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Foraminiferal stratigraphy in the Plio-Pleistocene
Kap København Formation, North Greenland

Rolf W. Feyling-Hanssen

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Rolf W. Feyling-Hanssen
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Foraminiferal stratigraphy in the Plio-Pleistocene Kap København Formation, North Greenland

ROLF W. FEYLING-HANSSEN


Fossil foraminiferal assemblages occurring in fine-grained sediments of the Kap København Formation, Peary Land, North Greenland, are grouped into six assemblage zones: the *Elphidium funderi* Zone, oldest, the *Cassidulina laevigata* Zone, the *Elphidiella rolfi* Zone, the *Elphidium cf. excavatum* Zone, the *Elphidiella gorbunovi* Zone, youngest.

Comparison of these zones with fossil foraminiferal assemblages from other Arctic localities and with fossil assemblages from borings in the North Sea indicates that the *Elphidium funderi* Zone and the *Cassidulina laevigata* Zone are of Upper Pliocene age whereas the *Elphidium excavatum* Zone belongs to the Lower Pleistocene. The *Elphidiella rolfi* Zone is an uppermost Pliocene shallow water zone, and the *Elphidium cf. excavatum* Zone probably represents a transition zone between the Pliocene and the Pleistocene.

Rolf W. Feyling-Hanssen, Geological Institute, University of Aarhus, DK-8000 Århus C, Denmark.

The Kap København Formation is a shallow water deposit of unconsolidated marine sediments in coastal areas of eastern Peary Land, North Greenland (Funder & Hjort 1980; Funder et al. 1984; 1985). It covers an area of 500 km² and is at least 100 m thick (Figs 1 and 2). At the type section two distinctive lithological units have been distinguished (Fig. 3); the lower member A is composed of finely laminated, red or grey clay and silt, and the upper member B is composed mainly of sand, excluding subunit B2, which is composed of silt (Funder et al. 1984). This member is noteworthy for its abundant and well preserved plant and insect remains (Bennike & Böcher in press; Bennike in press).

The age of the Kap København Formation has been assessed by a number of different methods. Previous foraminifer stratigraphical work located the Plio-Pleistocene boundary in unit B2 at the type section (locality 50) (Funder et al. 1985; Feyling-Hanssen 1987). Vertebrate remains from unit B3 indicated an age between 2 and 2.4 ma (Repenning et al. 1987; Bennike in press). These results are in agreement with palaeomagnetic measurements from member B (Abrahamsen & Marcussen 1986), and amino acid analyses of bivalve shells (Funder et al. 1987).

The sediments of the Kap København Formation are in many places tectonically deformed and disturbed. Thrust sheets of older parts of the deposit may occur above younger units (Funder et al. 1984; 1985). A major objective of the present study has been to throw light on the age relationships between the many exposures scattered over a large area.

**Material and methods**

Foraminifera occur in the fine-grained sediments of member A and unit B2 (Fig. 3). Some of them are well preserved with glistening test surfaces; others are in a poor state of preservation with broken chambers or, more often, with etched test surfaces. This may be due to the dissolution of calcium carbonate by the ground water becoming acidic by percolating through sediments rich in plant remains. This may also explain why many sediment samples were barren or nearly barren of fossil foraminifera even though molluscan shells occurred in them. Maybe for the same reason some samples contained relatively many agglutinating specimens and only a few, badly preserved calcareous tests.

A total of 152 samples have been examined, they originate from 23 localities scattered over the Kap København area (Fig. 2). The dry weight of the samples was 100–200 g. One hundred and eleven samples contained fossil foraminifera, 41 were barren. Only some of the fossiliferous samples, however, contained reasonably well preserved foraminifera. Examples of counts of some of these samples are given below, and the total counts from the type locality (loc. 50) are shown in Table 9 (in pocket).

Despite the fact that subsequent glacial-tectonic squeezing and displacement of the sediment, solifluction (Funder et al. 1985) and even deformation of single foraminiferal tests, have obliterated the original depositional order, it is still possible to reconstruct a stratigraphical succession based on the foraminifera. The
following assemblage zones are defined: The *Elphidium funderi* Zone, oldest, the *Cassidulina laevigata* Zone, the *Elphidiella rolfi* Zone, the *Elphidium cf. excavatum* Zone, the *Elphidium excavatum* Zone, and the *Elphidiella gorbunovi* Zone, youngest. The *Elphidium funderi* and the *Cassidulina laevigata* Zones represent a subdivision of the *Nonion erucopsis* Zone of Feyling-Hanssen (1987).

These zones are described below, starting with assemblages from member A (Fig. 3).

### Assemblage zones and their age

**The *Elphidium funderi* Zone**

Examples of this assemblage are shown in Tables 1, 2 and 9. In the fauna shown in Table 1, from the upper part of member A, many specimens had slightly etched test surfaces but were otherwise well preserved. Of particular note in this assemblage is the frequent occurrence of *Nonion erucopsis* Todd. This species was origi-
nally described from the Miocene-Oligocene (?) (cf. McNeil et al. 1982) of Carter Creek, northern Alaska. It is an intermediate species between *Nonion barleeanum* (Williamson), which is larger and broader, with a wider umbilicus and a more conspicuous limbate ring around it, and *Nonion affine* (Reuss), which is smaller and laterally more compressed. The second diagnostic feature of the assemblage is the frequent occurrence of *Elphidium funderi* n. sp. This is an *Elphidium* species with an acute, almost keeled periphery. It shows a slight resemblance to *Polystomella cryptostoma* Egger from the Miocene of Nieder-Bayern, Germany, and a still weaker resemblance to *Polystomella angulata* Egger, also from the Miocene of Nieder-Bayern. It shows also affinity to *Cribrnonion occidentalis* Margerel (1968) from the Redonien (Pliocene) of north-western France.

The specimens of *Cassidulina* present in this zone seem to belong to the species *C. reniforme* Nørvang.

Table 1. Locality 120, sample no. 53212, dry weight 100 g

<table>
<thead>
<tr>
<th>Species</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Nonion erucopsis</em> Todd</td>
<td>43</td>
</tr>
<tr>
<td><em>Elphidium funderi</em> n. sp.</td>
<td>37</td>
</tr>
<tr>
<td><em>Cassidulina reniforme</em> Nørvang</td>
<td>9</td>
</tr>
<tr>
<td><em>Epistominella vitrea</em> Parker</td>
<td>4</td>
</tr>
<tr>
<td><em>Glandulina inaequalis</em> d’Orbigny</td>
<td>3</td>
</tr>
<tr>
<td><em>Elphidium cf. excavatum</em> (Terquem)</td>
<td>2</td>
</tr>
<tr>
<td>6 other species each accounting for &lt;1%.</td>
<td></td>
</tr>
<tr>
<td>Counted 339 specimens (the whole sample).</td>
<td></td>
</tr>
<tr>
<td>Number of species: 12.</td>
<td></td>
</tr>
</tbody>
</table>
They are, however, smaller than normal and have some kind of a recrystallized coating on their surfaces. The specimens referred to as *Elphidium cf. excavatum* (Terquem) show affinity to both *E. funderi* and *E. excavatum*. They have a subacute periphery and lack sutural bridges in their earlier sutures. They have a faint resemblance to *Cribrnonion* sp.2 of Margerel (1968) from the Pliocene of north-western France.

The fauna shown in Table 2, from lower part of member A, is dominated by *Nonion erucopsis*, but has more *Cassidulina reniforme* than *Elphidium funderi*. *Cassidulina teretis* Tappan, a characteristic species of Pliocene and Lower Pleistocene deposits (Tappan 1951; Feyling-Hanssen 1980a) also occurs, as does an elongated *Quinqueloculina* species referred to *Quinqueloculina longa*.

<table>
<thead>
<tr>
<th>Species</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Nonion erucopsis</em> Todd</td>
<td>37</td>
</tr>
<tr>
<td><em>Cassidulina reniforme</em> Nørvang</td>
<td>35</td>
</tr>
<tr>
<td><em>Elphidium funderi</em> n. sp.</td>
<td>14</td>
</tr>
<tr>
<td><em>Buccella frigida</em> (Cushman)</td>
<td>3</td>
</tr>
<tr>
<td><em>Quinqueloculina longa</em> Gudina</td>
<td>3</td>
</tr>
<tr>
<td><em>Cassidulina teretis</em> Tappan</td>
<td>2</td>
</tr>
<tr>
<td><em>Elphidium cf. excavatum</em> (Terquem)</td>
<td>2</td>
</tr>
<tr>
<td><em>Cassidulina cf. teretis</em> Tappan</td>
<td>1</td>
</tr>
<tr>
<td><em>Nonion orbiculare</em> (Brady)</td>
<td>1</td>
</tr>
<tr>
<td><em>Pyrgo simplex</em> d’Orbigny</td>
<td>1</td>
</tr>
</tbody>
</table>

4 other species each accounting for <1%. Counted 447 specimens (½ of the sample).

Number of species: 14. Number of specimens/100 g: 335.
The **Cassidulina laevigata** Zone

Typical examples of these assemblages are shown in Tables 3 and 4. At locality 16 (Fig. 2) a dislocated thrust sheet is found at the top of the section. It is most probably derived from the lower part of member A. A sample from this thrust sheet yielded an assemblage dominated by *Cassidulina reniforme* with many *Cassidulina laevigata* d’Orbigny as well as many *Nonion erucopsis* and *Cassidulina teretis* (Table 3).

