall base preserved, indicating that extensive decalcination has taken place. This may have been accomplished by acid ground water from below the bituminous clay and peat layers.

Jessen (1918, 1920, 1931 and 1936) described the *Littorina* deposits, which extend for about 100 m along the coast cliff at Løkkens Blånæse, north of Løkken. His observations correspond well with the present results.

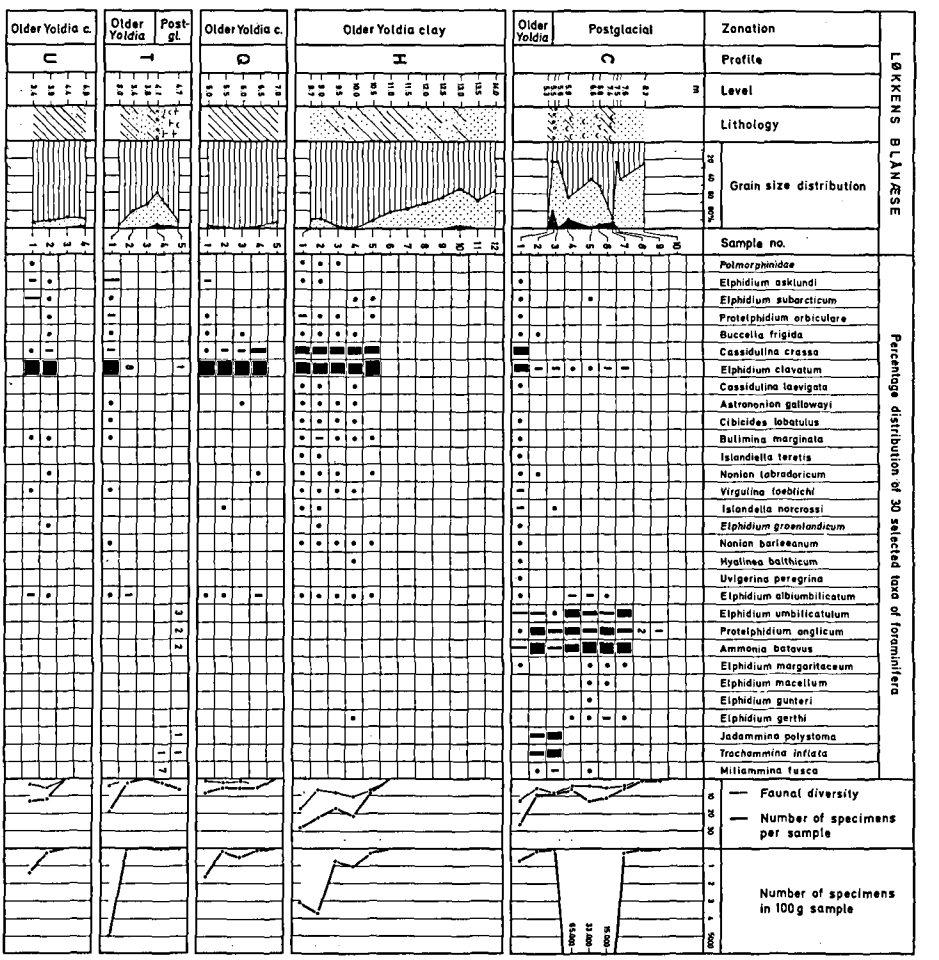


Fig. 26. Range chart for the profiles C, H, Q, T and U at Løkkens Blånæse. Legend p. 71.

The Postglacial deposits at Løkkens Blånæse consist of clay containing varying amounts of organic material. Some layers consist of almost black, peat-like organic material with well-preserved leaves and even logs, whereas other layers are very rich in mollusc shells. *Cerastoderma edule, Scrobicularia plana, Mytilus edulis,* and *Littorina littorea* are frequently found.

Below the Postglacial deposits at Løkkens Blånæse (figs. 25 and 26) the sediments mostly consist of hard grey clay. In 1898 Jessen described this clay as Older *Yoldia* Clay, but later (Jessen, 1918 and 1936) he considered it to be a glacifluvial deposit. Investigations of the content of foraminifera in these deposits show an assemblage in which *Elphidium clavatum* and *Cassidulina crassa* are the most frequent species. In addition *Nonion labradoricum, Virgulina loeblichi, Elphidium asklundi, E. groenlandicum, Protelphidium orbiculare, Buccella frigida, Islandiella norcrossi, I. teretis, Trifarina fluens, Nonion barleeanum, Hyalinea baltica,* and *Uvigerina peregrina* are characteristic species, but usually constitute only a small percentage of the total fauna. The faunal diversity is low, mostly ranging from 2 to 10, the number of species usually ranging from 10 to 25. The number of specimens is often less than 500 (maximum 5,000) per 100 g sediment. A comparison of the assemblage with assemblages from Hirtshals coast cliff and from the *Portlandia arctica* Zone in the Skærumhede boring indicates that all these deposits are referable to the Older *Yoldia* Clay.

