

SEDIMENTS AND FORAMINIFERS OF THE MIDDLE OLIGOCENE VIBORG FORMATION, DENMARK

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CHRISTENSEN, L. & ULLEBERG, K.: Sediments and foraminifers of the Middle Oligocene Viborg Formation, Denmark. *Bull. geol. Soc. Denmark*, Vol. 23, pp. 109–117. Copenhagen, August 22th 1974.

The Middle Oligocene Viborg Formation of Jutland, Denmark mainly consists of sticky pyritic clays, deposited in an outer continental shelf area in the Danish Embayment. The lithology and foraminiferal content is very uniform as seen in a traverse section of the Embayment. Rapid submergence of low-lying land areas under an advancing sea has in certain areas produced a basal glauconitic clay grading upwards into sticky pyritic clay. The rate of subsidence has evidently been greater in the central part of the Embayment.

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There are striking lithological differences among the sediments which make up the Danish Tertiary sedimentary column. Sticky clays and marls dominate the sequence from Palaeocene up to and including Middle Oligocene, whereas more sandy, micaceous and darker materials dominate the rest of the sedimentary column (Rasmussen 1961). The two units are divided into Older/Younger or Lower/Upper Tertiary in Denmark (Rasmussen 1961 and Sorgenfrei 1969). After a break in the sedimentation at the Upper Eocene, the Middle Oligocene sedimentation starts with sticky pyritic clay in the central part of the Danish Embayment, which is the northwestern part of the Danish – Polish Trough. The sticky clay unit, Viborg Clay, is grouped as a new formal member of the Viborg Formation (Christensen & Ulleberg, 1973). Very little has as yet been published about these sediments and their faunas (Ravn 1907, Olsen 1955 and Tank 1963). The spatial relationships of the Viborg Formation under investigation are given briefly in the following, together with a preliminary account of the lithology and the foraminiferal content.

The investigation is based on material from the Viborg I deep bore (Geological Survey of Denmark file No. 66.318) carried out in 1939 by the Danish American Prospecting Co. The core recovery of this bore was very high in the Oligocene interval. Furthermore two borings at the Sofien-

lund outcrop and one at Rodstenseje, all with high core recovery, have been carried out by the authors. Samples from the Grundfjør area were collected from the clay pit at Grundfjør brickworks, where the Viborg Formation crops out. The localities represent a traverse section southeastwards in the Danish Embayment from the deepest part of the Embayment towards the present outermost extension of Middle Oligocene sediments in Jutland.

The present limit of Oligocene deposits in Denmark is mainly determined by glacial erosion during cold periods of the Pleistocene (fig. 1). This means that existent localities with preserved near-shore deposits from the Middle Oligocene are at present not available.

The Viborg Formation

The Viborg Formation can be traced in Jutland from Rodstenseje in the southeast to Ulstrup in the central part and in the subsurface in the Danish Embayment. The Viborg Formation overlies the distinctly pale Søvind Marl, which in some areas is glauconitic in its top part (fig. 1). In central Jutland the Viborg Formation underlies the Sofienlund Formation (Christensen & Ulleberg, 1973) (fig. 1). In the central part of the Danish Embayment in the Viborg I deep bore the Viborg Formation is penetrated in the interval from 169.5 m to 255.3 m below ground surface. The unit underlies a sticky clay sequence, which shows lithological affinities to the Branden Clay. In eastern Jutland the Viborg Formation underlies Pleistocene glacial tills in several areas. As it is traced laterally towards the east and southeast, the Viborg Formation pinches out on account of erosion and glacial erosion during cold periods of the Pleistocene (fig. 1). To the west and northwest the Viborg Formation usually thickens in the Danish Embayment. In our material the unit attains a maximum thickness of 85.8 m in the Viborg I deep bore (fig. 1). However, salt domes in Upper Permian (Zechstein) and salt deposits in the northwestern part of the Embayment (Ødum 1960, Sorgenfrei & Buch, 1964) suggest a variation in thickness of the Viborg Formation. The thickness is probably greater in the deep bores Viborg 2, 4 and 5.