*Cassidulina laevigata* is known from the Tertiary as well as from the Quaternary and Recent. Many of the specimens from this sample are large with a carinate periphery, as is often seen in Pliocene deposits of the North Sea and of the Netherlands (cf. *C. plicatarina* van Voorhuyzen 1950). *Cassidulina teretis* is common in Pliocene and Lower Pleistocene deposits, but according to Sejrup *et al.* (1987), it continues into the Middle Pleistocene in part of the North Sea region as well. Five specimens of the large and conspicuous *Cibicides grossa* have a subacute periphery and often an irregular, lobulate outline. These specimens are close to *Cassidulina saginensis* described by Asano & Nakamura (1937) from Pliocene deposits in Japan.

As demonstrated by these two examples, the *Elphidium funderi* Zone possesses considerable number of *Nonion erucopsis* and also many *Cassidulina reniforme*. It is, however, characterized by the new species, *Elphidium funderi*, which has been named after.

Foraminiferal assemblages from the *Elphidium funderi* Zone were usually not well preserved.

### Table 3. Locality 16, sample no. 56714, dry weight 200 g

<table>
<thead>
<tr>
<th>Species</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Cassidulina reniforme</em> Nørvang</td>
<td>47</td>
</tr>
<tr>
<td><em>Cassidulina laevigata</em> d’Orbigny</td>
<td>16</td>
</tr>
<tr>
<td><em>Nonion erucopsis</em> Todd</td>
<td>10</td>
</tr>
<tr>
<td><em>Elphidium excavatum</em> (Terquem)</td>
<td>3</td>
</tr>
<tr>
<td><em>Epistominella vitrea</em> (Parker)</td>
<td>3</td>
</tr>
<tr>
<td><em>Quinqueloculina obliquecamerata</em> Grigorenko</td>
<td>3</td>
</tr>
<tr>
<td><em>Elphidium albumbilicatum</em> (Weiss)</td>
<td>2</td>
</tr>
<tr>
<td><em>Nonion matchigarcus</em> Voloshinova</td>
<td>2</td>
</tr>
<tr>
<td><em>Buccella frigida</em> (Cushman)</td>
<td>1</td>
</tr>
<tr>
<td><em>Cibicides grossa</em> Ten Dam &amp; Reinhold</td>
<td>1</td>
</tr>
<tr>
<td><em>Elphidium cf. excavatum</em> (Terquem)</td>
<td>1</td>
</tr>
<tr>
<td>14 other species each accounting for &lt;1%.</td>
<td></td>
</tr>
<tr>
<td>Counted 656 specimens (½ of the sample).</td>
<td></td>
</tr>
<tr>
<td>Five additional species occurred in the uncounted part.</td>
<td></td>
</tr>
<tr>
<td>Number of species: 31.</td>
<td></td>
</tr>
<tr>
<td>Number of specimens/100 g sediment: 1770.</td>
<td></td>
</tr>
</tbody>
</table>

Ten Dam & Reinhold were also found. The latter species is known from Upper Pliocene deposits in the Arctic (cf. Feyling-Hanssen 1980a, 1985; McNeil 1989) as well as in the North Sea basin (cf. King & Hughes 1983). *Nonion erucopsis* is also quite frequent, whereas *Elphidium funderi* n. sp. is rare. *Quinqueloculina obliquecamerata* Grigorenko has been recorded in Upper Miocene and Pliocene deposits of Sakhalin, and *Nonion matchigarcus* Voloshinova was found in the Miocene there. A few specimens of *Quinqueloculina parkeri* (Brady), similar to those figured by Voloshinova *et al.* (1970) from the Pliocene of Sakhalin, also occur in the sample.

The faunal composition of another sample from the same locality and apparently from the same thrust sheet, although 100 m away, is shown in Table 4.

*Cassidulina reniforme* also dominates this assemblage, and *Cassidulina teretis*, *C. laevigata*, and *Nonion erucopsis* are firmly represented. The two samples are thus considered to belong to the same zone. This is also demonstrated by the relatively high incidence of species in both samples. A difference is the high frequency of *Elphidium cf. excavatum* in sample no. 56609.

### Table 4. Locality 16, sample no. 56609, dry weight 200 g

<table>
<thead>
<tr>
<th>Species</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Cassidulina reniforme</em> Nørvang</td>
<td>34</td>
</tr>
<tr>
<td><em>Cassidulina teretis</em> Tappan</td>
<td>9</td>
</tr>
<tr>
<td><em>Elphidium cf. excavatum</em> (Terquem)</td>
<td>9</td>
</tr>
<tr>
<td><em>Nonion erucopsis</em> Todd</td>
<td>8</td>
</tr>
<tr>
<td><em>Cassidulina laevigata</em> d’Orbigny</td>
<td>7</td>
</tr>
<tr>
<td><em>Elphidium excavatum</em> (Terquem)</td>
<td>7</td>
</tr>
<tr>
<td><em>Nonion matchigarcus</em> Voloshinova</td>
<td>7</td>
</tr>
<tr>
<td><em>Elphidium albiumbilicatum</em> (Weiss)</td>
<td>3</td>
</tr>
<tr>
<td><em>Elphidium funderi</em> n. sp.</td>
<td>3</td>
</tr>
<tr>
<td><em>Buccella frigida</em> (Cushman)</td>
<td>2</td>
</tr>
<tr>
<td><em>Elphidium hallandense</em> Brothen</td>
<td>2</td>
</tr>
<tr>
<td><em>Elphidium hughesi</em> Cushman &amp; Grant</td>
<td>1</td>
</tr>
<tr>
<td><em>Elphidium subglobosum</em> Voloshinova</td>
<td>1</td>
</tr>
<tr>
<td><em>Epistominella vitrea</em> (Parker)</td>
<td>1</td>
</tr>
<tr>
<td><em>Guttulina austriaca</em> d’Orbigny</td>
<td>1</td>
</tr>
<tr>
<td><em>Guttulina lactea</em> (Walker &amp; Jacob)</td>
<td>1</td>
</tr>
<tr>
<td><em>Guttulina roemeri</em> (Reuss)</td>
<td>1</td>
</tr>
<tr>
<td><em>Nonion barleeanum</em> (Williamson)</td>
<td>1</td>
</tr>
<tr>
<td><em>Nonion orbiculare</em> (Brady)</td>
<td>1</td>
</tr>
<tr>
<td>4 other species each accounting for &lt;1%.</td>
<td></td>
</tr>
<tr>
<td>Counted 318 specimens (the whole sample).</td>
<td></td>
</tr>
<tr>
<td>Number of species: 23.</td>
<td></td>
</tr>
</tbody>
</table>

### Age of the *Elphidium funderi* Zone and the *Cassidulina laevigata* Zone

The four examples of foraminiferal assemblages from the clay of member A of the Kap København formation shown above, and other investigated samples from this unit, are all characterized by *Nonion erucopsis*, *Elphidium funderi*, *Cassidulina laevigata*, and *Cassidulina teretis*. None of these species could belong in the cryophilic assemblages of the Pleistocene – particularly not
at the high latitude of Kap København. The same is the case with most of the other species from member A. They do not reflect a cold Pleistocene environment. They are, however, known from Upper Tertiary deposits, particularly from the Pliocene but some of them also from the Miocene. On the other hand, typical Miocene forms such as members of the family Uvigerinidae, and species like Cibicidoides sp. 800 McNeil and Asterigerina staeschei (Franke), which characterize the Miocene of the Beaufort-Mackenzie Basin (McNeil 1989), are completely absent in the member A assemblages. A Pliocene age for member A is, therefore, most likely.

Furthermore, the assemblages within member A fall into two groups, one characterized by Nonion erucopsis and Elphidium funderi and another characterized by Nonion erucopsis, Cassidulina reniforme, and C. teretis. The former is referred to the Elphidium funderi Zone and the latter the Cassidulina laevigata Zone. Because of glaciotectonic activity in the area it is not immediately clear what stratigraphical relationship those two zones have. We do know, however, from other localities that Cassidulina teretis together with Cibicides grossa belong in the Upper Pliocene. The Cassidulina laevigata Zone of Kap København could, therefore, also belong in the Upper Pliocene. It has, furthermore, been observed at least in one North Sea boring that a Nonion dominance occurs below a unit with Cassidulina teretis and Cibicides grossa (Asbjørndottir 1987) which could indicate a greater age for the Elphidium funderi Zone than for the Cassidulina laevigata Zone of the Kap København Formation. This view is supported by the occurrence of both Elphidium excavatum, a typical Pleistocene cold-water species, and of the transitional form between Elphidium funderi and E. excavatum, viz. Elphidium cf. excavatum, in the assemblages of the Cassidulina laevigata Zone. This and the occurrence of some other species known from the Pleistocene in the Cassidulina laevigata Zone signals an approach to harsher palaeoenvironmental conditions.

The Elphidium funderi Zone, which seems to form the lower part of the Nonion erucopsis-bearing deposits, might then have a Lower Pliocene age. However, certain Lower Pliocene markers seem to be absent. The Elphidium funderi Zone may, therefore, also be of Upper Pliocene age, but older than the Cassidulina laevigata Zone.