The frequency of selected species from profile C at Løkken Blånæse and from the profiles, H, Q, T and U farther south is shown in the range chart, fig. 26. The assemblages of the Older *Yoldia* Clay at Løkkens Blånæse and southwards in the coast cliff to profile P, and of the upper part of profile Q, are dominated by *Elphidium clavatum* and *Cassidulina crassa. Nonion labradoricum, Virgulina loeblichi,* and *Islandiella norcrossi* occur in most samples, and *Elphidium asklundi, E. groenlandicum, Uvigerina peregrina, Nonion barleeanum, Hyalinea baltica,* and *Astrononion gallowayi* are characteristic, but usually account for only a small percentage of the total fauna. The faunal diversity is low, and the number of specimens usually less than 600 per 100 g sediment. This assemblage is comparable to the zone A assemblage of Hirtshals (Andersen, this paper) and the zone 1 assemblage of Sandnes (Feyling-Hanssen, this paper).

The Older *Yoldia* Clay in the lower part of profile Q, and in the profiles farther south in the coast cliff (figs. 25 and 26), contains assemblages equivalent to the zone C assemblage of Hirtshals (Andersen, this paper) and the zone 3 assemblage of Sandnes (Feyling-Hanssen, this paper). *Elphidium clavatum* is the dominant species (75–95 % of the total fauna), whereas *Cassidulina crassa* usually accounts for less than 10 %. *Elphidium asklundi* is a characteristic and rather common species (1–10 %). *Elphidium subarcticum, Protelphidium orbiculare,* and *Buccella frigida* are

characteristic accessory species. *Nonion labradoricum, Virgulina loeblichi, Islandiella norcrossi,* and *I. teretis* occur in many samples from this part of the coast cliff. They are very rare in the corresponding deposits from Sandnes (Feyling-Hanssen, this paper). The faunal diversity is extremely low, ranging between 1 and 5. The number of specimens range from less than 50 to 2,400, with a maximum of 5,000 per 100 g sediment.

At Løkkens Blånæse (profiles B – G, fig. 25), the Older *Yoldia* Clay consists of hard grey clay, whereas the silt and sand fractions are dominant farther south (profiles H – O). In the southernmost part of the coast cliff (profiles P – U) the Older *Yoldia* Clay mostly consists of clay with interbedded sand layers.

In the coast cliff extending for a distance of 150 m to the north from Løkkens Blånæse, the Older *Yoldia* Clay gradually changes into very disturbed clayey and sandy sediments. Foraminiferal analyses of samples from this part of the coast cliff (profile A) show assemblages corresponding to those from the Older *Yoldia* Clay at Løkkens Blånæse. However, some of the samples are completely devoid of fossils. Farther to the north the coast cliff is composed of well-sorted sand without fossils, this sand probably being of glacifluvial origin.

A sample from the Older *Yoldia* Clay north of Løkkens Blånæse contains the following assemblage:

Løkkens Blånæse, profile A. Coll. Knudsen, 1968.

| Species | Frequency | Percentage |
|---|---|---|
| *Elphidium clavatum* | 150 | 46 |
| *Cassidulina crassa* | 135 | 41 |
| *Bulimina marginata* | 6 | 2 |
| *Islandiella norcrossi* | 4 | 1 |
| *Nonion labradoricum* | 4 | 1 |
| *Virgulina loeblichi* | 3 | 1 |
| *Virgulina fusiformis* | 2 | 1 |
| *Trifarina fluens* | 2 | 1 |
| *Hyalinea baltica* | 2 | 1 |
| *Cibicides lobatulus* | 2 | 1 |
| *Astrononion gallowayi* | 2 | 1 |
| *Elphidium albiumbilicatum* | 2 | 1 |
| *Cassidulina laevigata* | 1 | <1 |
| *Nonion barleeanum* | 1 | <1 |
| *Elphidium asklundi* | 1 | <1 |
| *Elphidium magellanicum* | 1 | <1 |
| *Elphidium subarcticum* | 1 | <1 |
| Indeterminate species | 7 | 2 |
| Total | 326 | |

This count represents the whole sample (100 g). The number of species is 17, and the faunal diversity 9.

## Furreby Å

Profile T (figs. 25 and 26) is seen at the coast cliff just north of the outlet of the rivulet Furreby Å. In the upper part of this section a layer of approximately 1 m thickness consists of clay rich in organic material. The lower part is particularly rich in plant remains, whereas the upper part contains many mollusc shells. *Cerastoderma edule* and *Littorina littorea* are the most frequent species. Below this peat-like layer a 10 cm thick layer of sand is seen. This sand bed contains pebbles and small pieces of wood in the lower part.

The layers described above contain foraminiferal assemblages comparable to the Postglacial assemblages from the borings at Løkken and from the cliff of Løkkens Blånæse. The frequency of some selected taxa from profile T is shown in the range chart, fig. 26. The uppermost sample (no. 5) contains a poor boreal, brakish and shallow water assemblage with both arenaceous and calcareous species. In the sand layer (sample no. 4) only the two arenaceous species *Miliammina fusca* and *Trochammina inflata* are found. Calcareous species may have been present in the original assemblage and later decalcinated by acid ground water from below the bituminous clay- and peat layers. The two arenaceous species occurring in the sandy layer are typical boreal, and the bed is referred to the Postglacial *Littorina* deposits.

Jessen (1918, 1931 and 1936) described a profile from the coast cliff north of Furreby Å. He found a peat layer below the *Littorina* deposits and considered this to have been deposited during a continental phase which prevailed in Vendsyssel towards the end of Lateglacial and through early Postglacial time. The presence of boreal foraminifera in the sandy layer below the peat indicates, however, a Postglacial age for these deposits. The peat layer may be a brakish-marine deposit, or it might have been deposited during a temporary Postglacial regression of the *Littorina* Sea.