The Viborg Formation consists of a lithologically uniform sequence of greenish grey pyritic clay, the Viborg Clay member. In the Viborg I deep bore the basal layer indicates a slight intercalation of Søvind Marl with a few grains of glauconite. In the Grundfjør area a glauconitic clay member 1 m thick, the Grundfjør Clay (Christensen, 1969) occurs, which grades upwards into Viborg Clay and forms the basal transgression layer of the Viborg Formation in this area.

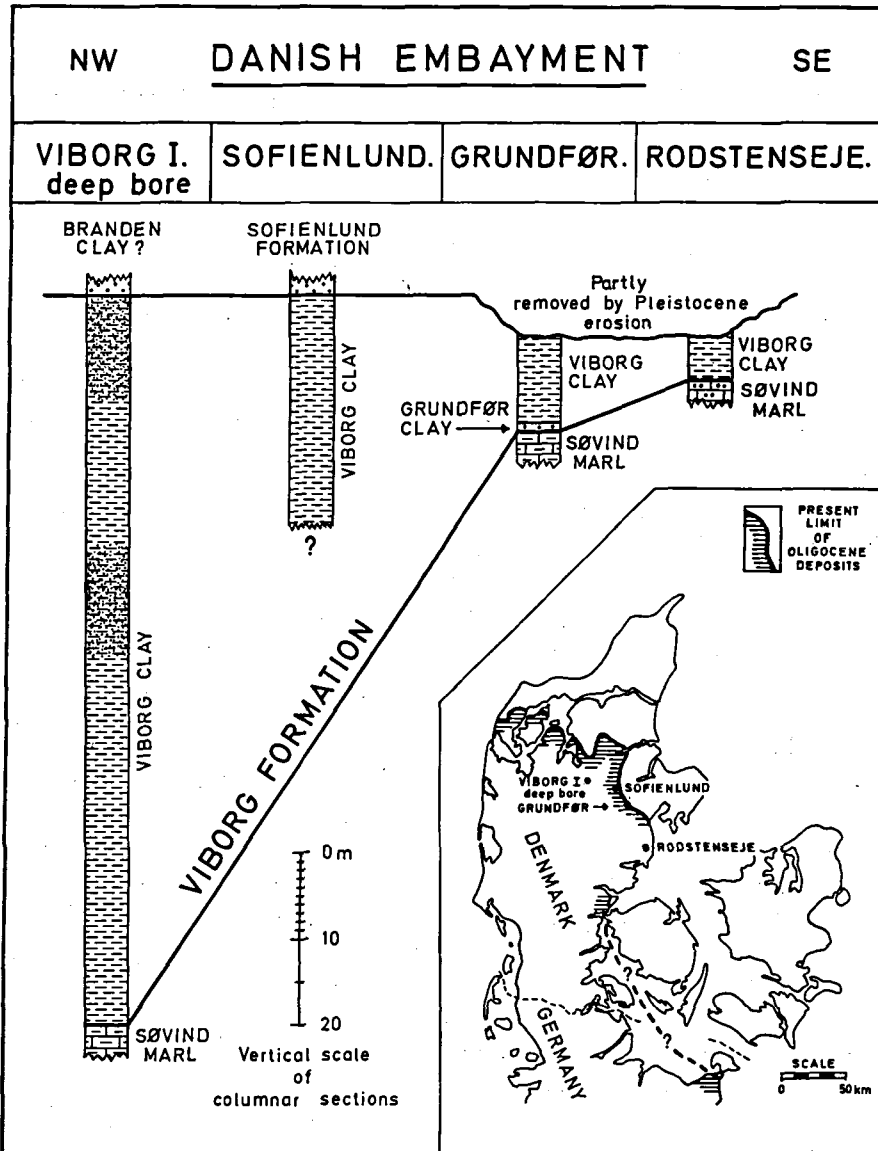


Fig. 1. Regional stratigraphic cross section of Middle Oligocene strata shown in a northwest-southeast section of the Danish Embayment.