The Elphidium funderi Zone and Cassidulina laevigata Zone correspond to the Cibicides grossa Interval zone of McNeil (1989) from the Beaufort-Mackenzie Basin, which is considered to be of Lower Pliocene age.

The Elphidiella rolfi Zone

At the type section (loc. 50) of the Kap København Formation (Figs 2 and 3), only poorly preserved remnants of the Cassidulina laevigata Zone were found in the clays of member A. Foraminifera were not observed in the lower sands of unit B1 of member B. But in the upper part of unit B1 and in the lowest part of the silty unit B2 well preserved assemblages with a very characteristic species association occurred (Fig. 4 and Table 9). An example is given in Table 5.

Even though the small species Nonion niveum Lafrenz, dominates this assemblage, the large and conspicuous Elphidiella rolfi Gudina & Polovova characterizes it. This species, which resembles Elphidiella subcarinata Voloshinova from the Miocene and Pliocene of Sakhalin (cf. Funder et al. 1985), was described from uppermost Pliocene/lowermost Pleistocene deposits of the Beaufort Sea, which has been referred to the Seward Peninsula, illustrated in Hopkins et al. (1974) also possess a few Elphidiella hannai. One of the species from the Seward Peninsula, illustrated in Hopkins et al. (1974) and referred to Cribrorronion obscurus Gudina, may very well turn out to be Elphidiella rolfi.

This lowest part of unit B2 in the type section, locality 50, is here called the Elphidiella rolfi Zone (Fig. 4 and Table 9).

Other species occurring frequently in this zone are Elphidium hughesi Cushman & Grant (1927), originally described from the Pliocene of Monterey, California, and the laterally compressed form of Nonion orbiculare (Brady), as is found in the Neogene deposits of the Netherlands (Doppert 1980). Frequent and characteristic is also the small Nonion niveum, originally de-

---

Table 5. Locality 50, sample no. 197134, dry weight 160 g

<table>
<thead>
<tr>
<th>Species</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonion niveum Lafrenz</td>
<td>28</td>
</tr>
<tr>
<td>Globulina cf. granulosa Egger</td>
<td>25</td>
</tr>
<tr>
<td>Nonion orbiculare (Brady)</td>
<td>23</td>
</tr>
<tr>
<td>Elphidiella rolfi Gudina &amp; Polovova</td>
<td>8</td>
</tr>
<tr>
<td>Elphidium hughesi (Cushman &amp; Grant)</td>
<td>7</td>
</tr>
<tr>
<td>Buccella frigida (Cushman)</td>
<td>3</td>
</tr>
<tr>
<td>Elphidium ustulatum Todd</td>
<td>2</td>
</tr>
<tr>
<td>Nonion matchigariucus Voloshinova</td>
<td>2</td>
</tr>
<tr>
<td>Pseudopolymorpha dollfusi Cushman &amp; Ozawa</td>
<td>1</td>
</tr>
<tr>
<td>5 other species each accounting for &lt;1%</td>
<td></td>
</tr>
</tbody>
</table>

Number of species: 14.
Number of specimens/100 g sediment: 640.

---

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The *Elphidium cf. excavatum* Zone

The foraminiferal assemblages occurring above the *Elphidium rolfi* Zone in unit B2 of the type section (Figs 3, 4 and Table 9) may indicate a slight deepening of the water. Typical large shallow-water species disappeared and species of the family Glandulinidae become frequent, particularly *Esosyrinx curta* (Cushman & Ozawa) and *Glandulina laevigata* (Table 6). Characteristic is, above all, *Elphidium cf. excavatum*. This species resembles *Elphidium excavatum* but has a nearly subacute peripheral margin and possesses sutural bridges only in the last two sutures. True *Elphidium excavatum* is rare in this part of the section. *Ammodiscus cf. concinnum* Kuznetzova, originally described from the Lower Miocene of Sakhalin (Voloshinova et al. 1970), occurs higher up in the section. A broad *Pyrgo*, most probably referable to *Pyrgo simplex* (d’Orbigny), an elongated

Scutuloris and large specimen of *Nonion barleanum* (Williamson) characterize the uppermost fossiliferous part of unit B2 at locality 50 (Tables 7 and 9, Fig. 4). *Buccella frigida* is frequent throughout the lower half of the zone (Table 6).

Table 6. Locality 50, sample no. 223283, dry weight 100 g

<table>
<thead>
<tr>
<th>Species</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Elphidium cf. excavatum</em> (Terquem)</td>
<td>31</td>
</tr>
<tr>
<td><em>Buccella frigida</em> (Cushman)</td>
<td>12</td>
</tr>
<tr>
<td><em>Esosyrinx curta</em> (Cushman &amp; Ozawa)</td>
<td>11</td>
</tr>
<tr>
<td><em>Scutuloris pyriformis</em> (Gudina)</td>
<td>11</td>
</tr>
<tr>
<td><em>Glandulina laevigata</em> d’Orbigny</td>
<td>7</td>
</tr>
<tr>
<td><em>Nonion orbiculare</em> (Brady)</td>
<td>5</td>
</tr>
<tr>
<td><em>Elphidium usutilatum</em> Todd</td>
<td>3</td>
</tr>
<tr>
<td><em>Globulina cf. granulosa</em> (Egger)</td>
<td>3</td>
</tr>
<tr>
<td><em>Nonion matchiguricus</em> Voloshinova</td>
<td>3</td>
</tr>
<tr>
<td><em>Elphidium albiumblicatum</em> (Weiss)</td>
<td>2</td>
</tr>
<tr>
<td><em>Miliolinella subrotunda</em> (Montagu)</td>
<td>2</td>
</tr>
<tr>
<td><em>Nonion niveum</em> Lahrenz</td>
<td>2</td>
</tr>
<tr>
<td><em>Elphidium excavatum</em> (Terquem)</td>
<td>1</td>
</tr>
<tr>
<td><em>Gutulina austriaea</em> d’Orbigny</td>
<td>1</td>
</tr>
<tr>
<td><em>Gutulina roemeri</em> (Reuss)</td>
<td>1</td>
</tr>
<tr>
<td><em>Quinqueloculina seminulum</em> (Linné)</td>
<td>1</td>
</tr>
<tr>
<td>6 other species each accounting for &lt;1%</td>
<td></td>
</tr>
<tr>
<td>Counted 553 specimens (% of the sample)</td>
<td></td>
</tr>
<tr>
<td>Number of species: 22.</td>
<td></td>
</tr>
<tr>
<td>Number of specimens/100 g sediment: 1250.</td>
<td></td>
</tr>
</tbody>
</table>
Table 7. Locality 50, sample no. 223287, dry weight 200 g

<table>
<thead>
<tr>
<th>Species</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elphidium cf. excavatum (Terquem)</td>
<td>34</td>
</tr>
<tr>
<td>Elphidium excavatum (Terquem)</td>
<td>23</td>
</tr>
<tr>
<td>Cassidulina reniforme Nervang</td>
<td>7</td>
</tr>
<tr>
<td>Elphidium albiomilicatum (Weiss)</td>
<td>7</td>
</tr>
<tr>
<td>Nonion barleeanum (Williamson)</td>
<td>6</td>
</tr>
<tr>
<td>Glandulina laevigata d’Orbigny</td>
<td>4</td>
</tr>
<tr>
<td>Quinqueloculina longa Gudina</td>
<td>2</td>
</tr>
<tr>
<td>Scutularia pyriformis (Gudina)</td>
<td>2</td>
</tr>
<tr>
<td>Elphidium bartletti Cushman</td>
<td>1</td>
</tr>
<tr>
<td>Elphidium hallandense Brotzen</td>
<td>1</td>
</tr>
<tr>
<td>Epistominella virrea Parker</td>
<td>1</td>
</tr>
<tr>
<td>Eosyrinx curta (Cushman &amp; Ozawa)</td>
<td>1</td>
</tr>
<tr>
<td>Miliolinella valvulinares (Reuss)</td>
<td>1</td>
</tr>
<tr>
<td>Nonion machigaricus Voloshinova</td>
<td>1</td>
</tr>
<tr>
<td>Paraffissurina lateralis (Cushman)</td>
<td>1</td>
</tr>
<tr>
<td>Pyrgo simplex (d’Orbigny)</td>
<td>1</td>
</tr>
<tr>
<td>9 other species each accounting for &lt;1%.</td>
<td>1</td>
</tr>
<tr>
<td>Counted 213 specimens (the whole sample).</td>
<td>1</td>
</tr>
<tr>
<td>Number of species: 25.</td>
<td></td>
</tr>
<tr>
<td>Number of specimens/100 g sediment: 100.</td>
<td>1</td>
</tr>
</tbody>
</table>

The age of this approximately 10 m thick unit is uncertain. It could belong to the lowest Pleistocene as it displays some similarity to the Miliolinella pyriformis Zone established by Gudina (1969) in the Lower Pleistocene of the Yenisey lowland of Siberia. In fact the elongated Scutuloris of the upper part of the Elphidium cf. excavatum Zone of the type section may be conspecific with Miliolinella pyriformis Gudina, and this latter species may belong to the genus Scutuloris rather than to Miliolinella (cf. Gudina 1969, Pl. 5, Fig. 5a and Pl. 6, Figs 1a and b).

On the other hand, many of the species present in the Elphidium cf. excavatum Zone at locality 50 – and of other localities of the Kap København area – are not typical Pleistocene species as most of them have also been recorded in the Tertiary.

