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Geology and Biostratigraphy

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Leif Banke Rasmussen

Dansk sammendrag:
De danske marine yngre miocæne formationers molluskfaunaer og biostratigrafi

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I kommission hos
C. A. REITZELS FORLAG (JØRGEN SANDAL)
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PREFACE

The investigations on which the following paper is based, were made during the years from 1958 to 1964, with certain interruptions. The first collections of fossils, however, were made as early as 1939, in my school days. Later the investigations were concentrated on the North Slesvig deposits, from which collections had been started in 1938, and which were finished and published in 1956. At the same time collections were regularly made in the clay pits at Måde east of Esbjerg, and in 1947 the clay pits at Brande Brickworks were often visited. The other outcrops were more rarely visited. Travels to all outcrops in Northern Jutland were made in 1949 with financial aid by JAPETUS STEENSTRUP's Foundation. Later, travels to the localities have been made partly at my own expense, partly as official journeys.

From 1957 the samples from the borings for lignite made by Danmarks Geologiske Undersøgelse were included in my investigations. I am highly indebted to the Heads of the Raw Material Department, first, the late State Geologist KELD MILTHERS, Ph. D., and, later, State Geologist HELGE GRY, Ph. D., for permission to utilize the great material of samples. Mr. ERIK HELLER, Cand. Mag., has in various ways given me valuable assistance in connexion with this work.

During a stay in Vienna in 1951 I had an opportunity to go through the collection of molluscs from the Miocene of the Vienna Basin at the Hofmuseum under the guidance of Dr. R. SIEBER, and during a study tour to Germany in 1959 I visited the localities Morsum Kliff on the island of Sylt and Twistringen south of Bremen, where extensive collections were made.

Material from the classic localities at Langenfelde and Reinbek in North Germany, which have disappeared long ago, has been lent to me by the Geological Museum of the University of Copenhagen through Dr. H. WIENBERG RASMUSSEN's kind agency.

The present biostratigraphical investigations are based on a large material of molluscs from Danish localities. All these fossils, including the rather considerable material collected by myself during the years, belong to Danmarks Geologiske Undersøgelse.

The investigations were made partly at home during my leisure hours, partly at the Institute, in the Well Record Department of which I have had very favourable working conditions, first under State Geologist (now Professor) TH. SORGENFREI, Ph. D., later under State Geologist (now Director) OLE

Berthelsen, Ph. D., Professor Sorgenfrei, who himself has a very thorough knowledge of Danish Miocene molluscs, has meant very much to me as a source of inspiration.

The result of my investigations is now available as a work in two volumes, the first of which is the present paper, and the second, which is in manuscript, contains descriptions and pictures of the molluscs examined. I am highly grateful to the former Director of the Institute, H. Ødum, Ph. D., for permitting me to use the present volume with a special title as a thesis for the doctorate. Both he and his successor in the office of Director, Ole Berthelsen, Ph. D., have given me invaluable support during the work and afterwards.

I owe a great debt of gratitude to a large number of collaborators for assistance of various kinds: Mrs. Birte Dinesen, B. Eng., has executed some chemical analyses, Mr. Thomas Eriksen, Curator, has washed a large number of samples of clay, Miss Ingrid Villadsen, has washed the great material of samples from the borehole at Gram Brickworks made by the Institute, Mr. Chr. Westergaard, Photographer, has taken most of the photographs and done all the work in the dark-room, Mrs. Rigmor Borg has done the work of drawing, Mr. J. Spang Nielsen, Master Driller, has with his usual care made certain boreholes, thus at Gram and Sæd, Mrs. Kirsten Sperling has typed the Danish manuscript, and Mr. Niels Haislund, Cand. Mag., has made the translation into English. Finally I am indebted to a number of owners of brickworks for permission to examine their claypits. My wife, Mrs. Inger Banke Rasmussen, Cand. Mag., has assisted me at the proof-reading.

To all the helpers mentioned above and to all those who are unnamed I offer my most cordial thanks.

The Danish manuscript was finished in March 1965 and the English one in February 1966.

Nærum, February 23, 1966.

Leif Banke Rasmussen

CONTENTS

ABSTRACT

The result of biostratigraphical investigations into the marine Younger Miocene formations in Denmark on the basis of the molluscan faunas shows the presence of six assemblage zones, distributed by two on the older formation, viz. the Hodde Formation, and four on the younger formation, viz. the Gram Formation:

Upper Miocene (Gram Formation)	The *Nassa slieswicia* zone The *Astarte reimersi – Nuculana pygmaea* zone The *Astarte reimersi – Goodallia esbjergensis* zone The *Astarte vetula* zone
Late Middle Miocene (Hodde Formation)	The *Nassa fuchsi – Limopsis lamellata* zone The *Nassa cimbrica – Aquilofusus festivus* zone.

In Denmark all the zones have only been recorded from West and Central Jutland and North Slesvig. So far they all seem to be distributed over the same region, except for the *Nassa slieswicia* zone, which has so far been recorded only from the region farthest south, close to the Danish-German frontier.

The marine Younger Miocene formations in Denmark include an unbroken, at least 35 m. thick series of clay, consisting at the bottom of Hodde Clay (belonging to the Hodde Formation), above that of Glauconite Clay, and at the top of Gram Clay (the last two belonging to the Gram Formation). Fairly homogeneous bottom conditions make it possible to follow the evolution of a few species from the Hodde Clay to the uppermost parts of the Gram Clay.

The basis of the investigations is partly collected, partly sorted-out material from about 90 localities scattered over the whole area of distribution. The most important basis, however, is a borehole at Gram in North Slesvig, where the complete series of clay was penetrated, and a borehole at Sæd, also in North Slesvig. Most of the other localities have only yielded fossils from a few assemblage zones. The geological conditions in the main part of the localities show that the series of clay to a great extent has been glacially deformed in the Quaternary Period, which has to some degree complicated the stratigraphical investigations.

It has been tried to substantiate the results mentioned through rather a detailed mention of the geological conditions in each locality and through analyses of the sampled and sorted-out fauna from each locality.

IMPORTANT DANISH ABBREVIATIONS AND TERMS USED IN THE TEXT AND FOUND ON THE REPRODUCED MAPS

aa = å   ø = ö   æ = ä

Aa = Å	= River	Mølle	= Mill
Bjærg = bjerg = berg	= Hill	Nørre (Nre)	= North(ern)
Brunkulsleje	= Lignite pit	Plantage	= Plantation
By	= Town, Village	Skov	= Wood
Bæk	= Brook	Slot	= Castle
Eng	= Meadow	Stationsby	= Railway village
Gaard = Gård (Gd)	= Farm	Store (St.)	= Great
Kirke (K^e or K)	= Church	Sønder (Sr. or Sdr.)	= South(ern)
Kro	= Inn	Sø	= Lake
Lille (Ll)	= Little	Teglværk (Tglv.)	= Brickworks
Mejeri	= Dairy	Vester (Vr.)	= West(ern)
Mose	= Bog	Øster (Ør.)	= East(ern)

D. G. U. = Danmarks Geologiske Undersøgelse (Geological Survey of Denmark)

N.B.

The Lignite Department of the D. G. U. is identical with the Raw Material Department of the D. G. U.
These two designations are used more or less casually in the text.

Capital letters have only been used in the following sediment names (cf. p. 11): Mica Clay, Mica Sand, Mica Silt, Kaolin Sand, Limonite Sand(stone), Gram Clay, Glauconite Clay and Hodde Clay. Unlike e. g. quartz sand, boulder clay, etc., they are understood as particularly defined proper names.

INTRODUCTION

The Danish Miocene basin constitutes the Northwestern part of the Miocene North Sea Basin, which also includes parts of North Germany, Holland, Belgium, and – perhaps – England. In Denmark the distribution of the Miocene deposits is restricted to Central and Western Jutland, where beds of clay, sand, and lignite in all of more than 200 m. of thickness were deposited.