Mörner (1969, p. 381) has described a section in the coast cliff north of Furreby Å, in which he found a 17 cm thick layer of peat-like clay containing a brackish-marine diatom flora below approximately 1 m of marine clay-mud with shells. According to Mörner, soil identification showed Jessen's "peat" layer to be a brackish-marine deposit showing a gradual transition into marine clay-mud with shells. Mörner believed the peat-like layer at the bottom to have been deposited in shallow water during the Postglacial transgression. Nothing is known about presence of foraminifera in the lower peat-like layer, but the occurrence of boreal shallow-water foraminifera in the sandy layer below, agrees very well with Mörner's interpretation.

The Postglacial deposits at Furreby Å overlie interbedded sands and clays, each layer being a few cm thick. The total thickness of these beds is approximately 1 m. At the bottom of the section an olive-grey clay is seen. Jessen (1918 and 1936) considered this deposit to be of glacifluvial origin. However, investigations reveals a foraminiferal assemblage equivalent to an Older *Yoldia* Clay assemblage.

A sample from this Older *Yoldia* Clay in profile T contains the following assemblage:

Løkkens Blånæse, profile T, sample no. 1. Coll. Knudsen, 1967.

| Species | Frequency | Percentage |
|---|---|---|
| *Elphidium clavatum* | 315 | 85 |
| *Elphidium asklundi* | 23 | 6 |
| *Protelphidium orbiculare* | 7 | 2 |
| *Cassidulina crassa* | 6 | 2 |
| *Elphidium albiumbilicatum* | 2 | 1 |
| *Elphidium subarcticum* | 2 | 1 |
| *Fissurina laevigata* | 1 | <1 |
| *Bulimina fossa* | 1 | <1 |
| *Bulimina marginata* | 1 | <1 |
| *Virgulina loeblichi* | 1 | <1 |
| *Bolivina pseudoplicata* | 1 | <1 |
| *Buccella frigida* | 1 | <1 |
| *Epistominella takayanagii* | 1 | <1 |
| *Cibicides lobatulus* | 1 | <1 |
| *Nonion barleeanum* | 1 | <1 |
| *Nonionella auricula* | 1 | <1 |
| *Nonionella turgida* | 1 | <1 |
| *Astrononion gallowayi* | 1 | <1 |
| *Elphidium incertum* | 1 | <1 |
| Indeterminate species | 4 | 1 |
| Total | 372 | |

This count represents about 2 % of the sample (337 g). The number of species is 19, with a faunal diversity of only 4. This assemblage is comparable to those from zone C in Hirtshals (Andersen, this paper) and from zone 3 of Sandnes (Feyling-Hanssen, this paper).

## Kodals Rende

Kodals Rende is a stream gully in the coast cliff approximately 1,500 m north of Løkkens Blånæse. Here Jessen (1931) found a peat, overlain by marine clay containing numerous bivalves, e.g. *Cerastoderma edule, Mytilus edulis,*

*Littorina littorea.* A few layers of peat were found within the clay unit. Jessen classified this deposit as Postglacial *Littorina* Clay, and through borings he was able to connect it with Postglacial deposits east of Løkken. Below the peat Jessen found clay, silt, and sand which he considered to be of glacifluvial origin.

The Postglacial *Littorina* Clay at Kodals Rende is less than 3 m thick and is exposed over a stretch of about 50 m in the cliff.

Mörner (1969, p. 381) attempted more detailed stratigraphical subdivisions of this locality. He described the following profile: At the top a layer of sand (layer A). Then 0.4 m of coarse detrital mud (layer B) which contained a brackish-marine diatom flora. A sample from this layer was dated at 3,365 ± 100 B.C. Layer C was 1.0–1.5 m of clayey mud with numerous shells. This unit rested upon 1.0 m of peat-like organic material (layer D), the upper part of which contained a brackish-marine diatom flora. Mörner had two samples from the upper part of this unit radiometrically dated at 5,115 ± 135 B.C. and 5,450 ± 120 B.C. and a sample from the lowermost part at 6,125 ± 125 B.C. Accordingly, Mörner considered the lower part of this unit to be a terrestrial formation from the time before the *Littorina* transgression, whereas the upper part was deposited at the beginning of this transgression. Below layer D there was a 0.8 m thick layer of mixed sand and peat (layer E) which Mörner assumed to be of Boreal age. In the lowermost part of the section at Kodals Rende Mörner found varved sediments consisting of clay, silt and sand, layer I. He considered these to be of Lateglacial age. These are the glacifluvial deposits of Jessen.

The present author collected a series of samples from the cliff at Kodals Rende in 1968 and 1969. The foraminiferal content of some of them is presented below. A sample of clayey mud rich in plant remains and shells of molluscs (= Mörner's layer C) yielded the following assemblage:

Kodals Rende. Coll. Knudsen, 1969.

| Species | Frequency | Percentage |
|---|---|---|
| *Protelphidium anglicum* | 198 | 48 |
| *Ammonia batavus* | 133 | 32 |
| *Elphidium umbilicatulum* | 55 | 13 |
| *Elphidium clavatum* | 14 | 3 |
| *Elphidium albiumbilicatum* | 3 | 1 |
| *Elphidium gerthi* | 3 | 1 |
| *Elphidium margaritaceum* | 3 | 1 |
| *Nonion umbilicatulum* | 1 | <1 |
| *Elphidium incertum* | 1 | <1 |
| Total | 411 | |

This count represents about 2 % of the sample (100 g) which means that the number of specimens per 100 g sediment is 18,500. The number of species, however, is only 9, and the faunal diversity as low as 4.