The Elphidium cf. excavatum Zone may, therefore, represent a transition Zone between the Pliocene and the Pleistocene in the area.

A slight deepening of the sedimentation basin seems to be reflected in this fauna.

The Elphidium excavatum Zone

Some fossil foraminifera assemblages in the northern part of the Kap København area are characterized by the dominance of Elphidium excavatum and by the frequent occurrence of quite large shallow-water species such as Nonion orbiculare, Elphidium asklundi, and Elphidium bartletti. Cassidulina reniforme is present in all but the shallowest samples, Nonion niveum is also firmly represented, as is Elphidium usutulatum. All these species are well known from the Pleistocene of numerous other localities in the Northern Hemisphere.

The frequency distribution of foraminifera of samples from a 4 m thick part of a section at locality 72 is illustrated in Fig. 5 (symbols explained in Fig. 6). The sediment in this fossiliferous part of the section is silt.

The Elphidium excavatum Zone at locality 72 represents a shallow-water deposit throughout. The content of shallow-water specimens is high in all the samples, approximately 30%.

A slight deepening upwards is reflected in the upwards increasing frequency of Cassidulina reniforme. But the palaeodepth was hardly more than 20 m, certainly less in the lower part of the section.

Elphidiella hannai occurs commonly in the two lowest samples at locality 72, and is present also in the uppermost sample. Elphidiella rolfi is present in four of the samples and Elphidium hughesi in five (cf. Fig. 5).

These three species indicate a Lower Pleistocene age for the fossiliferous part of the section at locality 72, referable to the Elphidium excavatum Zone of Kap København.

The zone is most probably younger than the Elphidium cf. excavatum Zone at locality 50. For one thing the species occurring at locality 72 are undubitably Pleistocene, whereas many of those present in the Elphidium cf. excavatum Zone are not. Moreover, the transitional form between Elphidium funderi and Elphidium excavatum, viz. Elphidium cf. excavatum, which was frequent at locality 50, does not occur – or is extremely rare – at locality 72.

As is shown above, Elphidium cf. excavatum occurs in the Elphidium funderi Zone, becomes more common in the Cassidulina laevigata Zone, is present in the Elphidiella rolfi Zone, flourishes in the Elphidium cf. excavatum Zone at locality 50, and is practically absent in the Elphidium excavatum Zone at locality 72. Also for this reason the Elphidium excavatum Zone of the section at locality 72 is considered to be younger than the Elphidium cf. excavatum Zone at locality 50.

It is also known from borings in the North Sea that forms comparable to Elphidium cf. excavatum flourish stratigraphically below the Elphidiella rolfi Zone, and to the Elphidium excavatum Zone in the Lower Pleistocene (cf. Asbjörnsdóttir 1987).

It is interesting to note here that Brouwers et al. (in press) found a similar difference in the ostracod faunas between localities 50 and 72, with the “young” species Rabilimis septentrionalis (Brady) occurring only at locality 72 (one individual at locality 75). However, they interpreted this as due to a difference in environment, not in age.

The Elphidiella gorbunovi Zone

In the uppermost sample of the section at locality 72 a few specimens of the large and conspicuous species Elphidiella gorbunovi Stschedrina occurred.

This species, with its narrow, subacute peripheral margin, was originally described from the eastern Arctic Ocean (Stschedrina 1946; Voloshinova et al. 1970). It is also known from a few borings in the North Sea (in the
Fig. 5. Frequency distribution of the most common foraminifera from the section at locality 72. (Symbols explained in fig. 6).

Foraminiferal frequency

\[ \begin{align*}
\times & \quad \text{(see text)} \\
0 & \quad < 1 \% \\
1 & \quad 1 \% \\
2 - 5\% & \quad 2 - 5\% \\
6 - 10\% & \quad 6 - 10\% \\
11 - 20\% & \quad 11 - 20\% \\
21 - 40\% & \quad 21 - 40\% \\
41 - 60\% & \quad 41 - 60\% 
\end{align*} \]

Fig. 6. Symbols used in fig. 5 (x means that the species occurred in the uncounted part of the sample).

Balder Field, the Tyra Field, and the Josephine Boring). \textit{Elphidiella gorbunovii} gives its name to a distinct foraminiferal zone which occurs well above the Pliocene/Pleistocene boundary but under the Brunhes/Matuyama palaeomagnetic boundary in two borings in the Central North Sea, TWB-12, Tyra Field and the Josephine boring, (Pedersen 1987). This zone thus belongs in the upper part of the Lower Pleistocene but is older than 700,000 years.

In the northern part of the Kap København area a sample from locality 129 contained 10 specimens of \textit{Elphidiella gorbunovii} (Table 8). This is the only analysed sample from what is considered the youngest part of the Kap København Formation. It is taken to represent the uppermost part of its foraminiferal zonation: The \textit{Elphidiella gorbunovii} Zone.

Tertiary/Quaternary foraminiferal morphogenesis

A morphological transformation and succession within the foraminiferal populations seem to appear at the boundary between the Tertiary and the Quaternary periods in North Greenland. The Tertiary \textit{Elphidium funderi} has an acute, sometimes even keeled (carinate), peripheral margin. This margin becomes subacute to...
Table 8. Locality 129, sample no. 53259, dry weight 100 g

<table>
<thead>
<tr>
<th>Species</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elphidium excavatum</td>
<td>25</td>
</tr>
<tr>
<td>Nonion orbiculare</td>
<td>21</td>
</tr>
<tr>
<td>Cassidulina reniforme Nørvang</td>
<td>17</td>
</tr>
<tr>
<td>Buccella frigida (Cushman)</td>
<td>7</td>
</tr>
<tr>
<td>Elphidium bartletii (Cushman)</td>
<td>7</td>
</tr>
<tr>
<td>Nonion barleeanum (Williamson)</td>
<td>3</td>
</tr>
<tr>
<td>Nonion niveum Laffrenz</td>
<td>3</td>
</tr>
<tr>
<td>Buccella tenerrima (Bandy)</td>
<td>2</td>
</tr>
<tr>
<td>Elphidium asklundii Brosten</td>
<td>2</td>
</tr>
<tr>
<td>Elphidiella gorbunovi Stschedrina</td>
<td>2</td>
</tr>
<tr>
<td>Milolinella subroundata (Montagu)</td>
<td>2</td>
</tr>
<tr>
<td>Buccella hannai arctica Voloshinova</td>
<td>1</td>
</tr>
<tr>
<td>Cassidulina cf. teretis Tappan</td>
<td>1</td>
</tr>
<tr>
<td>Elphidium albiumbilicatum (Weiss)</td>
<td>1</td>
</tr>
<tr>
<td>Elphidium groenlandicum Cushman</td>
<td>1</td>
</tr>
<tr>
<td>Elphidium ustulatum Todd</td>
<td>1</td>
</tr>
<tr>
<td>Milolinella enoplostoma (Reuss)</td>
<td>1</td>
</tr>
<tr>
<td>Glabratella wrightii Brady</td>
<td>1</td>
</tr>
</tbody>
</table>

20 other species, each accounting for <1%. Counted 570 specimens (1/3 of the sample).
Number of species: 38.
Number of specimens/100 g sediment: 2140.

rounded in Elphidium cf. excavatum in the uppermost Pliocene near the boundary, and develops into the more broadly rounded peripheral margin of Elphidium excavatum in an increasing number of specimens in the Pleistocene. This development, which in this case may be phylogenetic, may reflect a morphological response to decreasing water temperature.

Other lines of development can be mentioned, some with phylogenetic continuity, others without. The oligocene Nonion affinis, which is laterally compressed and with almost a subacute periphery, develops through the less compressed and with more rounded peripheral margin Nonion erucopsis, to the large and broadly rounded Nonion barleeanum in the Lower Pleistocene of Kap København. Elphidiella roffii with its subacute to almost acute periphery should also be mentioned. It occurs in the Pliocene, flourishes in its uppermost part and in the transitional zone between the Pliocene and Pleistocene and fades away in the Lower Pleistocene. Elphidiella hannai, with its more rounded peripheral margin, could be considered as a replacement for Elphidiella roffii in the lowermost Pleistocene, and the broadly rounded Elphidiella arctica could be a successor for Elphidiella hannai higher up in the Pleistocene (van Voorthuysen 1953). Sharp-edged, carinate species such as Cassidulina teretis and Cassidulina laevigata do not occur in the Pleistocene shallow-water deposits of Kap København. As far as is known, they do not occur at all in shallow cold water deposits in the Northern Hemisphere, either during the Pleistocene or at the present day. But they, or similar species, do occur in warmer Atlantic deep water in the Arctic region of to-day (for North Sea occurrences cf. Sejrup et al. 1987 and Mackensen & Hald 1988).

Narrow, flat, carinate and spinate forms are rare in Arctic shallow-water biotopes with low temperatures, whereas they are common in low-latitude shallow-water assemblages. Compare for instance in a general way shallow-water assemblages from Arctic coasts with those from Mediterranean coastal waters (Boltovskoy & Wright 1976).