Chronostratigraphically the Miocene in Denmark has long been divided into a lower, a middle, and an upper part, mainly on the basis of the contents of molluscs in the strata (Ravn 1907, 1928). This relative division in time is based on results of investigations from other parts of the North Sea Basin, especially North Germany, where there is a Miocene series which as regards sediments as well as contents of fossils reminds very much of the Danish series.

I shall not here give an account of the various stratigraphical classifications within the European Tertiary basins in general and the North Sea Basin in particular. Reference may be made to the detailed account in Theodor Sorgenfrei's work on Molluscan Assemblages from the Marine Middle Miocene of South Jutland (1958, pp. 9–19).

A brief historical review of the knowledge of the Miocene of Denmark is found in my survey of 1961(b), which, however, was written in Danish, but in the English abstract of which reference is made to the most important works. The present view of the classification of formations and the division according to time of the Miocene of Denmark appears from fig. 1, p. 10. The definitions of the various formations are found in the papers to which reference is made in the following list:

6. The Gram Formation (marine). Rasmussen 1956, p. 16. (Age: Upper Miocene).
5. The Hodde Formation (marine). Rasmussen 1961 b, pp. 4 and 32. (Age: Middle Miocene).
4. The Odderup Formation (limnic). Rasmussen 1961 b, pp. 4 and 30. (Age: Middle Miocene).
3. The Arnum Formation (marine). Sorgenfrei 1958, p. 28. (Age: Middle Miocene).
2. The Ribe Formation (limnic). Sorgenfrei 1958, p. 28. (Age: Middle or Lower Miocene).
1. The Klintinghoved Formation (marine), Klintinghoved Clay. Sorgenfrei 1940, p. 68 and p. 116. (Age: Lower Miocene).

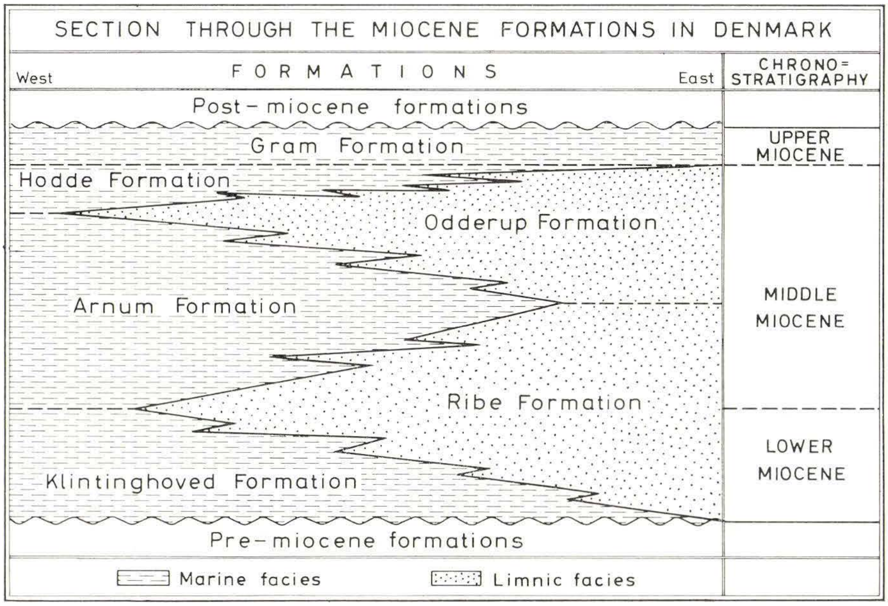

Fig. 1.

The age-determination of the formations must be considered preliminary. It may, e.g., be stated that the Arnum Formation is considered to be coeval with the Hemmoor Stufe in North Germany (SORGENFREI 1958, p. 408). This stage is now by German and French geologists (ANDERSON, MAGNE) considered synchronous with the Burdigalien in the Aquitanian Basin (France) because of the close agreement between the molluscan faunas (ANDERSON 1961 a, p. 152). If, on a close examination, it proves that this view can be confirmed, the Hemmoor Stufe as well as the at any rate in part equivalent Arnum Formation belongs to the Lower Miocene according to international usage. (ANDERSON 1961 b, p. 168).

The present work is concentrated on the molluscan faunas of the marine Hodde and Gram Formations and on the biostratigraphical conditions to be derived from these.

The sequence of strata within these formations is as follows (cf. RASMUSSEN 1961 b, pp. 14–16):

5. Clay, silty, very micaceous, partly bedded. 4. Clay, micaceous, darkish grey with a slightly brownish tint (Gram Clay). 3. Clay, containing very much glauconite, darkish green or black with a greenish tint (Glauconite Clay).	Gram Formation

2. Clay, black, on freshly fractured surfaces darkish brown, micaceous, sometimes coal-like and with glistening black, fractured surfaces (Hodde Clay).	Hodde Formation
1. Quartz gravel imbedded in black clay.	

Among these strata the bedded silty clay seems to be present only locally, but in several localities the upper part of the Gram Clay contains large amounts of light-coloured mica flakes.

The other beds are common in Central, West, and South Jutland, where the clay beds were previously known under the names of *Mica Clay* or *Astarte Clay*.

The sediment term of *Mica Clay* originates from the Danish geologist GEORG FORCHHAMMER, who in his printed works does not seem to have used the word until the publication of his paper from 1828 about the Tertiary strata in Morsum Kliff on the isle of Sylt. In this paper it says on p. 370:

"Mica Clay ("Glimmer-Leer"). Smoky grey clay with many fine white mica flakes; rather highly binding; effervesces very slightly or not at all at the application of acids." –

In a footnote on p. 369 in the same work FORCHHAMMER says about the terms which he uses here for the first time: Kaolin Sand, Limonite Sand, Mica Sand, Mica Clay, and Alum Earth:

"I attribute to these new names no further value at all than that of having relieved the writer of a multitude of tedious circumlocutions."

The names, however, were soon recognized by, i.a., the German geologist LUDWIG MEYN, who used them consistently as a term for the Miocene strata in Slesvig and Holstein (1848, 1872). Through MEYN and other German geologists (J. O. SEMPER 1856, 1861: "Nordalbingische Glimmerton") the name of "Glimmerton" (= Mica Clay) even was introduced into German geological literature as a special formation name for the Upper Miocene dark grey clay.

In Denmark FORCHHAMMER also retained the term "Glimmerler", but as a name of all micaceous Tertiary clays. In 1863 (published in FORCHHAMMER 1864) he divided the "Lignite formation" ("Brunkulformationen") in Denmark (i.e. the Tertiary strata) into two sections:

(1) "grey clay rich in mica (Glimmerleer, Forchh.)" and "yellow sand rich in iron, sandstone, and conglomerate (Limonitsand, Forchh.)", which were considered the oldest beds, and

(2) "very fine-slaty, plastic beds of clay", which were considered to be youngest.

FORCHHAMMER thus reversed the correct sequence. He referred to "Glimmerler" all strata of Mica Clay which were later recognized as of Oligocene and Miocene age. His defective knowledge of fossils furthermore involved a greater vagueness of his view of the sequence of the various strata than of that of the German geologists.

The name of the sediments, however, was retained in Danish geological literature of the following period in the same sense as in FORCHHAMMER. First through O. MØRCH's (1874), and later, more thoroughly, through J. P. J. RAVN's investigations (1907), it was established that there were Mica Clays of widely different ages. Hence, it was also realized that some of these strata had a special character as compared with the others.

P. HARDER thus (in USSING 1913, p. 163) designated the characteristic dark grey Mica Clay in Western and Central Jutland by the name of "Astarte Clay" because of the large number of valves of *Astarte* found in it. Until recently this term has been used in Denmark and often covers the concept of "Gram Clay".