A sample of sand collected below layer C, and probably corresponding to Mörner's layer D, contains the following assemblage:

Kodals Rende. Coll. Knudsen, 1969.

| Species | Frequency | Percentage |
|---|---|---|
| *Trochammina inflata* | 173 | 77 |
| *Jadammina polystoma* | 42 | 19 |
| *Haplophragmoides canariensis* | 7 | 3 |
| *Miliammina fusca* | 3 | 1 |
| Total | 225 | |

This count represents about 66 % of the sample (100 g), only 4 different species are present, the faunal diversity is 2.

Both of these faunas are boreal and they reflect shallow water of low salinity, but the latter one, with only four species present, indicates extremely shallow water. In fact, this fauna is comparable to a marsh fauna, whereas

Kodals Rende. Coll. Knudsen, 1969.

| Species | Frequency | Percentage |
|---|---|---|
| *Elphidium clavatum* | 124 | 52 |
| *Cassidulina crassa* | 72 | 30 |
| *Bulimina marginata* | 8 | 3 |
| *Elphidium albiumbilicatum* | 5 | 2 |
| *Buccella frigida* | 4 | 2 |
| *Nonion labradoricum* | 3 | 1 |
| *Cibicides lobatulus* | 2 | 1 |
| *Elphidium asklundi* | 2 | 1 |
| *Marginulina glabra* | 1 | <1 |
| *Virgulina loeblichi* | 1 | <1 |
| *Uvigerina peregrina* | 1 | <1 |
| *Trifarina fluens* | 1 | <1 |
| *Cassidulina laevigata* | 1 | <1 |
| *Nonion barleeanum* | 1 | <1 |
| *Pullenia bulloides* | 1 | <1 |
| *Pullenia subcarinata* | 1 | <1 |
| *Protelphidium niveum* | 1 | <1 |
| *Protelphidium orbiculare* | 1 | <1 |
| Indeterminate species | 7 | 3 |
| Total | 237 | |

the layer C assemblage indicates somewhat deeper water. The evidence from these assemblages thus supports Mörner's suggestions about the *Littorina* transgression at this locality. The poorer fauna dates from the initial stage of the transgression, whereas the other one reflects the conditions during a later stage.

Some samples were collected from the lowermost part of the section and might be expected to represent the glacifluvial deposits of Jessen, or the Lateglacial of Mörner. Examination of these samples revealed, however, the presence of foraminiferal assemblages related to those of the Older *Yoldia* Clay. In the northern part of Kodals Rende these deposits consist of clay with layers of sand and silt in the lower part. A sample from this lower part contains the assemblage listed on p. 148.

The whole sample (100 g) was counted. The number of different species is 18, the faunal diversity 13.

In the southern part of the coast cliff at Kodals Rende the lower sediments consist of a hard olive-grey clay. The following assemblage was found in a sample from these deposits:

Kodals Rende. Coll. Knudsen, 1969.

| Species | Frequency | Percentage |
|---|---|---|
| *Elphidium clavatum* | 68 | 39 |
| *Cassidulina crassa* | 57 | 33 |
| *Cibicides lobatulus* | 5 | 3 |
| *Islandiella norcrossi* | 4 | 2 |
| *Elphidium albiumbilicatum* | 4 | 2 |
| *Bulimina marginata* | 3 | 2 |
| *Uvigerina peregrina* | 3 | 2 |
| *Nonion labradoricum* | 3 | 2 |
| *Virgulina fusiformis* | 2 | 1 |
| *Virgulina loeblichi* | 2 | 1 |
| *Trifarina fluens* | 2 | 1 |
| *Islandiella teretis* | 2 | 1 |
| *Nonion barleeanum* | 2 | 1 |
| *Oolina acuticosta* | 1 | 1 |
| *Oolina caudigera* | 1 | 1 |
| *Fissurina danica* | 1 | 1 |
| *Fissurina lucida* | 1 | 1 |
| *Nonionella auricula* | 1 | 1 |
| *Elphidium groenlandicum* | 1 | 1 |
| *Elphidium incertum* | 1 | 1 |
| *Elphidium macellum* | 1 | 1 |
| *Protelphidium orbiculare* | 1 | 1 |
| Indeterminate species | 7 | 4 |
| Total | 173 | |

Also this count represents the whole of the sample (100 g). The number of different species is 22, the diversity 17.

These assemblages compare with those from the Older *Yoldia* Clay at Løkkens Blånæse, with those from zone A in Hirtshals (Andersen, this paper), and with those from zone 1 in Sandnes (Feyling-Hanssen, this paper). Accordingly, the deposits in the lower part of the coast cliff at Kodals Rende are regarded as Older *Yoldia* Clay.

## Palaeoenvironment and stratigraphy

### Older *Yoldia* Clay

The Older *Yoldia* Clay is exposed in the coast cliff extending from Løkken to Løkkens Blånæse (fig. 25), and farther north at Kodals Rende. The maximum number of foraminifera in the Older *Yoldia* Clay is 5,000 per 100 g sediment, but the majority of the samples contains less than 500 specimens. The number of different species in each sample usually ranges between 5 and 26, whereas the faunal diversity ranges from 1 to 13, in a single sample it is 17.