Textural composition

In the study of the Viborg Formation it was found convenient to use the textural classification used by Marlowe (1965). The study of predominantly fine-grained materials has resulted in a division of the silt – clay end member series into classes at 33 %, 55 % and 80 % clay. The textural analyses of the 104 samples were carried out in an Andreasen pipette to give standard grain size classes to 2 micron by weight percent.

The distribution of textural types is shown in fig. 2. On the basis of this study it appears that clay mud and mud constitutes most of the Viborg Formation. In the top interval of the Viborg I deep bore there is a slight coarsening of texture. The transgressive Grundfjør Clay is very fine-grained and consists of clay, sandy clay and clay mud. The general aspects of the samples analysed suggest continuous deposition in a fairly stable environment under conditions of gradually decreasing current competence. Such conditions could be brought about by a rising sea level. In the upper part of the Viborg I deep bore the coarseness of textural type in the opposite direction might indicate increasing current competence brought about by a falling sea level.

Foraminiferal fauna

The foraminiferal fauna of the Viborg Formation mainly consists of calcareous benthonic tests. Qualitatively the fauna of the columnar sections is very uniform throughout and shows great stability in composition both vertically and horizontally, and has been divided into 11 foraminiferal groups, as described by Christensen and Ulleberg (1973). The observed range and mean relative frequency throughout the columnar sections are compiled in fig. 3.

Viborg I deep bore

The Viborg Formation amounts to 85.8 m in the Viborg I deep bore. Only the lowermost 71 m contain microfossils. One sample has been investigated from each 5 m interval. The uppermost 15 m of the sequence are more or less unfossiliferous probably due to dissolution and only some strongly pyritic tests of foraminifers have been observed. They all correspond to tests found in the fauna in the lowermost interval.

Some slight faunal variations throughout the fossiliferous interval can be observed. *Uvigerina gracilis* forma *tenuistriata* (Reuss) and *Cibicides* cf. *ungerianus* (d'Orbigny) are frequently represented in the basal part of the unit. The planktonic tests (Globigerinaceae) increase to a maximum of 7 % in a zone about 15 m above the base of the unit, but are sparsely re-

