

FORAMINIFERAS IN SOME DANISH GLACIAL DEPOSITS

Peter B. Konradi

Geological Survey of Denmark

Abstract. As a secondary result of an investigation of foraminiferal faunas in Danish marine Pleistocene deposits, it appeared that the glacial deposits—tills as well as glaciofluvial deposits—sometimes contain foraminiferas belonging to Pleistocene deposits. These re-deposited faunas can often be assigned to a specific marine deposit of an interglacial or interstadial age. In this way, the oldest possible age of the glacial deposit can be determined. An example of this is given from Møns Klint.

glacial deposit can be determined, because it must be younger than the interglacial or interstadial which is incorporated in it.

FORAMINIFERAS DERIVED FROM PLEISTOCENE DEPOSITS OF KNOWN AGE

INTRODUCTION

The following is not a separate study, but an outline of some of the secondary results of an investigation in progress of the foraminiferal faunas in some Danish marine Pleistocene deposits.

Though foraminifera exclusively live in marine environments and therefore belong to marine deposits, they are often found in Danish glacial deposits, both in till and in glaciofluvial sand and clay. Their occurrence in these deposits must be in a re-worked state and must be explained as an embedding of the original marine sediment in the glacial deposit. These foraminiferas can be divided into two groups: foraminiferas belonging to the pre-Quaternary deposits, which form the substratum of the Quaternary deposits, and foraminiferas originating in Pleistocene marine sediments.

Frequently the pre-Quaternary foraminiferas are very abundant in tills, which indicates that the tills originated at least to some degree from the pre-Quaternary sediments. Determination of these foraminiferas and thereby the strata to which they belong may perhaps reveal the place of origin of the pre-Quaternary constituent of the till. This can be used in the interpretation of the movement of the ice sheet forming the till. But this is not the scope of the study.

This paper deals mainly with the Quaternary foraminiferas, which are found in tills and glaciofluvial deposits. These foraminiferal assemblages can often be assigned to specific deposits of interglacial or interstadial age. In this way the oldest possible age of the

The Danish marine Pleistocene deposits are found partly as glacially disturbed and detached slices in coastal cliffs or clay pits and partly in borings.

In the coastal cliff at Stensigmosse, southern Jylland, marine deposits from the Eem Interglacial have been described (Madsen, Nordmann and Hartz, 1908). Beneath the marine deposit is a series of glaciofluvial sand and clay, presumably belonging to the Saale Glaciation, and a lacustrine clay from the Eemian. These strata contain only foraminiferas, which are derived from pre-Quaternary deposits.

The marine Eemian strata consists of the *Cyprina* Clay and the *Tapes* Sand. They are superposed by a thin bed of glaciofluvial sand, overlain by a gravelly till, followed by a clayey till. The top of the cliff consists of a few metres of horizontally layered glaciofluvial sand and clay. The lower glaciofluvial sand and the gravelly till contain a few foraminiferas, of which two-thirds originate from the Eemian deposits. The clayey till contains several foraminiferas, but only 5–20 % originate from the Eemian. The horizontally layered glaciofluvial sand and clay contain many foraminiferas, and about two-thirds of these come from the Eemian strata.

It is quite evident that the glacial deposits overlying the marine Eemian strata and partly consisting of them must have been formed during the Weichsel Glaciation.

From a boring at Sønderborg, about 5 km from Stensigmosse, a sample of clayey till was investigated. The sample contained some foraminiferas and about half of them originated from the *Cyprina* Clay.

Obviously the till was formed in the Weichsel Glaciation.

Ødum (1933) correlated the dislocated marine deposits found at Strandegårds Dyrehave, southeastern Sjælland, and at Stubberup Have on the island of Møn to the Skærumhede Series. An investigation of the foraminiferas of these deposits revealed that they are of Eemian age, because they contain the same characteristic fauna as the *Cyprina* Clay. The relative frequencies of the species are partly different, indicating that they originated from another facies than the *Cyprina* Clay, but still from a low water depth. The glacial deposits below and above the marine clay contain also foraminiferas from the Eemian strata. This indicates that the whole sequence is of Weichselian age.