The studies have disclosed two distinctly different assemblages in the Older *Yoldia* Clay. In samples from Kodals Rende and from the northern part of the coast cliff between Løkkens Blånæse and Furreby Å the assemblage is dominated by *Elphidium clavatum* and *Cassidulina crassa* (22–94 % of the total fauna). In addition *Nonion labradoricum, Virgulina loeblichi, Islandiella norcrossi, Elphidium asklundi, E. groenlandicum, Uvigerina peregrina, Nonion barleeanum,* and *Hyalinea baltica* are characteristic, but account only for a small percentage of the total fauna. The faunal diversity ranges from 6 to 13. This is an arctic assemblage with an element of boreal species, e.g. *Uvigerina peregrina, Nonion barleeanum,* and *Hyalinea baltica.* The presence of the species *Nonion labradoricum, N. barleeanum,* and *Uvigerina peregrina* indicate that the water depth was probably more than 20 m. The assemblage is much like those from zone A in the Older *Yoldia* Clay at Hirtshals (Andersen, this paper) and from zone 1 in Sandnes (Feyling-Hanssen, this paper).

Samples from the southern part of the Løkkens Blånæse and Furreby Å cliff contain another type of fauna. *Elphidium clavatum* is the most frequent species (75–95 % of the total fauna), whereas the content of *Cassidulina crassa* usually is below 10 %. Other characteristic species are *Elphidium asklundi, E. subarcticum, Buccella frigida,* and *Protelphidium orbiculare.* The faunal diversity is low, between 1 and 5. This is an arctic shallow-water assemblage, and it is remarkable by the absence of boreal species. The water was more shallow and the temperature lower during deposition of this se-

quence, than during deposition of the above-mentioned part of the Older *Yoldia* Clay. The assemblage is comparable to those classified as zone C at Hirtshals (Andersen, this paper) and zone 3 at Sandnes (Feyling-Hanssen, this paper).

The assemblages in the Older *Yoldia* Clay are different from those of the Younger *Yoldia* Clay at Løkken. This is probably caused by different ecological conditions during sedimentation, and not by the difference in age. It seems that *Elphidium asklundi* is the most characteristic species of the Older *Yoldia* Clay. This species has not been recorded in the Lateglacial deposits from Løkken, nor from those in the Oslofjord area (Feyling-Hanssen, 1964 a). However, the species was originally described from Lateglacial deposits in Sweden (Brotzen, 1943). *Elphidium asklundi* is not recorded from Recent waters. Another characteristic species in the Older *Yoldia* Clay is *Elphidium groenlandicum*. This species was not recorded from the Lateglacial deposits in the Oslofjord area (Feyling-Hanssen, 1964 a). A few fragmentary specimens from the Younger *Yoldia* Clay at Løkken are probably reworked. The boreal species *Uvigerina peregrina* which occurs in many samples of Older *Yoldia* Clay, has not been recorded from the Lateglacial deposits at Løkken, nor from the Oslofjord area (Feyling-Hanssen, 1964a). *Islandiella teretis* is rather common in the Older *Yoldia* Clay, but is not present in the Younger *Yoldia* Clay at Løkken. A few specimens have been found in the Lateglacial of the Oslofjord area. Some specimens of *Islandiella islandica* occur in the Older *Yoldia* Clay, but this species was not recorded from the Lateglacial at Løkken nor in the Oslofjord area. *Hyalinea baltica* also seems to be a characteristic species in the Older *Yoldia* Clay; only a few specimens occur in the Lateglacial deposits at Løkken.

The foraminifera of the Older *Yoldia* Clay at Løkken are mostly the same as those from the *Portlandia arctica* Zone of the Skærumhede boring in the material left by the late dr. A. Nørvang. Jessen (1918 and 1936) referred the Older *Yoldia* Clay in Vendsyssel to the Eem Interglacial. However, the assemblages compare closely with the assemblages of the Sandnes Clay in southwestern Norway, described by Feyling-Hanssen (1966, and this paper). He considered these deposits to be of Weichselian interstadial age and correlated them with the Paudorf Interstadial. Mörner (1969) proposed a correlation of the entire Older *Yoldia* Clay in Vendsyssel with the Lower- and Interpleniglacial of the Netherlands. See also the discussion on pp. 101–104 and p. 160 in the present paper.

## Lateglacial deposits

The Lateglacial Younger *Yoldia* Clay is found in the deepest part of the three borings I, II, and IV at Løkken (figs. 19, 24). These deposits contain assemblages in which *Elphidium clavatum* and *Cassidulina crassa* are the

most frequent species. In addition, the following species occur in many of the samples: *Virgulina loeblichi, Trifarina fluens, Nonion labradoricum, Buccella frigida, Elphidium incertum, E. subarcticum,* and *Protelphidium orbiculare.* It is characteristic that the accessory species only constitute a small percentage of the total fauna. The faunal diversity is low, and the number of specimens usually less than 500 per 100 g sediment. This assemblage is typically arctic. The species are equivalent to those recorded from Recent arctic assemblages in Hudson Bay (Leslie, 1965) and from Spitsbergen (Nagy, 1965). The assemblages also compare with those found in Lateglacial deposits of Læsø (Michelsen, 1967), of the Oslofjord area (Feyling-Hanssen, 1964 a) and of Surte, Sweden (Brotzen, 1951).