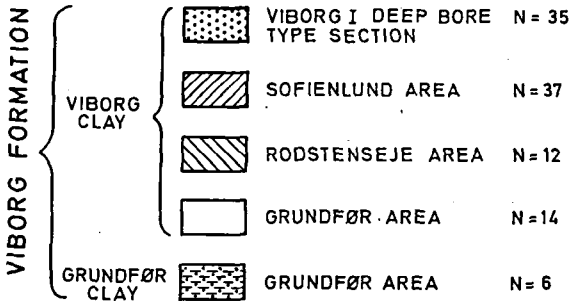
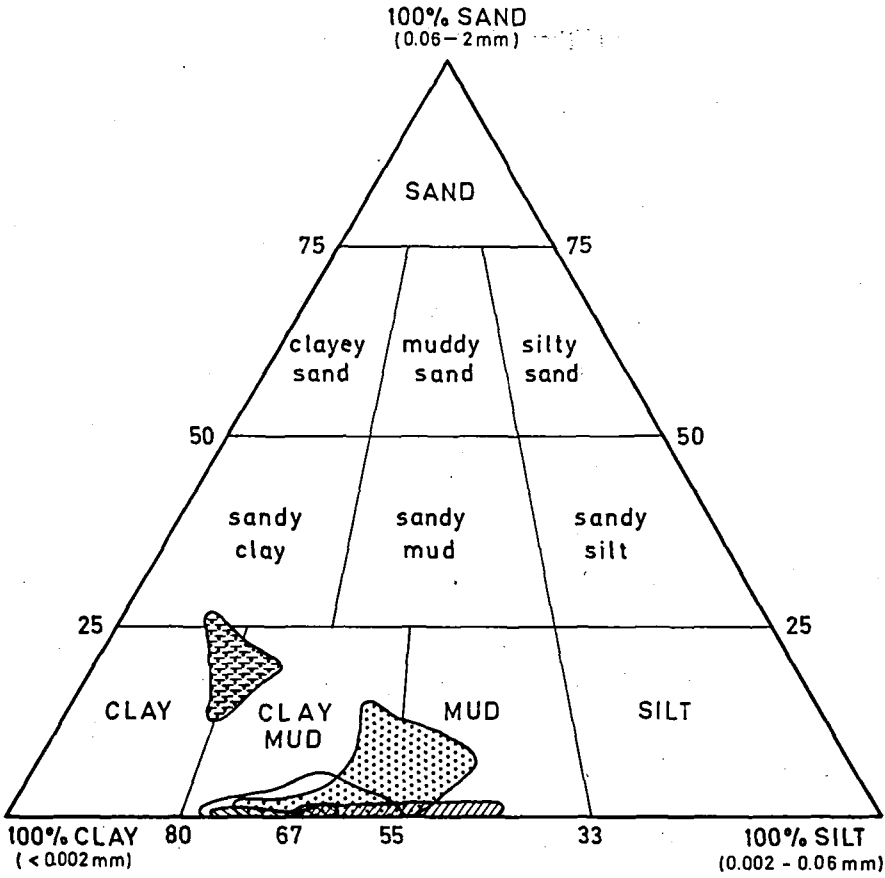


Fig. 2. Triangular plot of textural composition occurring in samples of the Viborg Formation. N = number of samples analyzed.