The dark grey Gram Clay and the black Hodde Clay, however, often occur in so close connexion with each other in the highly dislocated occurrences in Western Jutland that geologists have only spoken about particularly dark Astarte Clay where Hodde Clay was observed. Analogously Glauconite Clay has been viewed as particular glauconitic parts of the Astarte Clay. It does not seem that anybody previously was aware of any sequence proper in the complex of clay which has been called Astarte Clay.

The first to observe the sequence Gram Clay – Glauconite Clay – Hodde Clay was the late State Geologist KELD MILTHERS, Ph. D., who demonstrated it in many of the systematic borings carried out during the search for lignite in 1941–49. In 1948 I found the same sequence of deposits in the slopes of the Karlsgårde Canal at Hoddemark and had there an opportunity to collect molluscs in the Gram Clay as well as the Hodde Clay. It then appeared that the faunas in the two types of clay were widely different and that the molluscan fauna of the Hodde Clay contained Middle Miocene forms, only. In 1958, besides the usual Gram Clay, both Glauconite Clay and Hodde Clay were found in a new section dug in the easternmost clay pit at the brickworks of Måde. The strata were highly dislocated (cf. RASMUSSEN 1959). In this section, too, there was an opportunity of collecting fossils in the Hodde Clay, and it proved possible to find the species which according to GRIPP (1933, pp. 54 and 92, and 1964, p. 121) are characteristic of the youngest marine Middle Miocene (Reinbek Stufe) in North Germany.

During the years between 1948 and 1958 the sequence had been observed in several outcrops and in many boreholes in West and Central Jutland; only in North Slesvig it had not yet been found. Only at an examination of a long series of samples from North Slesvig borings, more especially through a boring at the clay pit of the brickworks of Gram, which D.G.U. made in the early summer of 1963, it has been definitively established that the same sequence of strata occurs in North Slesvig. The occurrence of the Gram Clay and the Hodde Clay was easy to ascertain, both through observation of the samples of clay and through an examination of the contents of fossils. The glauconitic zone, on the other hand, was so dark-coloured that the green colour of glauconite only stood out after the particles of clay had been washed away.

In the records from the other boreholes in North Slesvig there are rarely remarks on changes of strata within the clay series mentioned here. This is due to the fact that all the three types of clay in a ground-moist state are often so closely merged in colour that the drillers have noted clay in the whole interval and only taken a single sample from a random place. Often the interval has only been characterized as "dark clay." Only a consistent washing of all samples from borings in the Younger Miocene beds of North Slesvig available in the Well Record Department of the D.G.U. has shown that the occurrence of the glauconitic zone must be taken for granted in this province, too.

The basal part of the Hodde Clay contains quartz gravel. Sometimes (e.g. at Hodde and Alkærsig) there is immediately below the gravel a much laminated series consisting of dark clay of the same type as the Hodde Clay alternating with light grey micaceous silt. The beds are only one millimetre thick and often alternate so frequently that the whole of it resembles a varve series. At the top in this series there was at Hodde a shelly bed which will be discussed in detail in what follows and which contains the molluscan fauna of the Hodde Clay as well as a great many forms known from the Arnum Formation. Fig. 2, which shows a segment of an early section in the clay pit of the brickworks of Alkærsig, gives an idea of the appearance of the laminated series.

In its basal parts the series contains quartz gravel, and according to the definition it is included in the Hodde Formation, as it seems to introduce the depositing of the black Hodde Clay.

Thus, even though there is a shelly bed with a rich molluscan fauna within the Hodde Formation, it should be pointed out that the main stress should be laid on a description of the molluscan faunas in the clay series and its bio-

Fig. 2. Rhythmically deposited beds under the Hodde Clay in the clay pit of the brickworks of Alkærsig.

Phot. L.B.R. 10/8 1956.

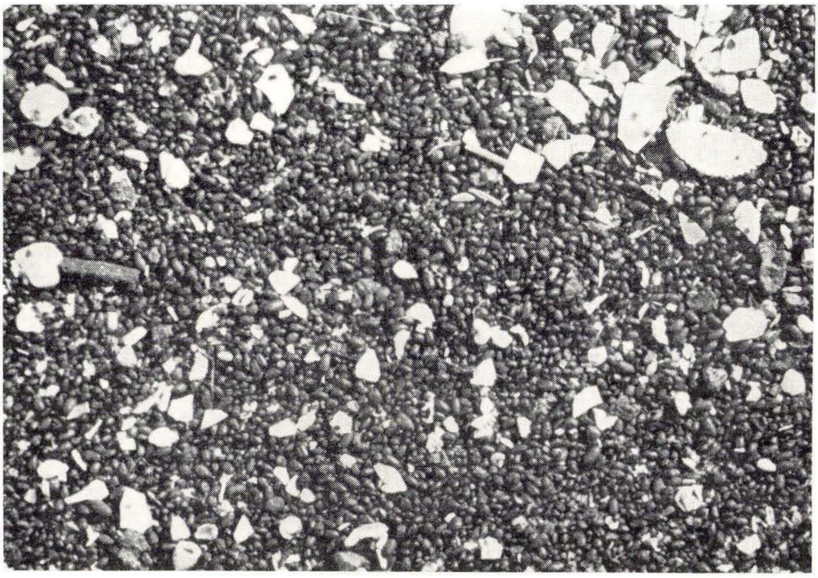

Fig. 3. Wash residue of Gram Clay from borehole at the custom-house of Sæd, D.G.U.
File No. 167.145. Depths: 91.0–91.5 m. ×5.
Phot. Chr. Westergaard

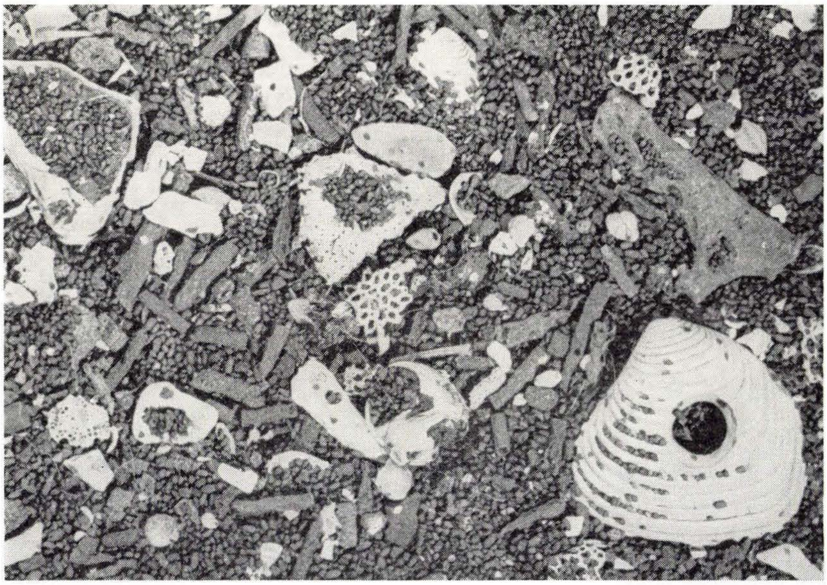

Fig. 4. Wash residue of Gram Clay from the clay pit of the brickworks of Gram. ×5.
Phot. Chr. Westergaard

Fig. 5. Wash residue of Glauconite Clay from the clay pit of the brickworks of Forsum. ×5.

Phot. Chr. Westergaard

Fig. 6. Wash residue of Hodde Clay from boring at the brickworks of Gram, D.G.U. File No. 141.277. Depths: 29.0–29.5 m. ×5.

Phot. Chr. Westergaard

stratigraphy, the clay series facially constituting a unit apart. However, an accessory examination has been made of the molluscan faunas in the shelly beds mentioned as well as in other layers which are situated comparatively closely below the basis of the clay series, partly for the sake of the biostratigraphical discussion, partly for palaeontological reasons.