When compared with the Lateglacial foraminifera zones in the Oslofjord area (Feyling-Hanssen, 1964 a), it is evident that the assemblages from Løkken are very much like those of his subzones $A_l$ and $A_u$. The two subzones are dominated by *Elphidium clavatum* and *Cassidulina crassa,* whereas all other species are sparsely represented. The faunal diversity is small, indicating extreme ecological conditions. Feyling-Hanssen regards the subzone $A_l$ to have been deposited during a rapid retreat of the ice margin to the Ra stage, and the subzone $A_u$ during a retreat from the Ra to the Ås-Ski stage. During these periods of retreat the sea water in front of the ice margin was diluted by cold, fresh and turbid meltwater of low transparency. The foraminiferal assemblages were affected by these severe conditions, and it is characteristic that such assemblages are dominated by only one or two species.

Jessen (1918 and 1936) described two different types of Younger *Yoldia* Clay in Vendsyssel. In the northern and eastern part the Younger *Yoldia* Clay was deposited in normal marine water. The stratification of the sediment is often indistinct, and the clay rich in biogenic matter. In the southern and western part, where the deposition took place in brackish or even in fresh water, the clay is well stratified and almost unfossiliferous. Jessen believed that the unfossiliferous *Yoldia* Clay was deposited during a rapid retreat of the ice margin from the southern and western part of Vendsyssel. The meltwater must have flowed westwards to the western part of the Limfjord area and to the area around Løkken, restricted to the south by the moraine landscape, to the east by the ice margin, and to the north first by the ice margin and later on by moraines.

The foraminiferal assemblages in the Younger *Yoldia* Clay at Løkken are dominated by the two species *Elphidium clavatum* and *Cassidulina crassa.* The low faunal diversity may indicate ecological conditions similar to those in the Oslofjord region during deposition of the subzones $A_l$ and $A_u$. The small number of specimens may be due to a high rate of sedimentation in front of the ice margin.

The similarity of the Lateglacial assemblage from Løkken with those from subzone $A_l$ and $A_u$ of the Oslofjord area indicates similarity of ecological environment, but not necessarily of age.

The highest Lateglacial beach deposits that are known in the area around Løkken are situated 20–25 m above sea level. The lowermost sample containing a Lateglacial assemblage was found 9.4 m below sea level, which means that the water depth in which the Younger *Yoldia* Clay at Løkken was deposited must have been less than 30–35 m.

There are no dates for the Younger *Yoldia* Clay in the Løkken area, but elsewhere in Vendsyssel the deposit has been radiometrically dated at 10,700 –12,330 B.C. (Tauber, 1966 and personal information from H. Krog). The deposition of the Younger *Yoldia* Clay in Vendsyssel thus took place during the Oldest *Dryas* time (Pollen zone I a) which is also called the Daniglacial tundra period.

## Postglacial deposits

Postglacial *Littorina* deposits have been recorded from the four borings at Løkken (figs. 19, 24) and from the coast cliff north of Løkken, viz. at Furreby Å, Løkkens Blånæse and Kodals Rende (figs. 25, 27). The foraminiferal assemblages are dominated by *Ammonia batavus* and *Protelphidium anglicum* and in addition the following species occur frequently: *Elphidium umbilicatulum, E. albiumbilicatum, E. clavatum, E. macellum, E. margaritaceum, E. gerthi* and *E. subarcticum. Trochammina inflata, Jadammina polystoma, Ammoscalaria runiana,* and *Miliammina fusca* are the most common arenaceous species. The number of specimens per 100 g sediment is usually great, but the faunal diversity low, ranging between 3 and 9. Similar assemblages are known from boreal shallow-water areas to-day, e.g. from the Recent Dollart-Ems estuary in the Netherlands (van Voorthuysen, 1960), from Langeoog (Haake, 1962), from the Jade Bay in northern Germany (Bartenstein, 1938; Richter, 1964 a and b), and from the Plymouth district (Murray, 1965 a). Similar assemblages have also been recorded from Postglacial deposits of Læsø (Michelsen, 1967) and of the Oslofjord region (Feyling-Hanssen, 1964 a). The foraminifera of the Postglacial deposits at Løkken not only seem to indicate shallow water, but most probably were influenced by reduced salinity as well. *Protelphidium anglicum* (often recorded as *Nonion depressulus* (Walker & Jacob)) is known from brackish water, and is common in the tidal zone (Murray, 1965 a). *Ammonia batavus* is a shallow-water species which may also inhabit greater depths (Richter, 1961; van Voorthuysen, 1960). *Elphidium umbilicatulum* prefers quiet water of low salinity (Richter, 1964 a and b) and *Elphidium gerthi* is also a brackish-water species (van Voorthuysen, 1957). *Elphidium margarita-*