That these differences are controlled by water temperature is apparent from studies of foraminiferal faunas from North Sea borings penetrating glacial and interglacial deposits. Arctic, cold water faunas dominate the glacial sequences of the borings. These are all rounded and broad forms. Temperate water faunas with carinate and spine-carrying taxa return to the locality during interglacials. The decrease in temperature through the Upper Tertiary into the Quaternary was worldwide. McNeil suggests that it started near the end of the Miocene, marked by a regionally recognized “Late Miocene unconformity” in the Arctic (McNeil et al. 1982; McNeil 1989). It was particularly felt in the northern (and the Antarctic) regions of the globe where Tertiary woodlands were transformed into the Arctic deserts of to-day. Most of the present-day cold water foraminiferal species must have developed during these transitional epochs.

The above-mentioned morphological changes took place during the transition from the Tertiary temperate water conditions to the Quaternary cold-water condition also at Kap København. There are, however, certain exceptions to this general trend. One of these is Elphidiella gorbunovi, mentioned above.

Concluding remarks

The sediments of the Kap København formation are tectonically disturbed, most probably by glacier ice overriding the area after their deposition. In addition to this, many of the examined samples were barren of fossil foraminifera, and others contained only badly preserved remnants which could not safely be identified. Any certain pattern in the geographical distribution of the stratigraphical zones dealt with above, has thus not been observed.

Pliocene as well as Pleistocene layers occur in a few cases at the same locality. At others only Pliocene or only Pleistocene deposits occur. Pliocene deposits have been frequently recognized in the southern and south-eastern part of the Kap København area, whereas Pleistocene layers are more often met within the northern and north-eastern part. The apparently youngest Lower Pleistocene sample was collected from locality 129 in the north-east.

Stratigraphically the Kap København Formation correlates with the Iperk Sequence of the Beaufort-Mackenzie Basin (Dixon & Dietrich 1988) when compared with the foraminiferal zonation presented by McNeil.
(1989) (cf. also McNeil 1985). All the foraminiferal zones from the Kap København Formation seem to belong to McNeil’s *Cribroelphidium* Assemblage Zone. The *Elphidiella gorbunovi* Zone, the *Elphidium excavatum* Zone, the *Elphidium cf. excavatum* Zone and the *Elphidiella rolfi* Zone may all fit in the upper part of McNeil’s inner neritic *Cribroelphidium clavatum* biofacies, and the deeper water *Cassidulina laevigata* Zone and *Elphidium funderi* Zone in the lower part of McNeil’s outer neritic *Cassidulina teretis* biofacies. McNeil’s *Cibicides grossus* Interval Zone probably corresponds to the *Elphidium funderi, Cassidulina laevigata, and Elphidiella rolfi* Zones of Kap København, and his *Cibroelphidium ustulatum* Interval Zone correlates with the *Elphidium cf. excavatum* Zone, the *Elphidium excavatum* Zone and the *Elphidiella gorbunovi* Zone. McNeil’s zonation was based on borehole material.

Local differences in environmental conditions make it difficult in may cases to recognize assemblages of the same age from one locality to another. Still, the presence or absence of certain stratigraphical markers usually makes it possible to make out the age in spite of “environmental noise”. An attempt at this is illustrated in Fig. 7, where the stratigraphy of the outcrops of the Kap København Formation are compared with the stratigraphy of other outcrops in Greenland and on Baffin Island, and with occurrences in some North Sea borings.

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**Fig. 7.** Proposed correlation of the foraminiferal zones of Kap København with other outcrops in Greenland and on Baffin Island, and with occurrences in some North Sea borings.
Systematic notes on the foraminifera

Very few agglutinating foraminifera are present in the Kap København material.

Family AMMODISCIDAE

*Ammodiscus* cf. *concinnus* Kuznetzova

Plate 1, figs 1, 2.


The specimens in the present material are smaller than those described by Kuznetzova (1970) from the Miocene of Sakhalin. They frequently occur in the upper half of the *Elphidium* cf. *excavatum* Zone at locality 50. They are most probably overrepresented in those samples due to the dissolution of calcareous tests.

Family TEXTULARIIDAE

*Textularia* cf. *canaensis* Bermudez

Plate 1, figs 3, 4.

*Textularia canaensis* Bermudez 1949, p. 59; pl. 2, figs 25–27.

A few specimens of this species occur in the *Cassidulina laevigata* Zone at locality 16. These are somewhat twisted along the longitudinal axis, and are smaller than the specimens described by Bermudez from the Middle Miocene.

Family TROCHAMMINIDAE

*Trochammina*

A few fragments occur in the *Elphidium* cf. *excavatum* Zone at locality 50.

Quite a number of species with porcelaneous test occur:

Family MILIOLIDAE

*Quinqueloculina lamarckiana* d’Orbigny

Plate 1, figs 5, 6.

d’Orbigny 1839, p. 188; pl. 2, figs 14–15.

This species, with its almost carinate edges, occurs in the *Cassidulina laevigata* Zone at locality 16.

*Quinqueloculina longa* Gudina

Plate 1, figs 7, 8.

Gudina 1969, p. 9; pl. 2, figs 2–4.

This species occurs quite commonly in the Upper Pliocene and the Lower Pleistocene of the Kap København area.

*Quinqueloculina obliquecamerata* Grigorenko

Plate 1, figs 9, 10.

Voloshinova *et al.* 1970, p. 69; pl. 12, figs 3–9.

This species is quite common in the Upper Pliocene *Cassidulina laevigata* Zone of Kap København.

*Quinqueloculina parkeri* (Brady)

*Miliolina parkeri* Brady 1881, p. 46, 1954, p. 177; pl. 7, figs 14a–c.

A few specimens of this species occur in the Upper Pliocene *Cassidulina laevigata* Zone of Kap København.

*Quinqueloculina seminulum* (Linné)

Plate 1, figs 11, 12.

*Serpula seminulum* Linné 1758, p. 786; pl. 2, fig. 1.

Plate 1

Fig. 1.2. *Ammodiscus* cf. *concinnus* Kuznetzova

1, side view of a specimen from the upper part of the *Elphidium* cf. *excavatum* Zone of locality 50. 2, edge view of the same specimen. ×75.

Fig. 3.4. *Textularia* cf. *canaensis* Bermudez

3, side view of a specimen from the *Cassidulina laevigata* Zone of locality 16. 4, edge view of another specimen from the same locality. ×75.

Fig. 5.6. *Quinqueloculina lamarckiana* d’Orbigny

Edge and side view of a specimen from the *Cassidulina laevigata* Zone of locality 16. ×75.

Fig. 7.8. *Quinqueloculina longa* Gudina

Edge and side view of a specimen from the *Elphidium* cf. *excavatum* Zone of locality 50. ×75.

Figs. 9.10. *Quinqueloculina obliquecamerata* Grigorenko

A specimen from the *Cassidulina laevigata* Zone of locality 16. ×75.

Figs. 11.12. *Quinqueloculina seminulum* (Linné)

A specimen from the *Elphidium* cf. *excavatum* Zone of locality 50. ×75.

Figs. 13.14. *Pyrgo simplex* (d’Orbigny)

13, apertural view, 14, side view of a specimen from the upper part of the *Elphidium* cf. *excavatum* Zone of locality 50. ×75.

Figs. 15–18. *Pyrgo williamsoni* (Silvestri)

15–16, front view and side view of a specimen from the *Cassidulina laevigata* Zone of locality 16. 17.18, side view and oblique view of a specimen from locality 72. Both ×75.

Meddelelser om Grønland, Geoscience 24 · 1990
Scattered specimens occur both in the Upper Pliocene and in the Lower Pleistocene of Kap København.

**Triloculina tricarinata** d'Orbigny
d'Orbigny 1826, p. 299, no. 7, model no. 94. Feyling-Hanssen 1964, p. 258; pl. 6, figs 7-8.

A few specimens of this species are present in the Elphidium cf. excavatum Zone.

**Pyrgo simplex** (d'Orbigny)
Plate 1, figs 13, 14.

* Biloculina simplex* d'Orbigny 1846, p. 264; pl. 15, figs 25–27. Pyrgo simplex (d'Orbigny) – Laga 1972, p. 44; pl. 6, figs. 2.

* P. simplex* occurs in the upper part of the Elphidium cf. excavatum Zone at the type section, locality 50. This species was originally described from the Tertiary of the Vienna Basin.

**Pyrgo williamsoni** (Silvestri)
Plate 1, figs 15–18.

* Biloculina williamsoni* Silvestri 1923, p. 73. Pyrgo williamsoni (Silvestri) – Feyling-Hanssen 1964, p. 264; pl. 7, figs 5, 6; pl. 8, figs 3–5.

This species occurs in the upper part of the Lower Quaternary section at locality 72 and in several other samples from the Lower Quaternary of Kap København. It is a common species in Quaternary and Recent deposits in the Northern Hemisphere.

**Scutulorilis pyriformis** (Gudina)
Plate 2, figs 1–6.

*Miliolinella pyriformis* Gudina 1969, p. 14; pl. 5, figs 4–5; pl. 6, figs 1a-b.

This species is frequent in the upper part of the Elphidium cf. excavatum Zone of the section at locality 50, Kap København. It was originally described from the Lower Pleistocene of the Yenisey lowland of Siberia.

**Miliolinella enoplostoma** (Reuss)
* Triloculina enoplostoma* Reuss 1851, p. 86; pl. 7, fig. 57.

This species is present in the upper part of the Elphidium excavatum Zone at localities 72 and 129 of Kap København.