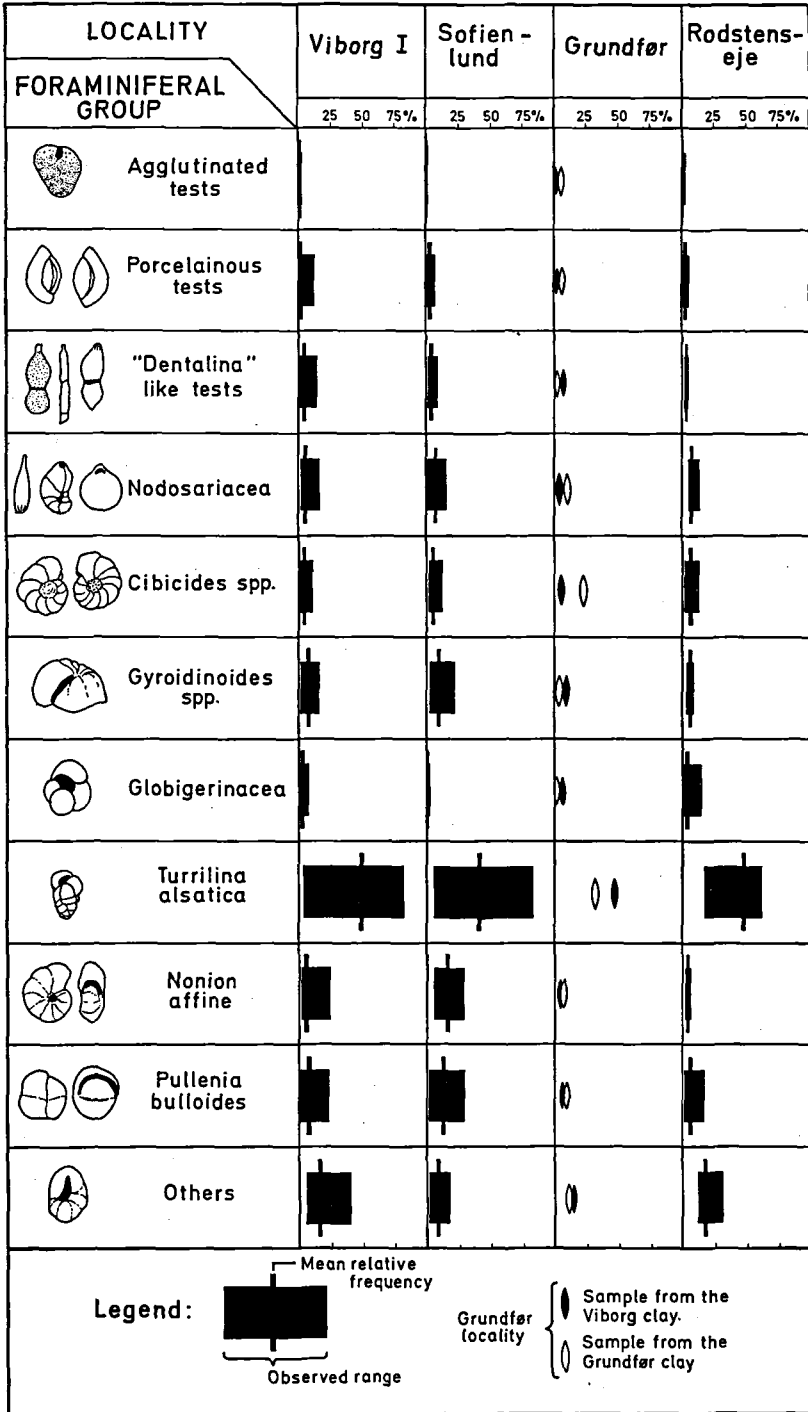


Fig. 3. The foraminiferal fauna in the Viborg Formation compiled into 11 groups, showing the observed range and mean of relative frequency.

presented or absent in the rest of the unit. *Epistominella oveyi* (Bhatia) is commonly found together with the planktonic tests. In the maximum zone of Globigerinaceae this species reaches a maximum representation of 17.5 %.

Sofienlund area

The foraminiferal fauna of the 27 m sequence of the Viborg Clay (fig. 3) has been presented by Christensen & Ulleberg (1973). Only small faunal variations have been observed in this sequence. Biostratigraphically the unit can be divided into three zonules (Ulleberg, in prep.).

Grundfjør area

The foraminiferal fauna of this area has been described by Kristoffersen (1965), who states that the fauna of the basal glauconitic Grundfjør Clay is a transgression fauna to the superimposed sticky clay. One sample from the Grundfjør Clay and one from the sticky Viborg Clay have been examined in the present study. The most striking difference between these samples is the variation in *Cibicides* spp. – group, probably confirming the statement that the Grundfjør Clay is a transgressive layer to the sticky Viborg Clay. The *Cibicides* spp. – group is dominated in both samples by *Cibicides* cf. *ungerianus* (d'Orbigny) and *Cibicides aknerianus* (d'Orbigny). The transgressional tendency is also seen in the representation of planktonic tests from 1.4 % in the Grundfjør Clay to 4.3 % in the Viborg Clay. A difference is also seen in the representation of *Turrilina alsatica* (Andreae). The species seems to be more abundant in deeper environments (46.8 % in the Viborg Clay) compared with transgressional environments (22.9 % in the Grundfjør Clay).

Rodstenseje boring

From the approximately 6 m thick sequence of the Viborg Clay 12 samples from about 0.5 m intervals have been examined. Small faunal variations in the sequence are observed. *Uvigerina gracilis* forma *tenuistriata* (Reuss) and *Cibicides* cf. *ungerianus* (d'Orbigny) are frequently found in the lowermost part, whereas they are very rare or absent in the uppermost part, which is the reverse of the planktonic tests, which increase from almost zero to 14.6 % in the uppermost sample. Almost the same variation is seen in *Epistominella oveyi* (Bhatia), which increases to a maximum of 17.7 % in the uppermost sample.