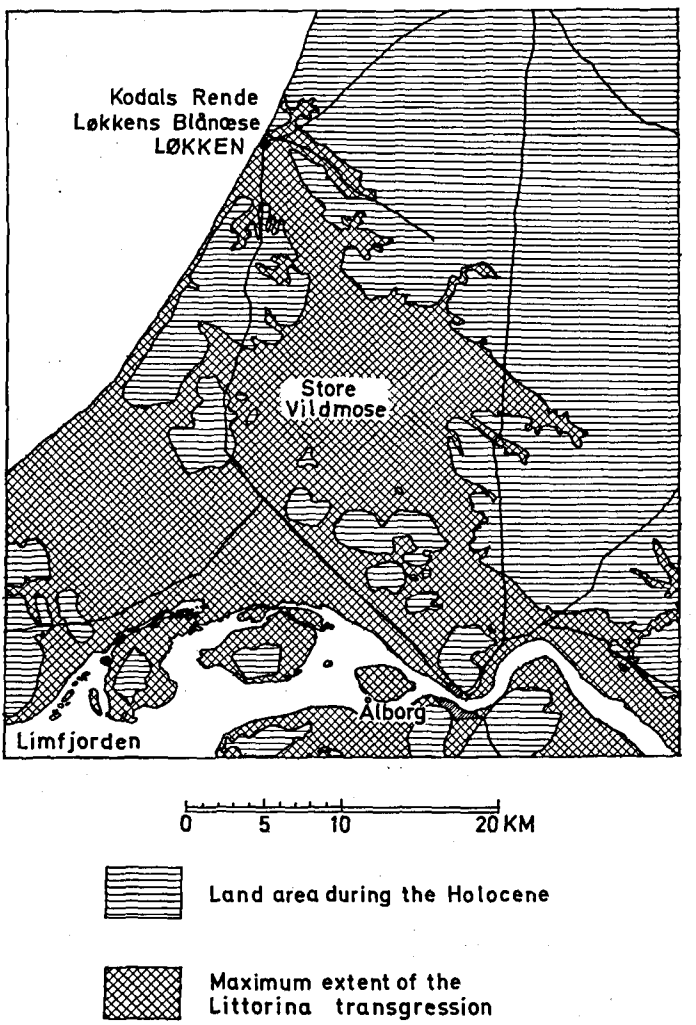


Fig. 27. Maximum extent of the *Littorina* transgression in the Løkken area. After Jessen, 1920.

*ceum* is known from the tidal zone (Haake, 1962) and *Elphidium albiumbilicatum* (syn. *Nonion depressulus asterotuberculatus* van Voorthuysen) seems to prefer the same environment. *Quinqueloculina seminulum* is recorded from more turbulent water (Murray, 1965 a). *Miliammina fusca* and *Ammoscalaria runiana* indicate shallow water and, in addition, the species *Trochammina inflata, Jadammina polystoma,* and *Miliammina fusca* prefer brackish water (Bartenstein, 1938).

The low faunal diversity associated with the Postglacial assemblages from

Løkken may thus have been caused by low salinity and shallow water. The large number of specimens per 100 g sediment, on the other hand, may have been caused by a relatively rich supply of food, although a low rate of sedimentation cannot be excluded.

Beach deposits from the *Littorina* transgression are not observed at Løkken at heights greater than 9.5 m above sea level. The lowest Postglacial deposit was found at 5.4 m below sea level. Therefore the Postglacial sediments in the Løkken area must have been deposited at a depth of less than approximately 15 m.

Jessen (1920) interpreted the *Littorina* deposits at Løkken as fjord deposits, because they contained a fossil assemblage with much greater affinity to the present-day Limfjord bios than to that of the North Sea. He assumed a Postglacial fjord to have extended from the Limfjord northwestward over Store Vildmose to the area around Løkken (fig. 27). The *Littorina* deposits in the coast cliff at Furreby Å, Løkkens Blånæse, and Kodals Rende represent sections through the inner ramifications of this fjord. The west coast of Vendsyssel must have been situated farther to the west at that time, or some kind of a barrier separated this fjord from the open sea to the northwest. In general, the ecological interpretations of the foraminiferal assemblages in the Postglacial deposits of the Løkken area support Jessen's view. However, the content of up 22 % of the species *Quinqueloculina seminulum* in samples from boring no. I, and 17 % in a single sample from Løkkens Blånæse, may indicate temporary connections with the open sea, as

The Limfjord, Nissum Bredning. Coll. J. Bendtsen, 1969.

| Species | Frequency | Percentage |
|---|---|---|
| *Ammoscalaria runiana* | 90 | 30 |
| *Ammonia batavus* | 42 | 14 |
| *Elphidium umbilicatulum* | 40 | 13 |
| *Protelphidium anglicum* | 35 | 12 |
| *Eggerella scabra* | 30 | 10 |
| *Miliammina fusca* | 21 | 7 |
| *Jadammina polystoma* | 9 | 3 |
| *Reophax pilulifera* | 6 | 2 |
| *Trochammina inflata* | 6 | 2 |
| *Elphidium clavatum* | 3 | 1 |
| *Elphidium gerthi* | 3 | 1 |
| *Textularia* aff. *earlandi* | 2 | 1 |
| *Haplophragmoides canariensis* | 1 | <1 |
| *Trochammina astrifica* | 1 | <1 |
| Indeterminate species | 14 | 5 |
| Total | 303 | |

*Quinqueloculina seminulum* prefers rather turbulent water of normal marine salinity.

Nordmann (1905) compared the mollusc assemblages of the *Littorina* deposits southeast of Løkken with Recent assemblages in the Limfjord and in shallow-water areas of the North Sea. He found a good correlation with the Limfjord assemblages, whereas the mollusc assemblages of the North Sea were different.

For comparison, the present author examined the content of foraminifera in some Recent samples from the Limfjord. A sample from Nissum Bredning, collected at a water depth of about 0.5 m, contained the assemblage listed on p. 155.

This count represents 50 % of the sample (100 g). The number of different species in the sample is 14.