**Miliolinella subrotunda** (Montagu)
Plate 2, figs 7–9.


This is a rare species in the Lower Pleistocene of the Kap København Formation.

**Miliolinella valvularis** (Reuss)

Single specimens of this species occur in a few samples in the Lower Pleistocene of Kap København. It was originally described from Tertiary deposits of the Berlin
area, and was found in some quantity in a sample from the Pleistocene of Broughton Island, Baffin Island, Canada (Feyling-Hanssen 1976b).

Family NODOSARIIDAE


Family POLYMORPHINIDAE

This family is treated collectively in the diagrams figs 4 and 5. It is characteristic of the *Elphidium cf. excavatum* Zone, particularly of its lower part. The following species occur:

*Guttulina austriaca* d'Orbigny
Plate 2, figs 13–15.
Cushman & Ozawa 1930, p. 29; pl. 4, figs 3–5.
This species is observed in the *Cassidulina laevigata* Zone at locality 16. Rare specimens also occurred in the *Elphidium cf. excavatum* Zone.

*Guttulina dawsoni* Cushman & Ozawa
Plate 2, figs 16, 17.
Cushman & Ozawa 1930, p. 47; pl. 12, figs 1–2.
Observed in the *Elphidium cf. excavatum* zone.

*Guttulina lactea* (Walker & Jacob)
Cushman & Ozawa 1930, p. 43; pl. 10, figs 1–4.
Observed in the *Cassidulina laevigata* Zone.

*Guttulina orientalis* Cushman & Ozawa
Plate 2, figs 18, 19.
Observed in the lower part of the *Elphidium cf. excavatum* Zone.

*Guttulina roemeri* (Reuss)
Cushman & Ozawa 1930, p. 41; pl. 9, figs 3a–c.
Observed in the Upper Pliocene *Cassidulina laevigata* Zone. Scattered specimens also occur in the lowermost Pleistocene of Kap København.

*Pyurulina cylindroides* (Roemer)
Plate 2, figs 20, 21.
Cushman & Ozawa 1930, p. 56; pl. 14, figs 1–5.

*P. cylindroides* is present in both the *Elphidiella rolfi* Zone and in the *Elphidium cf. excavatum* Zone. It occurs also in the Upper Pliocene of Kap København.

*Globulina cf. granulosa* Egger
Plate 2, fig. 22; pl. 3, figs 1–3.
Cushman & Ozawa 1930, p. 81; pl. 20, figs 5 and 7.
The present species is characterized by its very dense longitudinal striation which is much finer than that of *Polymorpha* (*Globulina*) *granulosa* Egger. It resembles *Guttulina pulchella* d’Orbigny as described by Laga (1972, p. 108; pl. 7, fig. 8) from the Plio-Pleistocene of the Antwerp area. But in this latter species each succeeding chamber is very little, if at all, removed from the base of the test. *Globulina granulosa* Egger was described from the Younger Tertiary of Europe. The present *Globulina cf. granulosa* is quite frequent in the *Elphidiella rolfi* Zone and in the lower half of the *Elphidium cf. excavatum* Zone of the section at locality 50.

*Globulina inaequalis* Reuss
Plate 3, figs 4–9.
Cushman & Ozawa 1930, p. 43; pl. 10, figs 1–4.
Observed in the *Cassidulina laevigata* Zone.

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Plate 3

Figs. 1–3. *Globulina cf. granulosa* Egger ........................................ p. 18
Three specimens from the *Elphidiella rolfi* Zone of locality 50. ×75.

Figs. 4–9. *Globulina inaequalis* Reuss ........................................ p. 18
4–6, three views of a specimen from the *Elphidium cf. excavatum* Zone of locality 50. 7–9, a specimen from the *Elphidiella rolfi* Zone of locality 50. Both ×75.

Figs. 10–13. *Globulina minuta* (Roemer) ........................................ p. 20
10,11, a specimen from the *Elphidiella rolfi* Zone of locality 50. 12,13, a specimen from the *Elphidium cf. excavatum* Zone of the same locality. Both ×75.

Figs. 14, 15. *Pseudopolymorphina decorum* (Reuss) .......................... p. 20

Figs. 16, 17. *Pseudopolymorphina dolfusi* Cushman & Ozawa .......... p. 20
A specimen from the *Elphidium cf. excavatum* Zone of locality 50. ×75.

Fig. 18. *Eosyrinx cura* (Cushman & Ozawa) .................................... p. 20
A specimen from the *Elphidium cf. excavatum* Zone of locality 50. ×75.

Figs. 19–22. *Glandulina laevigata* d'Orbigny ............................... p. 20
Two specimens of the *Elphidium excavatum* Zone of locality 72. ×75.

Fig. 23. *Oolina hexagona* (Williamson) ........................................ p. 20
A specimen from the *Elphidium cf. excavatum* Zone of locality 50. ×75.

Fig. 24. *Oolina melo* d'Orbigny ................................................. p. 20
A specimen from the *Elphidium cf. excavatum* Zone of locality 50. ×75.
Scattered occurrence in many of the samples from the Kap København Formation.

**Globulina minuta** (Roemer)
Plate 3, figs 10–13.
Cushman & Ozawa 1930, p. 83; pl. 20, figs 3–4.
Scattered occurrences in the *Elphidium cf. excavatum* Zone.

**Pseudopolymorphina decora** (Reuss)
Plate 3, figs 14, 15.
Cushman & Ozawa 1930, p. 96; pl. 24, figs 6–8.
Observed in the *Elphidium cf. excavatum* Zone of Kap København.

**Pseudopolymorphina dollfussi** Cushman & Ozawa
Plate 3, figs 16, 17.
Cushman & Ozawa 1930, p. 106; pl. 27, figs 6–7.
A few specimens occur in the *Elphidium cf. excavatum* Zone, and in the *Elphidiella rolfi* Zone.

**Polymorpha charlottensis** Cushman
Cushman & Ozawa 1930, p. 119; pl. 31, figs 1–6.
This species occurs in a sample at locality 129, most probably from the upper part of the *Elphidium excavatum* Zone.

Family **GLANDULINIDAE**
Specimens of this family have been treated as one taxon in the diagrams figs 4 and 5. The following species occurred:

**Glandulina laevigata** d’Orbigny
Plate 3, figs 19–22.
Cushman & Ozawa 1930, p. 143; pl. 40, figs 1a, b.
Scattered specimens of this species occur throughout the Kap København Formation, especially in the *Elphidium cf. excavatum* Zone. Many of the specimens show close affinity to *Glandulina nipponica* Asano (1951, p. 14; figs 71–72) (cf. Voloshinova et al. 1970, p. 102; pl. 23, figs 3–5) described from the Miocene and Pliocene of Japan.

**Esosyrinx curta** (Cushman & Ozawa)
Plate 3, fig. 18.

**Pseudopolymorphina curta** Cushman & Ozawa 1930, p. 105; pl. 27, fig. 3. *Esosyrinx curta* (Cushman & Ozawa) – Loeblich & Tappan 1953, p. 85; pl. 15, figs 1–5.
This species is quite common in the *Elphidium cf. excavatum* Zone.

Family **CASSIDULINIDAE**

**Cassidulina laevigata** d’Orbigny
Plate 4, figs 1–3.

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**Plate 4**

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<td>27. spiral side, 28, edge with aperture, 28, umbilical side of a specimen from the <em>Elphidium cf. excavatum</em> Zone of locality 50. ×100.</td>
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Meddelelser om Grønland, Geoscience 24 - 1990
This species occurs in the Upper Pliocene of Kap København, and is particularly frequent in its upper part, the Cassidulina laevigata Zone. The chambers extend over the central area of the tests in side view. Some of the specimens have a carinate periphery, and thus resemble Cassidulina laevigata carinata Silvestri or even C. laevigata plicaritana van Voorthuysen.

Cassidulina reniforme Nørvang
Plate 4, figs 4–9.

Cassidulina crassa d’Orbigny var. reniforme Nørvang 1945, p. 41; text-figs 6c-h.

Many specimens of this species, particularly those from the Upper Pliocene part of the Kap København Formation, are laterally compressed and have an almost subacute periphery. They resemble Cassidulina sagmennis Asano & Nakamura (1937) from the Pliocene of Japan. Asbjørnsdóttir (1987) also observed a slightly more compressed form for C. reniforme in the Upper Pliocene part of the Nort Sea Josephine boring, where they occurred together with a more globular form of the same species. A few specimens of the compressed form also occur in the Lower Pleistocene of the Kap København Formation.

Cassidulina reniforme is frequent or quite frequent in most of the samples from the Kap København area.

Cassidulina teretis Tappan
Plate 4, figs 10–14.

This species occurs in the Upper Pliocene of Kap København, and is quite frequent in its upper part, together with Cassidulina laevigata in the Cassidulina laevigata Zone. Some of the specimens have a wavy periphery (in edge view) and a nearly closed central area, thus conforming with the taxon described as Cassidulina cf. teretis Tappan (Feyling-Hanssen et al. 1982, p. 105; pl. 1, figs 6–9, 11–13) from the Lodin Elv Formation in East Greenland.

Family BULIMINIDAE

This family was represented only by the species

Stainforthia loeblichii (Feyling-Hanssen)

Virgulina loeblichii Feyling-Hanssen 1954, p. 191; pl. 1, figs 14–18; text-fig. 3.