THE SEDIMENTS

The sediments in the clay series mentioned here have not been closely investigated in a petrographical and clay-mineralogical respect. Such investigations are, however, being made by Dr. P. GRAFF PETERSEN, University Lecturer, and his assistants as regards the boring made by the D.G.U. at the brickworks of Gram in 1963. The results of these investigations will presumably be published later.

In connexion with the present work it has only been attempted to characterize the three types of clay on the basis of their appearance. Furthermore, a description has been given of the wash residues resulting from washing of the samples through a screen with a size of meshes of 0.1 mm. These wash residues have proved to be characteristic of each of the types of clay (cf. figs. 3–6).

In what follows the types of clay will be discussed apart in outline.

Hodde Clay

I suggest that the black and often coal-like Mica Clay under the Glauconite Clay should be termed *Hodde Clay*, a term which has already been used above. The stratotype locality is the Karlsgårde Canal at Hoddemark south of Hodde (NE of Varde), especially the borehole "Hodde I" (D.G.U. File No. 113.33.a) carried out close to the canal, in which boring this clay was found from depths of 13.8 to 19.0 m.

As will appear from the descriptions of localities Hodde Clay occurs in all places where the Gram Clay and its basal glauconitic zone (Glauconite Clay) have been pierced by the drill. Not a single undisturbed section has been found in which Gram Clay overlies Middle Miocene clay directly (Odderup Formation or Arnum Formation). Hodde Clay thus at least is distributed over the same area as Gram Clay. Probably it can be found farther east than this in certain places. This seems, e.g., to be the case in the region east of Gram in South Jutland. On the other hand, it is difficult to decide in these cases whether Gram Clay originally occurred there or whether it has later been removed by erosion.

A detailed mapping of the deposits of Hodde Clay will be of great interest, but no attempt to that effect has been made during the execution of the present work, as only certain samples have been examined. There may still be some samples of Hodde Clay with molluscs in the Well Record Department of the

D.G.U., but the clay usually contains so few of them that the small samples from borings are practically empty of fossils.

After washing with a screen the size of meshes of which is 0.1 mm., residues are obtained which preferably consist of small irregular bits of pyrite that are pitted and cavernous and look like slags. Especially these slag-like bits of pyrite make it difficult to mistake the wash residues of Hodde Clay for those of Gram Clay (cf. fig. 6). Some pyrite is also found in the shape of stems or "needles" as in the wash residues of Gram Clay. On the other hand there is normally none of the ellipsoidal, microscopical bodies characteristic of the latter species of clay. Grains of glauconite occur in certain layers.

The clay contains so much sulphur that a yellow film is often seen on dry, oxidized surfaces.

Glauconite Clay

The dark, greenish clay found between Hodde Clay and Gram Clay consists mostly (30–50 per cent.) of grains of glauconite the diameters of which are between 0.1 and 0.5 mm. The remaining part of the sediment consists of particles of clay. Besides there are a little pyrite in the shape of small stems and some very small, single grains of quartz. Fossils are rare. Because of the dominance of glauconite the clay in what follows has been called *Glauconite Clay*.

As a rule its colour makes it very conspicuous, but in a moist state it may in some places be so dark that the greenish tint can be overlooked at a fleeting glance. After washing with a 0.1 mm. screen residues are obtained which practically consist of grains of glauconite only (cf. fig. 5). These wash residues are considerably bigger as related to those of Hodde Clay and Gram Clay.

Minor parts of clay particularly rich in glauconite may occur in Gram Clay, but never as a real bed. The Glauconite Clay, on the other hand, forms a through-going zone, which is always found between Hodde Clay and Gram Clay in Denmark. Genetically it seems best to consider it the basal layer of the Gram Clay. The very few fossils known from the Glauconite Clay do not go against this.

Gram Clay

The appearance of Gram Clay has previously been described (Rasmussen 1956, p. 16). In this place it is only to be repeated that it is dark grey with a slightly brownish or very slightly greenish tint. The contents of mica are comparatively high in the late parts, but otherwise it contains comparatively few mica flakes. After washing by means of a 0.1 mm. screen residues are obtained which mainly consist of greyish green micro-ellipsoids (cf. figs. 3 and 4). These small bodies have not been examined in detail. Apparently they consist of clay, often perhaps in part of glauconite as well. Wetzel (1931) has interpreted them as coprolites. Furthermore, there is some pyrite, mostly in the shape of small

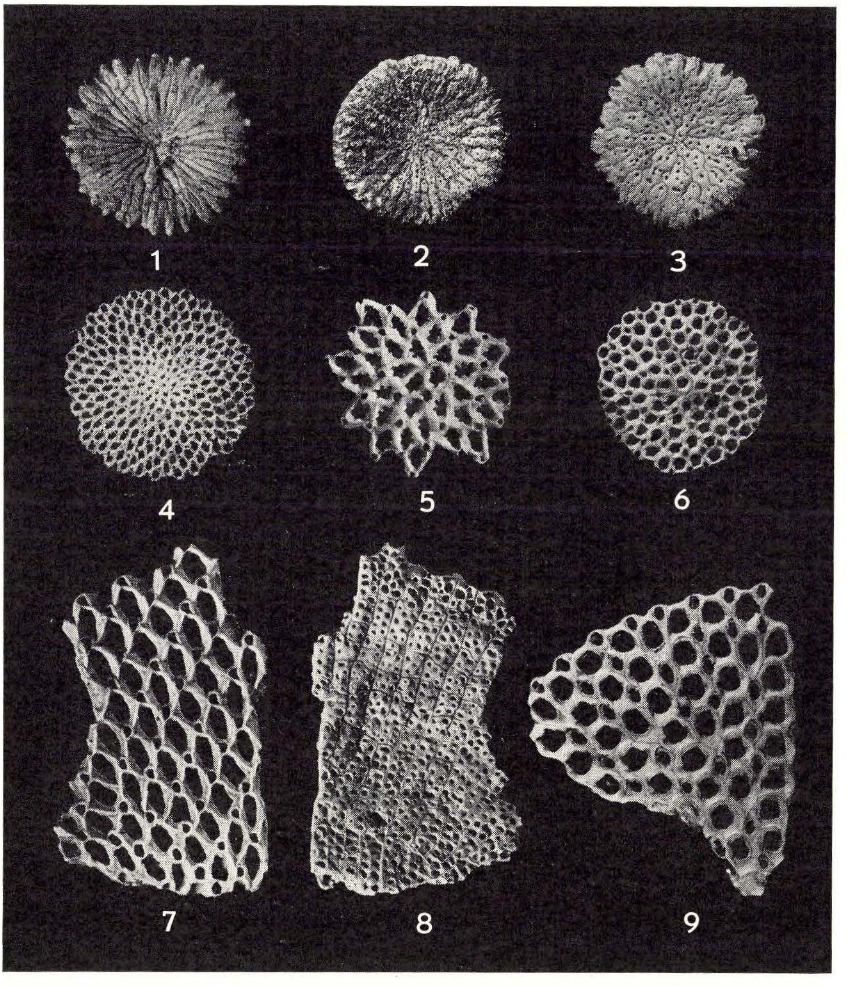

Fig. 7. Lunulitiform bryozoa from the Gram Clay in the clay pit of the brick-works of Gram.

Nos. 1, 4, and 7: *Cupuladria haidingeri* (REUSS).
Nos. 2, 5, and 8: *Cupuladria canariensis* (BUSK).
Nos. 3, 6, and 9: *Lunulites* sp.
No. 1: Upper side of zoarium $\times 4\frac{1}{2}$
No. 2: Upper side of zoarium $\times 4$
No. 3: Upper side of zoarium $\times 5$
No. 4: Under side of zoarium $\times 4\frac{1}{2}$
No. 5: Under side of zoarium $\times 10$
No. 6: Under side of zoarium $\times 5$
No. 7: Fragment of under side of zoarium $\times 10$
No. 8: Fragment of upper side of zoarium $\times 10$
No. 9: Fragment of under side of zoarium $\times 10$.