Another sample from Nissum Bredning, from a water depth of approximately 4 m, contained the following species:

The Limfjord, Nissum Bredning. Coll. J. Bendtsen, 1969.

| Species | Frequency | Percentage |
|---|---|---|
| *Ammonia batavus* | 155 | 45 |
| *Eggerella scabra* | 83 | 24 |
| *Elphidium clavatum* | 43 | 12 |
| *Ammoscalaria runiana* | 29 | 8 |
| *Protelphidium anglicum* | 10 | 3 |
| *Miliammina fusca* | 5 | 1 |
| *Elphidium gerthi* | 5 | 1 |
| *Elphidium subarcticum* | 3 | 1 |
| *Textularia* aff. *earlandi* | 2 | 1 |
| *Ammobaculites* sp. | 1 | <1 |
| *Jadammina polystoma* | 1 | <1 |
| *Trochammina astrifica* | 1 | <1 |
| *Quinqueloculina seminulum* | 1 | <1 |
| *Buliminella elegantissima* | 1 | <1 |
| *Elphidium albiumbilicatum* | 1 | <1 |
| *Elphidium incertum* | 1 | <1 |
| *Elphidium umbilicatulum* | 1 | <1 |
| Indeterminate species | 3 | 1 |
| Total | 346 | |

This count represents about 4 % of the sample (100 g). The number of different species is 17, with a faunal diversity of 8.

The assemblages from the Limfjord have much in common with those from the *Littorina* deposits at Løkken. However, the arenaceous species are

much more abundant in the Recent faunas from the Limfjord than in the *Littorina* deposits at Løkken. This may be due to a secondarily imposed scarcity of arenaceous specimens in the fossil material. Some of the arenaceous foraminifera may have been destroyed during and after sedimentation, others may have been destroyed during washing and treatment with hydrogen peroxide in the laboratory. Risdal (1963 and 1964), who studied Recent foraminiferal assemblages in the Oslofjord, found a distinct increase in arenaceous species towards the top layers of the cores and pointed out that this may be a result of destruction during sedimentation. On the other hand, he suggested that the apparent immigration of arenaceous forms during Sub-Atlantic time, was caused by an increased food supply generated by sewage pollution. Watkins (1961) showed that arenaceous forms have a distinct affinity for polluted sea water.

Again, for comparison, the count of a Recent North Sea sample from the beach at Nr. Lyngby, north of Løkken, is presented. The following species of foraminifera occur:

North Sea, Nr. Lyngby beach. Coll. Feyling-Hanssen, 1969.

| Species | Frequency | Percentage |
|---|---|---|
| *Elphidium clavatum* | 187 | 49 |
| *Quinqueloculina seminulum* | 53 | 14 |
| *Ammonia batavus* | 44 | 12 |
| *Pateoris hauerinoides* | 26 | 7 |
| *Cibicides lobatulus* | 17 | 4 |
| *Miliolinella subrotunda* | 10 | 3 |
| *Elphidium incertum* | 9 | 2 |
| *Protelphidium anglicum* | 6 | 2 |
| *Elphidium macellum* | 5 | 1 |
| *Elphidium umbilicatulum* | 5 | 1 |
| *Elphidium albiumbilicatum* | 4 | 1 |
| *Anomalina globulosa* | 2 | 1 |
| *Eggerella scabra* | 1 | <1 |
| *Lenticulina gibba* | 1 | <1 |
| *Bulimina marginata* | 1 | <1 |
| *Cassidulina crassa* | 1 | <1 |
| *Islandiella norcrossi* | 1 | <1 |
| *Rosalina vilardeboana* | 1 | <1 |
| *Discanomalina* sp. | 1 | <1 |
| *Elphidium magellanicum* | 1 | <1 |
| *Elphidium margaritaceum* | 1 | <1 |
| *Protelphidium orbiculare* | 1 | <1 |
| Indeterminate species | 2 | 1 |
| Total | 380 | |

This count represents about 33 % of the sample (100 g). The number of different species is 22, and the faunal diversity 11. The most frequent species is *Elphidium clavatum,* representing 49 % of the total fauna. It should be mentioned, however, that at least some of the specimens recorded as *Elphidium clavatum* in Recent and Postglacial deposits from Vendsyssel differ from the Lateglacial and interstadial *E. clavatum.* They should probably be referred to *Elphidium selseyense.* Transitional forms seem to occur; they are all at the present state of knowledge classed as *E. clavatum.*

*Ammonia batavus* and *Protelphidium anglicum* are the dominant species in most assemblages from Postglacial deposits in the Løkken area, whereas *Elphidium clavatum* usually is less abundant.

The high frequency of *Quinqueloculina seminulum* and other Miliolidae is another remarkable difference between the Postglacial assemblages in the Løkken area and the Recent ones from the North Sea. Only a few samples from the Postglacial deposits from boring no. I at Løkken and one from Løkkens Blånæse contain this species in any abundance. This may, as already mentioned, indicate one or more temporary connections between the Postglacial fjord and the North Sea during deposition of the *Littorina* deposits in the area.

Concerning the age of the *Littorina* deposits in the Løkken area, there are some dates from Kodals Rende (Mörner, 1969), showing ages from 5,115 ± 135 to 3,365 ± 100 years B.C. Elsewhere in Vendsyssel marine deposits from the *Littorina* transgression are dated at 6,330 to 550 years B.C. (Tauber, 1966 and personal information from H. Krog). Deposition of these sediments took place during Atlantic and Subboreal times, corresponding to the pollen zones VI, VII and VIII (Hansen, 1965, modified from Iversen, 1960).