Discussion and conclusions

The textural types of sediments constituting the Viborg Formation are predominantly clay mud and mud. Clay and sandy clay textural types are

found only in the Grundfjør Clay member, the basal transgressional layer of the Viborg Formation. The fine-grained sediments and the stability of the foraminiferal fauna together with the relatively high representation of planktonic tests above the base of the unit suggests a continuous deposition in a fairly stable environment under conditions of gradually decreasing current competence, brought about by a rising sea level. It is believed that deposition took place in an outer continental shelf area (Christensen & Ulleberg, 1973) and transgression and subsidence elapsed quickly giving uniform depositional conditions. Rapid submergence of low-lying land areas under the advancing sea produced a basal glauconitic clay, Grundfjør Clay, grading upwards into sticky Viborg Clay. The rate of subsidence was evidently larger in the central part of the Embayment.

The foraminiferal fauna of the Viborg Formation belongs biostratigraphically to the *Turrilina alsatica* zone, which is referred to the Middle Oligocene (Christensen & Ulleberg, 1973). The fauna is dominated by three species: *Turrilina alsatica* (Andreae), *Nonion affine* (Reuss) and *Pullenia bulloides* (d'Orbigny). Their joint relative frequency varies from approximately 20 % to 90 %. Horizontally the fauna is homogenous and vertically only some slight variations are observed. Thus *Uvigerina gracilis* forma *tenuistriata* (Reuss) and *Cibicides* cf. *ungerianus* (d'Orbigny) are frequent in the basal part whereas planktonic tests become gradually more abundant upwards in the lowermost part and more or less absent in the middle and upper part of the Viborg Clay sequence. The abundance of *Uvigerina gracilis* forma *tenuistriata* (Reuss) and *Cibicides* cf. *ungerianus* (d'Orbigny) at the basal part of the Viborg Formation in the Danish Embayment does not represent a time contemporaneous stratigraphic level. It is probably due to similar environments during the transgressive phase of the sea.

However, a time contemporaneous stratigraphic level is probably observed in the increase of planktonic tests at approximately 15 m above the base of the unit in the Viborg I deep bore. This zone is probably found too in the gradual increase of the same species upwards in the Rodstenseje sequence. The planktonic species are dominated by *Globigerina* cf. *danvillensis* (Howe & Wallace), *Globigerina angiporoides* Hornibrook and *Globigerina* ex. gr. *bulloides*. This level has not been observed in the Sofienlund area, probably on account of the restricted range of our boring equipment (fig. 1). In the examined samples from Grundfjør the Globigerinaceae increases upwards from 1.5 % to 4.3 %, distinctly higher than in the Sofienlund sequence.

Acknowledgements. We are grateful to Arne Dinesen who critically read the manuscript and we have profitted by his comments. R. W. Feyling-Hanssen provided facilities for this investigation in the Department of Micropalaeontology, University of Aarhus. The Geological Survey of Denmark kindly placed material from the Viborg I deep

bore at our disposal. Svend Meldgaard assisted in the field with the borings and treated most of our samples in the laboratory. Jette Gissel-Nielsen made the drawings and J. R. Wilson kindly improved the English text. Financial support for this study was provided by Statens Naturvidenskabelige Forskningsråd to L. Christensen.

Dansk sammendrag

I nærværende arbejde gives en kortfattet beskrivelse af den Mellem Oligocæne Viborg Formation i Jylland, Danmark. Formationen består overvejende af fede, pyritholdige lermaterialer, aflejret i et kystfjernt marint miljø i det Danske Sænkingsområde. Foraminiferfaunaen er i faunistisk henseende meget ensartet. Ved Mellem Oligocæn transgressionens begyndelse har der øjensynligt været forskellige hydrografiske forhold i forskellige egne, idet lagserien almindeligvis begynder med pyritholdige aflejringer, medens den i egnen omkring Grundfjør begynder med glaukonitholdige aflejringer, der opad går over i pyritholdige aflejringer.

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