Phot. Chr. Westergaard

stems or "needles." A few grains of glauconite are also seen, but otherwise there are a great many residues of organisms: foraminifera, mollusca, ostracoda, echinoidea, otolites, etc.

Among the most remarkable fossils in the wash residues are complete zoaria or, mostly, fragments of zoaria of lunulitiform bryozoa. Three species are common: *Cupuladria haidingeri* (Reuss), *C. canariensis* (Busk), and *Lunulites* sp., which are all well-known from the Miocene and Pliocene of Holland (cf. Rasmussen 1963). The species have been described and pictured by R. Lagaaij (1952, 1953) and are furthermore pictured here in fig. 7. Especially the two *Cupuladria* species are very common in the Gram Clay.

In its typical form the Gram Clay is easily distinguished from other kinds of clay, both in a washed and an unwashed condition. The lower parts of the Gram Clay are in several places (Gram, Drantum, etc.) brownish and full of brownish grains which presumably are reworked and partly replaced glauconite. The upper parts contain silt (Gram, Brande, etc.).

In its lower parts at Gram, Måde, and several other localities the Gram Clay contains two horizons of concretions of clay-ironstone. Furthermore, there are in various places in the clay isolated calcareous concretions, around remnants of animals containing $CaCO_3$: snails, crabs, etc. (so-called "crab-balls").

The brownish clay containing silt and mica previously (Rasmussen 1958, p. 5, and 1961, p. 38) termed Sæd Clay and found in borings at the customhouse of Sæd (D.G.U. File No. 167. 4 a and 167.445) has proved to be Gram Clay (cf. the description of the locality at Sæd p. 173), but contains more silt. At the former boring pieces of oolitic siderite was found, which perhaps occurs as lumps in the clay. This is overlain by micaceous clay frequently alternating with micaceous silt which reminds of the sediments above the Upper Miocene "Glimmerton" (Mica Clay) at Morsum in Sylt (cf. Staesche 1930, pp. 62–63). But because of the absence of determinable fossils, it was not possible to verify this view. I am, however, convinced that the uppermost part of the Tertiary beds at Sæd are later than the other Miocene strata found in Denmark and perhaps even date from Pliocene time (cf. the discussion in the stratigraphical part).

Distribution of Gram Clay

Gram Clay has been observed in a large number of localities in Central, Western, and Southern Jutland. They are apparently grouped within the following five fairly well-defined regions (cf. maps in figs. 8 and 9, p. 20 and 24):

I. A triangular area with the towns of Vemb, Bording, and Ringkøbing as extremes: *the Vemb-Bording-Ringkøbing area.*

II. An area oriented around the line of Høgild, Brande, Give: *the Høgild-Brande-Give area.*

III. Another area oriented NW–SE, around the line of Skern, Ølgod, Ansager: *the Skern-Ølgod-Ansager area.*

IV. *The Esbjerg region.*

V. *Western North Slesvig.*

Localities with Gram Clay are unknown outside these regions.

The area between Regions II and III have by the Raw Material Department of D.G.U. been drilled so intensively at the systematic search for lignite, that areas of Gram Clay of only a fair extent can be excluded with certainty.

The area between Regions III and IV + V is but little known from borings, so its delimitation is uncertain.

The same applies to the area along the west coast of Jutland from Ringkøbing Fjord to Skallingen, whereas the area between Nissum Fjord and Ringkøbing Fjord is fairly well-known, thanks to an interested and careful driller ANDERS TRABJERG of Ulfborg, from whom D.G.U. has received numerous logs and samples. This material shows that Younger Miocene strata occur immediately below the Quaternary deposits in the area, while Gram Clay apparently is missing.

North of Region I, between Bording and Give and east of Region V there is a possibility of findings of further occurrences of Gram Clay, but for the present

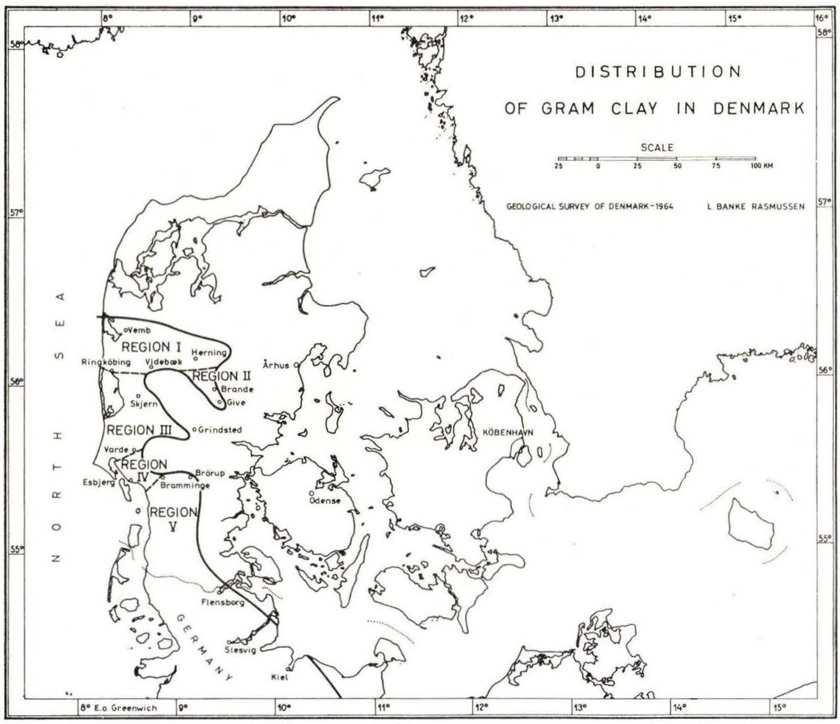

Fig. 8.

conditions suggest that the occurrence of Gram Clay is restricted to the abovementioned regions and the areas west of them.

At present it is not possible to decide whether Gram Clay was deposited in the areas between Regions II and III and between III and IV + V or not. There is a possibility that it was once present and then was removed during the Quaternary Period. At any rate conditions in the area between Regions II and III show that it is structurally higher than these regions. This is in agreement with the situation of the area above the great Ringkøbing-Funen High (see SORGENFREI & BUCH 1964).

DESCRIPTION OF LOCALITIES

Method

Below, each locality from which molluscs are available is described. The localities have been arranged by regions and for each of them the following conditions have been mentioned:

(1) Situation.
(2) Ground level.
(3) Description of outcrops or drilled sections (borehole logs).
(4) Level of the surface of the Miocene.
(5) Horizons or intervals of depths from which molluscs are available.
(6) Descriptions of the samples of clay from which molluscs have been sorted out.
(7) Remarks.

Each of these seven points is commented on as follows:

1. *Situation*: For each locality the situation is adduced in relation to characteristic buildings or to rivers, major roads, or the like.

All borings are denoted by their number in the Well Record Department of Danmarks Geologiske Undersøgelse (abbreviated D.G.U.). The number comprises two figures: (1) the number of the map-sheet on the scale of 1:40,000 on which the boring was made, and (2) the number of the borehole within the map-sheet, e.g. D.G.U. File No. 141.277.

In some cases, especially in the palaeontological and biostratigraphical part, only the locality and the number of the boring are indicated without a preceding "D.G.U. File No.", which, of course, is understood, e.g. Gram. 141.277.

The information that the locality consists of a borehole, and its file number, has often been indicated direct under the designation of locality, which, as a rule, is the headline. In the case of several boreholes situated close together, these may, however, be ranged under the same designation of locality.