At Møns Klint, the following glacially tilted sequence is found at the Hundevangsfald (Hansen and Nielsen, 1960): a lowermost basal white chalk of Senonian age, overlain by a lower clayey till, followed by a layer of stratified sand, which is conformable with the surface of the chalk. The sand is superposed by a clay with scattered stones, pebbles and grains of sand, and on the top of this there is an upper clayey till. Worn fragments of molluscs are found in the stratified sand, and Hintze (1937) considered this to be a true marine interglacial deposit.

A foraminiferal investigation reveals that the lower part of the lower till contains exclusively pre-Quaternary species, whereas in the upper part 95 % of the fauna correspond to the Eemian fauna at Strandegårds Dyrehave and Stubberup Have. For that reason, this till must consist in fact of two parts, in spite of the homogeneous appearance.

In the stratified sand, some foraminiferas are found, and most of them are of Eemian age. In the clay with scattered stones, a few foraminiferas are present, but only a small part of them come from the Eemian. The upper till contains some foraminiferas, but only a few per cent are derived from Quaternary deposits. Therefore the conclusion must be that at least the upper part of the lower till and the rest of the sequence above it were formed in the Weichsel Glaciation, and furthermore that the tilting of the sequence is of Weichselian age.

FORAMINIFERAS DERIVED FROM PLEISTOCENE DEPOSITS OF UNCERTAIN AGE

In many borings from northern and northwestern Sjælland, a specific Pleistocene foraminiferal assemblage is found in tills and in glaciofluvial deposits. This

assemblage includes some species which are characteristic of the Older *Yoldia* Clay of Vendsyssel. The rest of the fauna is also in accordance with the fauna of the Older *Yoldia* Clay.

Jessen, Milthers, Nordmann, Hartz and Hesselbo (1910) correlated the Older *Yoldia* Clay with the upper part of the Skærumhede Series, the *Portlandia arctica* Zone, and concluded that it was deposited in the Early Weichselian. Feyling-Hanssen, Jørgensen, Knudsen and Andersen (1971) confirmed the correlation and proposed that the Older *Yoldia* Clay was of Middle Weichselian interstadial age. This would indicate that the glacial deposits in northern and northwestern Sjælland containing this particular foraminiferal assemblage must have been formed late in the Weichsel Glaciation.

GLACIAL DEPOSITS OF KNOWN AGE WITHOUT DERIVED PLEISTOCENE FORAMINIFERAS

Glacial slices with marine clay of Eemian age are often observed in coastal cliffs around the western part of the Baltic Sea, and in clay pits and borings in this area. This indicates a Weichselian age of the glacial deposits in which they are embedded. The same applies to the cliff at Ristinge on the island of Langeland (Madsen, Nordmann and Hartz, 1908).

At this locality, about 30 slices have been thrust over one another in such a way that the original stratigraphic sequence is found in most of the floes. The sequence is as follows. Lowermost there is a fat clay overlain by a layer of freshwater sand, followed by the Eemian marine *Cyprina* Clay. This is superposed by a coarse-grained glaciofluvial sand overlain by a clayey till, which is followed by a fine-grained glaciofluvial sand, and on the top of it there is a clayey till. The strata above the *Cyprina* Clay are regarded as Weichselian.

Foraminiferal investigations show that the fat clay and the freshwater sand do not contain any foraminiferas. In samples from the Weichselian glacial deposits, exclusively foraminiferas belonging to pre-Quaternary deposits are found. Foraminiferas derived from the Eemian strata are not found, although Madsen (1895) mentions some Quaternary species from a till at Ristinge Klint.

The consequence is that, though a glacial deposit is resting directly upon a Pleistocene deposit, it does not

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necessarily contain any foraminiferas from the marine deposit. Therefore the absence of Pleistocene foraminiferas in a glacial deposit does not indicate anything in itself concerning the age of the glacial deposit, compared to a specific marine deposit.

CLOSING REMARKS

Further investigations of marine Pleistocene deposits will probably determine their stratigraphic age, their regional distribution and their foraminiferal assemblages. In this way, a specific Pleistocene foraminiferal assemblage found in a glacial deposit will be a tool which can be used for the determination of the oldest possible age of the glacial deposit and perhaps cautiously its place of origin. Several observations of this kind might also give an idea of the direction of the ice movements in a specific Glacial or Stadial.

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