A few specimens are present in the Lower Pleistocene of the Kap København Formation.

Family DISCORBIDAE

Eoeponidella pulchella (Parker)

Pninaella (?) pulchella Parker 1952, p. 421; pl. 6, figs 18–20. Eoeponidella pulchella (Parker) – Michelsen 1967, p. 234; pl. 4, figs 1–2; text-figs 5–7.

E. pulchella is a very rare species in the Elphidiella rolfi Zone at locality 50.

Buccella frigida (Cushman)
Plate 4, figs 15–20.

This species occurs commonly throughout all the zones of the Kap København Formation. It is particularly frequent in the *Elphidiella rolfi* Zone and in the *Elphidium cf. excavatum* Zone.

The specimens in the Upper Pliocene Zones of the Kap København Formation show affinity to *Buccella floriformis* Voloshinova (1960, p. 270-271; pl. 1, figs 1-5) from the Neogene of Sakhalin.

**Buccella hannai arctica** Voloshinova

*Buccella hannai* (Phleger & Parker), subs. arctica Voloshinova 1960, p. 286; pl. 8, figs 2-4.

This species occurs in the Lower Pleistocene of the Kap København Formation.

**Buccella tenerrima** (Bandy)

Plate 4, figs 21-23.


Specimens of this species are present both in the Upper Pliocene and Lower Pleistocene of the Kap København Formation, especially in the upper part of the *Elphidium excavatum* Zone.

**Family BAGGINIDAE**

**Glabratella wirghtii** (Brady).

*Discorbis writhii* Brady 1881, p. 413; pl. 21, fig. 6. *Glabratella wirghtii* (Brady) – Leslie 1965, p. 161; pl. 10, fig. 7.

A few specimens of this species were observed in the youngest part of the *Elphidium excavatum* Zone at locality 129.

**Family ALABAMINIDAE**

**Epistominella vitrea** Parker

Plate 4, figs 27-29.

Plate 6

Figs. 1-2. *Elphidium cf. excavatum* (Terquem) .......................................................... p. 28
Edge and side view of a specimen from the *Elphidium cf. excavatum* Zone of locality 50. ×75.

Figs. 3-8. *Elphidium funderi* n.sp. .................................................................................... p. 28
3,4, side and edge view of a hypotype (MMH no. 12151) from the *Elphidium funderi* Zone of locality 120. 5, 6, edge and side view of holotype (MMH no. 12150). 7, 8, side and edge view another specimen (MMH no. 12152) from the same locality. All ×75.

Figs. 9-10. *Elphidium groenlandicum* Cushman .................................................................................................................. p. 29
Side and edge view of a broken specimen from the *Elphidiella gorbunovi* Zone of locality 129. ×45.

Figs. 11,12. *Elphidium hinges* Cushman & Grant ................................................................................................. p. 29
Edge and side view of a specimen from the *Elphidiella rolfi* Zone of locality 50. ×75.

Figs. 13,14. *Elphidium ustulatum* Todd ......................................................................................... p. 29
Side and edge view of a specimen from the *Elphidium excavatum* Zone of locality 72. ×75.

Figs. 15,16. *Elphidiella gorbunovi* (Stschedrina) ................................................................................................. p. 29
Side and edge view of a specimen from the *Elphidiella gorbunovi* Zone of locality 129. ×75.

Parker, in Parker, Phleger & Peirson 1953, p. 9; pl. 4, figs 34-36, 40-41.

This species occurs both in the Upper Pliocene and the Lower Pleistocene of the Kap København Formation, though it is never frequent. Some of the Upper Pliocene specimens are close to *Epistominella naraensis* (Kuwano) (*Pseudoparella naraensis* Kuwano 1950, p. 317; text-figs 6a-c), from the Pliocene of Japan.

**Family ANOMALINIDAE**

**Cibicides grossa** Ten Dam & Reinhold

Plate 4, figs 24-26.

*Cibicides lobatulus* (Walker & Jacob) var. *gossa* Ten Dam & Reinhold 1941, p. 62; pl. 5, fig. 5; pl. 6, fig. 1. Feyling-Hanssen 1980a, p. 164; pl. 5, figs 1-6.

Two specimens of this species are present in the lowermost part (sample no 223307) of the type section at locality 50. Both specimens lack their final chambers. *C. grossa* is also present, though rarely in the upper part of the Upper Pliocene of the Kap København Formation, i.e. in the *Cassidulina laevigata* Zone at locality 16.

Taxa belonging to the superfamily Nonionacea are extremely common in the Kap København Formation. Species belonging to the family Nonionidae are most frequent in the Upper Pliocene part of the formation, whereas the Elphidiidae are most common and characteristic of the Lower Pleistocene part of the formation.

**Family CHILOSTOMELLIDAE**

**Pullenia subcarinata** (d'Orbigny)

*Nonionina subcarinata* d'Orbigny 1839, p. 28; pl. 5, figs 23-24. *N. quinqueloba* Reuss 1851, p. 71; pl. 5, fig. 31.

This species is present in the *Elphidium cf. excavatum* Zone.

**Family NONIONIDAE**

**Nonion barleeanum** (Williamson)

Plate 5, figs 1, 2.

This species occurs in some frequency in the Lower Pleistocene Elphidium excavatum Zone and in the Elphidium cf. excavatum Zone, particularly in its upper part. It has also been found in the Upper Pliocene Cassidulina laevigata Zone.

Specimens of Nonion barleeanum from the upper part of the section at locality 50 have a very broadly rounded peripheral margin, but at the same time not a smoothly rounded, but almost polygonal outline, in side view. Some of them have a more irregular lobulate outline. They are all very large, up to 1.1 mm in diameter.

Nonion erucopsis  Todd
Plate 5, figs 3, 4.

Todd 1957, p. 231; pl. 28, fig. 15. Feyling-Hansen 1976a, p. 358; pl. 8, figs 3–4.

This species was described from Carter Creek, northern Alaska (Miocene-Oligocene?. cf. McNeil et al. 1982). It has a firm circular outline and a narrow umbilicus with a much less conspicuous limbate ring than is the case with Nonion barleeanum. It is an intermediate species between this latter species, which is also larger, generally more compressed.

Nonion erucopsis  is frequent in and characteristic of the Upper Pliocene Elphidium funderi Zone of the Kap København Formation. This zone is probably the oldest zone of the formation. It is also common in the Cassidulina laevigata Zone.

Nonion matchigaricus  Voloshinova
Plate 5, figs 5, 6.


This species was described from the Miocene of Sakhalin, and has some similarity to Nonion niveum.

It occurs in the Upper Pliocene Cassidulina laevigata Zone of the Kap København Formation, and also in the Elphidiella rolfi Zone and in the Elphidium cf. excavatum Zone.

Nonion niveum  Lafrenz
Plate 5, figs 7, 8.


This small species is close to Nonion aitaensis  Asano (1950, p. 1; pl. 1, figs 1–2) and is probably conspecific with the Nonion tallahattensis from Clyde Foreland and from the Qivituq Peninsula, Baffin Island (Feyling-Hansen 1976a; 1980a).

N. niveum is quite frequent in the Elphidiella rolfi Zone, the Elphidium cf. excavatum Zone and in the Elphidium excavatum Zone of the Kap København Formation.

Nonion orbiculare  (Brady)
Plate 5, figs 9, 10.


This characteristic species is frequent in the Elphidiella rolfi Zone, the Elphidium cf. excavatum Zone, and in the Elphidium excavatum Zone of Kap København. It has also been found in the Upper Pliocene Cassidulina laevigata and rarely in the Elphidium funderi Zone there.

Nonionella lobsannensis  (Andreae)
Plate 5, figs 11–13.

Pulvinulina lobsannensis  Andreae 1884, p. 126; pl. 8, figs 10a-c. Batjes 1958, p. 144; pl. 7, fig. 4.

This species occurs in the Cassidulina laevigata Zone of profile 16 near Søndre Ladegårdselv. Nine chambers are present on the spiral side and 6 on the umbilical side. The species figured as Nonionella miocenica  Cushman by Voloshinova et al. 1970 (p. 86, pl. 14, figs 10a, c) from the Upper Miocene of Sakhalin shows many similarities with the present specimens.
Astronomion gallowayi Loeblich & Tappan

Loeblich & Tappan 1953, p. 90; pl. 17, figs 4–7.

This species occurs rarely in the upper part of the Elphidium excavatum Zone of the Kap København Formation.

Family ELPHIDIIDAE

Elphidium albiumbilicatum (Weiss)
Plate 5, figs 14, 15.


This species is quite frequent in the Elphidiella rolfi Zone and is also present throughout the Elphidium cf. excavatum Zone and the Elphidium excavatum Zone. Scattered specimens also occur in the older parts of the Kap København Formation.

Some of the specimens have relatively few chambers and thus come close to Elphidium magellanicum Heron-Allen & Earland (1932, p. 440; pl. 16, figs 26–28). These are here treated together with Elphidium albiumbilicatum (Weiss).

Elphidium asklundi Brotzen
Plate 5, figs 16, 17.