Each locality is marked on a segment of the maps of the Geodetic Institute on the scale of 1:20,000, which is provided with the letter M and a number. Example: M 3606.

In a few cases the segment of the map has been taken from the new 4 cm. map of the Geodetic Institute on the scale of 1:25,000. These maps are denoted by a number in Arabic numerals, a number in Roman numerals, and one of the points of the compass NW, SW, NE, or SE. Example: 1113 I SW.

In every case reference is made to the figure in the text in which the map segment is rendered. The information about the numbers on the map-sheets on which the locality in question is indicated, must be sought in the respective explanations of figures.

2. *Ground level*: All ground levels have been read on the maps if nothing else has been indicated, and therefore are stated in whole metres, only. As there is some uncertainty, which may amount to 1 m., or sometimes a little more, "about" is placed before each figure.

3. *Description or borehole logs*: The logs of the borings are often somewhat shortened in the case of the Quaternary beds.

The Miocene strata have been indicated on the basis of the available information at D.G.U., often supplemented by my own description after another inspection of the samples. The information is of different value according as samples of the beds in question are available.

When an interval in a borehole log has been described as Gram Clay or Hodde Clay without any addition, this is due to the fact that the layer in the interval in question has the appearance typical of the species of clay concerned. If a species of clay has been denoted as Mica Clay without Gram Clay or Hodde Clay being added in parenthesis, this is because it has not been possible to decide the particular character of this Mica Clay with certainty for want of drilling samples.

As to a number of data, e.g. driller, drilling diameter, position of casing, etc., reference is made to the reports in the files of D.G.U.

It has often been difficult in the early descriptions of samples in the files of D.G.U. to see what geologist made the description, as he in many cases did not indicate his name on the report. As in most cases I have made certain alterations after seeing the samples, I have found that I ought myself to take the responsibility for the logs published in the present work if nothing else is indicated.

In many cases I am, however, indebted to the unnamed geologist who first described the samples.

4. *Level of the surface of the Miocene*: The elevation at which the upper edge of the uppermost Miocene layer of a section is found, is indicated as level of the surface of the Miocene. As it is mostly cases of more or less glacially disturbed Miocene layers, this elevation thus is not expressive of the proper

conditions of height of the Miocene strata if these are supposed to have been without the influence of an inland ice.

The elevation figures, however, are of value in the respect that one gets an impression of the present conditions of height of the beds without regard to cause. Hence, in many cases it will be possible approximately to judge the primary levels if a certain number of observation points available are gathered in one area.

5. *Horizons or intervals of depths from which molluscs are available*: Here only the horizons or intervals of depths are indicated from which molluscs mentioned in the paper are available, while e.g. the molluscs which might be found in horizons deeply below the Younger Miocene clay series in the same boring have not been considered.

6. *Description of the samples containing fossils*: In the case of each sample examined are indicated its weight and the weight of the wash residue after washing with a screen having a size of meshes of 0.1 mm. In several cases, however, the sample was not weighed, and furthermore some large samples were washed with a 0.5 mm. screen. This was due to the fact that several samples were washed before the present investigations were started.

The descriptions themselves mostly include the wash residues only. Furthermore they offer some information about possible contaminations of the samples.

7. *Remarks*: At the end of each description of a locality various comments are given as explanations of certain special conditions or as supplements of what has previously been stated.

The purpose of the descriptions of localities is not that of giving an exhaustive mention of all the localities found in Denmark, but only to give a thorough basis of the stratigraphical and regional appearance of the fossils examined.

Most localities have not previously been mentioned in the literature.

Region I

The Vemb – Bording – Ringkøbing Area

The localities within this region are mainly grouped in minor, compact areas. Outside these there are isolated localities at Skærum Mølle, Lillelund, Vinding, and Aulum, which may be comprised under the designation of "The northernmost localities." The region therefore can be divided into the following five subsections:

1. The northernmost localities.
2. The Ørnhøj – Spjald – Videbæk area.
3. The Vildbjerg area.
4. The Sunds – Herning area.
5. The Bording area.

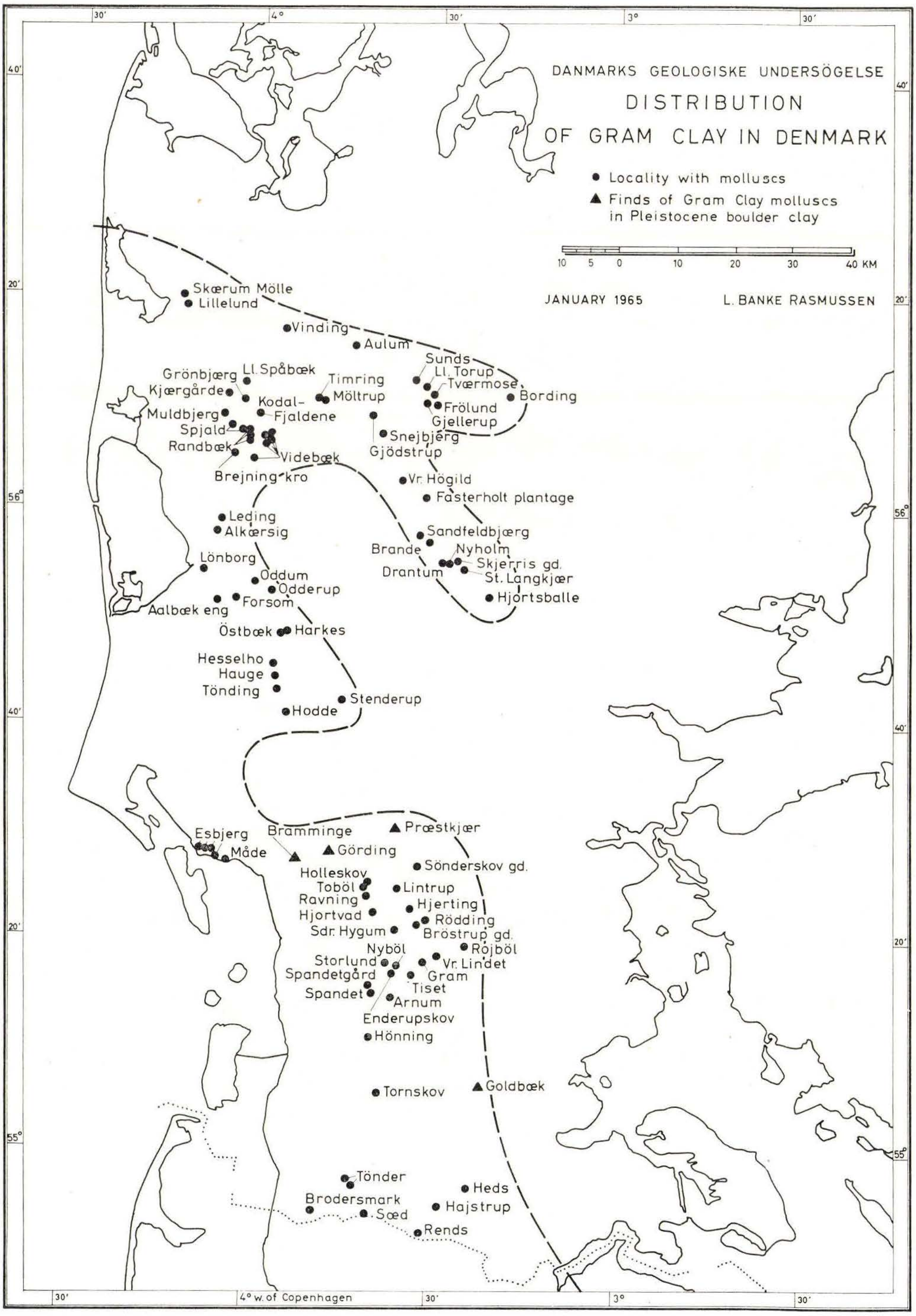
DANMARKS GEOLOGISKE UNDERSÖGELSE
DISTRIBUTION
OF GRAM CLAY IN DENMARK
Locality with molluscs
Finds of Gram Clay molluscs in Pleistocene boulder clay
10 5 0 10 20 30 40 KM
JANUARY 1965
L. BANKE RASMUSSEN
Skærum Mölle
Lillelund
Vinding
Aulum
Sunds
Ll. Torup
Tværmose
Bording
Frölund
Gjellerup
Grönbjærg
Ll. Spåbæk
Kjærgårde
Kodal-
Fjaldene
Timring
Möltrup
Muldbjerg
Spjald
Randbæk
Videbæk
Snejbjerg
Gjödstrup
Brejning kro
Vr. Högild
Fasterholt plantage
Leding
Alkærsig
Sandfeldbjærg
Brande
Nyholm
Skjerris gd.
Drantum
St. Langkjær
Hjortsballe
Lönborg
Oddum
Odderup
Forsom
Aalbæk eng
Östbæk
Harkes
Hesselho
Hauge
Tönding
Stenderup
Hodde
Esbjerg
Måde
Bramminge
Præstkjær
Görding
Sönderskov gd.
Holleskov
Toböl
Ravning
Hjortvad
Sdr. Hygum
Lintrup
Hjerting
Rödding
Bröstrup gd.
Röjböl
Nyböl
Storlund
Spandetgård
Spandet
Vr. Lindet
Gram
Tiset
Arnum
Enderupskov
Hönning
Tornskov
Goldbæk
Tönder
Brodersmark
Sæd
Heds
Hajstrup
Rends
40'
20'
56°
55°
30'
4°
3°
4° w. of Copenhagen

Fig. 9.

1. The Northernmost Localities

The locality of Gram Clay most northerly situated among those known at present is found at Skærum Mølle immediately south of Vemb. This locality is the only outcrop among the four mentioned above. The other three are boreholes.

Skærum Mølle

Situation: Pit of brickworks 1.5 km. SSE of the church of Vemb and 1.9 km. ENE of the manor Nørre Vosborg, close to the river Lilleå. Fig. 10.

Ground level: about + 5 m.

Sequence of strata: The pit of the brickworks, which is situated about 500 m. SE of the brickworks, during my three visits on 19/6 1944, 10/8 1956, and 6/5 1962 was full of water and the digging of clay had been stopped. Therefore it has not been possible to make observations of the sequence. In the slopes of the pit only typical Gram Clay was seen, which in the river valley itself is overlain by postglacial freshwater peat and mud and in the slope of the valley towards the west covered by meltwater sand, which in places contains spaces of fine-grained, yellowish Mica Sand.

The locality was already mentioned by FORCHHAMMER (1842) under the designation of "Nørre Vosborg", later by RAVN (1897, p. 14, and 1907, p. 231 (27)), NORDMANN (1905, p. 18) and H. WINGE (1910, p. 2). The latter two authors mentioned the locality as a finding-place for bones of whales, thus teeth of the extinct whale *Hoplocetus curvidens* GERVAIS. NORDMANN furthermore mentioned the finding of a humerus of a seal.

Level of the surface of the Miocene: about + 3.5 m.

Remarks: To illustrate the situation and character of the Tertiary beds in the neighbourhood of the brickworks there are only a few boreholes.

(1) Borehole near the dairy of Skærum, D.G.U. File No. 73.7c, 400 m. NW of the pit of the brickworks, with the following section according to the log of the driller (A. TRABJERG, Ulfborg) and the samples kept at D.G.U.:

Ground level: about + 3 m.

0.0– 2.0 m.	Rubbish
2.0– 8.0 –	Sand, grey, contaminated with clay
8.0–15.7 –	Sand, fine, with "lignite wood"
15.7–15.9 –	Lignite
15.9–20.6 –	Quartz sand, fine, with lignite
20.6–23.9 –	Mica Clay, sandy, with quartz gravel
23.9–30.0 –	Quartz sand
30.0– –	Mica Clay, sandy.

(2) Two boreholes near the house of the owner of the brickworks, D.G.U. File No. 73.149 a and b, about 150 m. west of borehole No. 73.7c, stopped at depths of 5.9 m. and 4.0 m.,

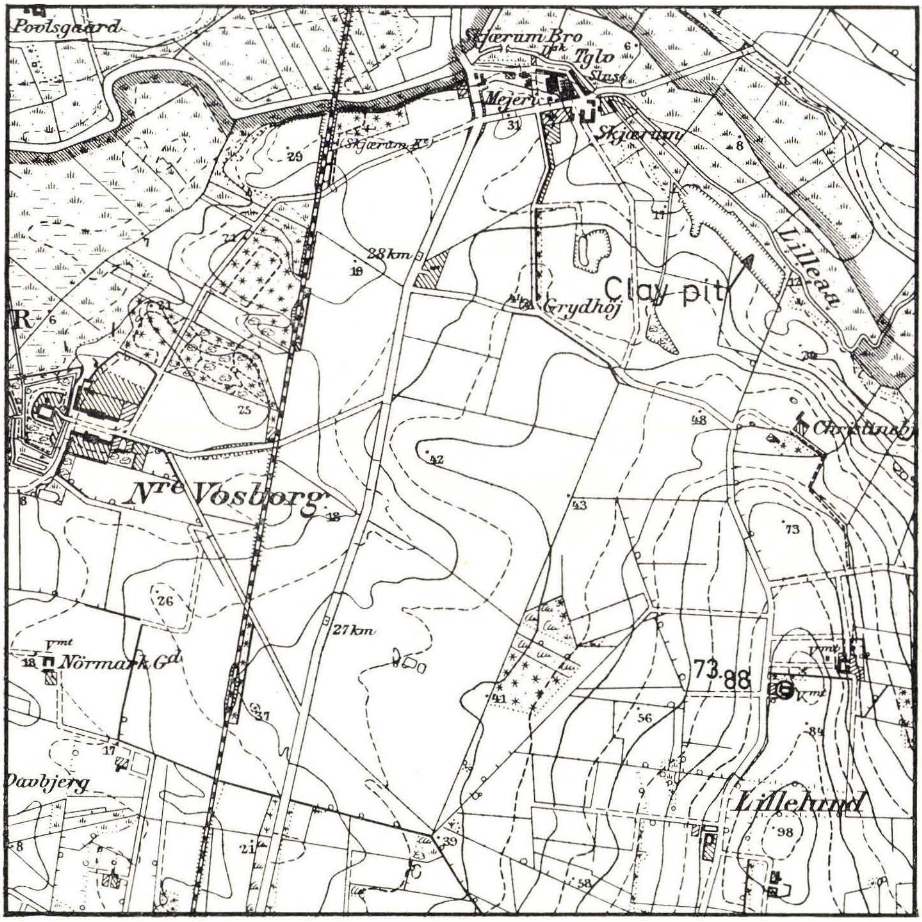

Fig. 10. Situation of the clay pit at Skærum Mølle and borehole, D.G.U. File No. 73.88 at Lillelund. (Segment of M 2202 on the scale of 1:20,000).

respectively, without penetrating the Quaternary strata, which in the case of the former boring consisted of Quaternary meltwater sand and in the latter of Quaternary clay (boulder clay?).

(3) An earlier borehole near the mill, mentioned in RAVN 1907, p. 231 (27), according to oral information from the owner of the brickworks (VILLEMOËS) penetrated into sand overlain by 15 m. clay. The character of these beds is not known in detail.

The borings suggest that the surface of the Miocene near the brickworks is at an elevation of about — 12.5 m. The Quaternary erosion in this place seems to have penetrated below the Hodde Formation. A more exact stratigraphical placing of the Miocene strata in the boring has not been possible, but it is probable that the beds denoted as "lignite" and "quartz sand" belong in the Odderup Formation.