This species is common in the Lower Pleistocene Elphidium excavatum Zone (e.g. section 72). Many of the specimens are large and somewhat compressed, often with slit-like sutural openings. Some of them are not easily distinguishable from Elphidium incertum (Williamson). Other specimens have a less broadly rounded periphery and also a slight asymmetry in edge-view, as is the case for Perfectonion incertaformis Kuznetzova (in Voloshinova et al. 1970, p. 91; pl. 17, figs 14–17), from the Miocene of Sakhalin. These specimens were observed in the Upper Pliocene Cassidulina laevigata Zone of the Kap København Formation.

Elphidium bartletti Cushman
Plate 5, figs 18, 19.

Elphidium bartletti Cushman 1933, p. 4; pl. 1, fig. 9. Feyling-Hanssen et al. 1971, p. 271; pl. 11, figs 6–9; pl. 20, figs 1–4.

This species is common in the Elphidium excavatum Zone of the Kap København Formation.

Elphidium excavatum (Terquem)
Plate 5, figs 20–22.

Polystomella excavata Terquem 1876, p. 429; pl. 2, figs 2a–d.

This species is both frequent and characteristic of the Elphidium excavatum Zone of the Kap København Formation, but occurs also in the Upper Pliocene.

Of the many morphotypes of this species described by Feyling-Hanssen (1972) and Miller et al. (1982). Elphidium excavatum forma excavatum (Terquem) (= forma selseyensis (Heron-Allen & Earland)) and E. excavatum forma clavata (Cushman) are the most common ones. No distinction has been made between them in tables and diagrams, though the latter form is more frequently met with in the Pleistocene part of the formation than in its older parts.

Elphidium cf. excavatum (Terquem)
Plate 5, figs 23, 24; pl. 6, figs 1, 2.

Elphidium excavatum (Terquem) var., Åsbjörnsdóttir 1987, p. 128; text-figs 2f–h.

This is a small yellowish-brown Elphidium with an entire or slightly lobulate outline and sometimes with an almost subacute peripheral margin; it may have a very distinct umbilical boss; the earlier sutures have no sutural bridges and may even be flush with the surface, one to three sutural bridges are developed in the last two or three sutures.

This form of Elphidium excavatum is particularly frequent in the Elphidium cf. excavatum Zone of the section at locality 50, and is quite frequent in the Upper Pliocene zones. This is in good agreement with its occurrence in the Central North Sea “Josephine” boring, where it was observed in the Lower Pleistocene and the Upper Pliocene (Åsbjörnsdóttir 1987). Elphidium cf. excavatum seems to be a transitional form between Elphidium funderi and Elphidium excavatum.

Elphidium funderi n. sp.
Plate 6, figs 3–8.

Name: After Svend Funder, Copenhagen, who found and first described the Kap København Formation of North Greenland.

Holotype: (MMH no. 12150) the specimen figured on pl. 6, figs 5 and 6.

Type level: Upper Pliocene.

Type locality: Locality no. 120, sample no. 53212 (clayey silt) from the upper part of a 10 m thick section at Nordre Ladegårdselv, Kap København, Peary Land.

Diagnosis: An Elphidium with acute, almost keeled periphery, umbilical boss and 10 chambers in the last whorl.
**Description:** Test lenticular, biconvex with an acute, sometimes carinate periphery so that the surface area between the periphery and the central part appears concave, involutely coiled with a broad, sometimes indistinct umbilical boss, 10–11 chambers in the final whorl, the two last chambers slightly lobulate. Sutures curved moderately backwards with usually three broad sutural bridges between the three or four last chambers, earlier sutures without bridges, and almost flush with the surface. Wall calcareous perforate, brownish hyaline to milky white, radial when viewed in polarized light, surface smooth: aperture at the base of the aper­tural face, a row of openings hardly discernable because of calcareous vesicular material at the base of the aper­tural face. Greatest diameter of holotype 0.38 mm, thickness 0.17 mm. Greatest diameters of paratypes varied from 0.40 mm to 0.51 mm, thicknesses from 0.17 mm to 0.28 mm.

**Occurrence:** This species occurs in the Upper Plio­cene of the Kap København Formation. It is frequent in and characteristic of the lower part of this unit which is here called the *Elphidium funderi* Zone.

Scattered specimens occur in the upper part of the Upper Pliocene and even a few in the *Elphidiella rolfi* Zone.

**Affinities:** *E. funderi* shows some resemblance to *Polystomella angulata* Egger (1857) from the Miocene of Nieder-Bayern, Germany, but this latter species has no umbilical plug and more, aperture at the base of the aper­tural face, a row of openings hardly discernable because of calcareous vesicular material at the base of the aper­tural face. *Elphidium funderi* also resembles *Polystomella cryptostoma* Egger (1857), also from the Miocene of Nieder-Bayern, but this species differs in its more nu­merous chambers, its strongly backwards curving su­tures and its almost indiscernable bridges in the last suture. *Elphidium funderi* n. sp. is similar to *Cribrono­nion occidentalis* Margerel (1968) from the Redonien (Pliocene) of north-western France, but this latter species has slightly fewer chambers (9), less curved sutures, and small sutural pores.

*Elphidium groenlandicum* Cushman

Plate 6, figs 9, 10.

Cushman 1933, p. 4; pl. 1, fig. 10. *Elphidiella groen­landica* (Cushman) – Loeblich & Tappan 1953, p. 106; pl. 19, figs 13–14.

This species is present in the uppermost part of the *Elphidium excavatum* Zone.

*Elphidium hallandense* Brotzen


This species occurs sparsely in the upper part of the Lower Pleistocene *Elphidium excavatum* Zone.

*Elphidium hughesi* Cushman & Grant

Plate 6,figs 11, 12.

Cushman & Grant 1927, p. 75; pl. 7, fig. 1.

*E. hughesi* is quite frequent in the *Elphidiella rolfi* Zone of Kap København, and occurs also in the lower part of the *Elphidium cf. excavatum* Zone and in the *E. excavatum* Zone. It is also present in the Upper Pliocene *Cassidulina laevigata* Zone.

*Elphidium subglobosum* (Voloshinova)


This species occurs in the Upper Pliocene *Cassidulina laevigata* Zone of Kap København.

*Elphidium ustulatum* Todd

Plate 6, figs 13, 14.


This species occurs quite commonly in the *Elphidiella rolfi* Zone, in the *Elphidium cf. excavatum* Zone, and in the *Elphidium excavatum* Zone of the Kap København Formation. It has also been observed in the Upper Pliocene part of the formation.

*Elphidiella gorbunovi* (Stschedrina)

Plate 6, figs 15, 16.

*Elphidium gorbunova* Stschedrina 1946, p. 144; pl. 4, figs 21a–b. *Pseudoelphidiella gorbunovi* (Stschedrina) – Voloshinova, Kuznetzova & Leonenko 1970, p. 179; pl. 49, fig. 3.

This species occurs fairly frequently in the upper part of the *Elphidium excavatum* Zone of the Kap København Formation. It has also been found in the *Elphi­diella rolfi* Zone at locality 58.

McNeil (1988) recorded *Elphidiella gorbunovi* from a Pliocene section on Ellesmere Island and from the Pleis­tocene and Pliocene of borings in the Beaufort-Macken­zie Basin of Arctic Canada (1989). Gudina (1969) rec­corded it, as a synonym of *Elphidiella groenlandica* (Cushman), from the Pleistocene of the Siberian low­lands. It was originally described as living in the eastern Arctic seas.

*Elphidiella hannai* (Cushman & Grant)

Plate 7, figs 1–7.

*Elphidium hannai* Cushman & Grant 1927, p. 77; pl. 8, fig. 1.
This species occurs in the *Elphidiella rolfi* Zone and in the lowest part of the *Elphidium excavatum* Zone at locality 72 (fig. 4).

*Elphidiella rolfi* Gudina & Polovova Plate 7, figs 8–13.


The present specimens of *Elphidiella rolfi* are mostly large and lenticular, compressed with subacute periphery, possessing 11–13 chambers in the last whorl – usually 12. A dark field in the central area gives the appearance of central knob, but this is flush with the surface. In some specimens it appears as several small knobs. The sutures are limbate, tapering towards the periphery; sutural pores are only slightly discernible. The aperture is obliterated by papillate shell material. Well preserved specimens are yellowish brown in colour.

This species was referred to as *Elphidiella cf. subcarinata* (Voloshinova) by Feyling-Hanssen (in Funder et al. 1985). *Elphidiella subcarinata* (Voloshinova) has more chambers – 17–18, but seems otherwise very close to the specimens from Kap København. *Elphidiella rolfi* has affinity also to *Elphidiella nitida* Cushman 1941, but also this species has more chambers. *Elphidiella brunnesensis* Todd 1957, from the Miocene (Oligocene?) of Carter Creek, is also related to the present species but has a limbate periphery and no sutural pores.

*Elphidiella rolfi* is frequent and characteristic of the *Elphidiella rolfi* Zone of the Kap København Formation. In some of the samples this large species may be overrepresented due to the dissolution of smaller, more delicate species. It is rare in the upper part of the *Cassidulina laevigata* Zone, in the lower part of the *Elphidium cf. excavatum* Zone and in the the lower part of the *Elphidium excavatum* Zone.

Family GLOBIGERINIDAE

*Globigerina pachyderma* (Ehrenberg)

*Asterospira pachyderma* Ehrenberg 1861, p. 303; 1873, p. 386; pl. 1, fig. 4.

Scattered specimens of this species have been observed in the samples from the section at locality 72.

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