Molluscs occur in the form of collections from the Gram Clay by various visiting geologists.

In the collection of D.G.U. there is material collected by V. MADSEN (without indication of date of collection), EIGIL HANSEN (29/4 1911 and 18–20/5 1911), H. ØDUM (18/11 1950), and a small collection without statement of collector (perhaps P. HARDER).

I have myself only been able to collect fossils in dug-out Gram Clay found near the clay pit. Faunal analysis, see Table 15, p. 228.

Lillelund

Borehole at NIELS ØSTERGAARD's farm made in 1937.
D.G.U. File No. 73.88.

Situation: 2.1 km. ESE of Nørre Vosborg, 2.6 km. NNE of the church of Ulfborg and 1.7 km. SE of Skærum Mølle. Fig. 10.

Ground level: about + 26 m.

Borehole log:

0.0– 0.2 m.	Rubbish
0.2–13.0 –	Meltwater sand, somewhat argillaceous, yellowish
13.0–15.1 –	Boulder clay, sandy, yellowish
15.1–26.0 –	Meltwater sand, brownish, with some gravel
26.0–28.5 –	Meltwater sand, argillaceous, greyish, with some gravel
28.5–62.0 –	Gram Clay, fossiliferous
62.0–69.5 –	Mica Clay, dark grey-black, carboniferous, containing glauconite, fossiliferous (the sample from this section seems to be heterogeneous; see description below).
69.5–70.5 –	Lignite with fragments of wood
70.5–76.3 –	Quartz sand, medium grained-coarse, grey, with graines of up to one or two mm. in diameter.

Level of the surface of the Miocene: about — 2.5 m.

Molluscs available from 28.5–49.5 m., 49.5–62.0 m., and 62.0–69.5 m. (not analyzed). Faunal analysis, see Table 16, p. 229.

Description of the fossiliferous samples:

28.5–49.5 m.
49.5–62.0 m. } Gram Clay, typical, the wash residues of which contain stems of pyrite and many fragments of lunulitiform bryozoa and of molluscs.

62.0–69.5 m. Hodde Clay contaminated with Gram Clay. The wash residues mainly consist of small particles of black clay and numerous fragments of yellowish brown concretions. Furthermore, there are numerous grains of quartz and glauconite, many foraminifera and stems of pyrite, besides some fragments of shells, spines of spatangids and fragments of *Cupuladria*.

Remarks: The samples are much contaminated, as they are ditch samples.

Vinding

Borehole at the Røjkjær farm made in 1961.
D.G.U. File No. 74.329.

Situation: 2.0 km. NW of the church of Vinding. Fig. 11.

Ground level: about + 53 m.

Borehole log: Badly elucidated. The driller only sent three samples from the boring, taken at the following depths: 17 m., 21 m., and 76 m. The sample from 17 m. consists of meltwater clay with silt and of a greenish grey colour. From the depth of 21 m. there is a sample of dark greenish grey-black, sandy, bedded clay containing mica and glauconite (in partly weathered grains).

Of greatest interest, however, is the sample from a depth of 76 m., which consists of black and greenish sticky Mica Clay with fossils. According to the driller's statement this bed starts at a depth of 55 m. The wash residue consists of micro-ellipsoids and some stems of pyrite. Among fossils there are numerous

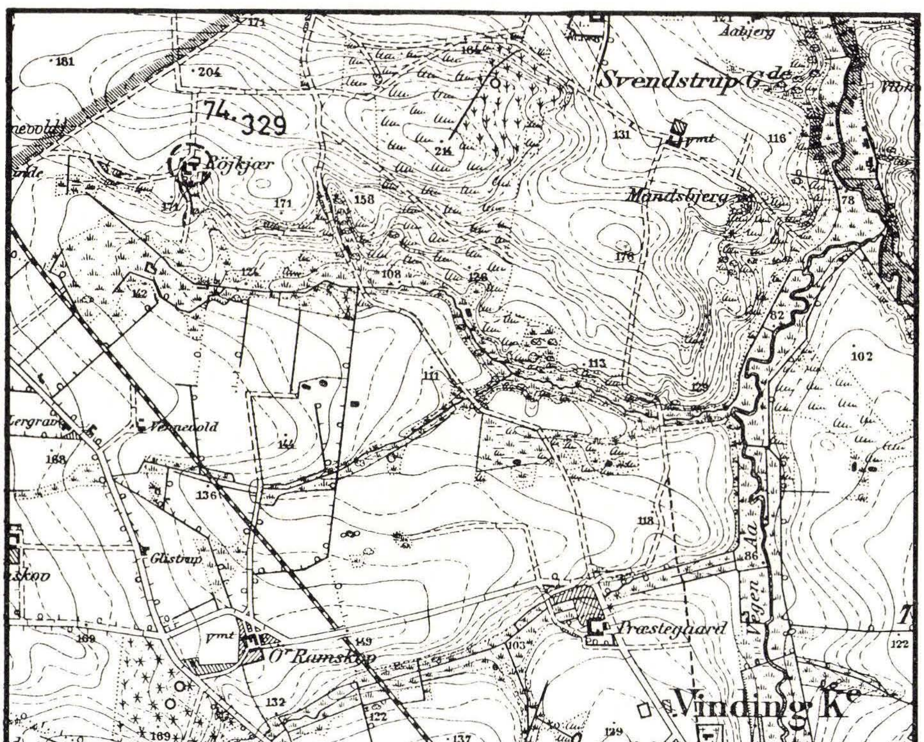

Fig. 11. Situation of borehole, D.G.U. File No. 74.329, at Vinding.
(Segment of M 2204 on the scale of 1:20,000).

foraminifera and some fragments of shells, furthermore a few spines of spatangids and fragments of *Cupuladria*. Under all conditions this Mica Clay has a very close similarity to Gram Clay.

Level of the surface of the Miocene: about — 2 m.?

Molluscs were found in the sample from 76 m., but only as small fragments. Faunal analysis, see Table 17, p. 229.

Description of the fossiliferous sample: see above.

Aulum

Borehole made by D.G.U. in 1961.
D.G.U. File No. 74.321.

Situation: 2.2 km. ESE of the church of Aulum and 1.2 km. NW of the plantation of Ørre. Fig. 12.

Ground level: about + 42 m.

Borehole log:

0.0– 6.4 m. Boulder clay, at the top mainly sand
6.4– 7.4 – Gram Clay, highly contaminated
7.4– 8.4 – Gram Clay, pure
8.4–11.4 – Gram Clay, highly contaminated
11.4–17.4 – Gram Clay, pure
17.4–19.2 – Gram Clay, highly contaminated
19.2–19.4 – Quartz sand or meltwater sand, with lumps of clay, impure (hardly Tertiary).

Molluscs are available in the shape of fragments from the following dephts: 9.4–10.4 m., 10.4–11.4 m., 11.4–12.4 m., 12.4–13.4 m., and 13.4–14.4 m. Faunal analysis, see Table 17, p. 229.

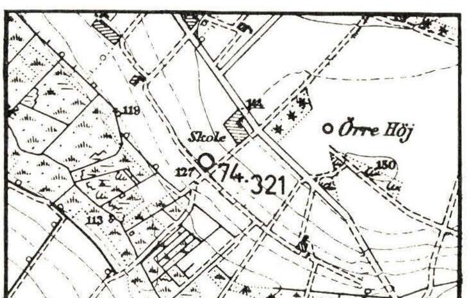

Fig. 12. Situation of borehole, D.G.U. File No. 74.321, at Aulum. (Segment of M 2305 on the scale of 1:20,000).

Description of the fossiliferous samples:

9.4–14.4 m. Gram Clay; the wash residues contain the micro-ellipsoids, stems of pyrite, foraminifera, fragments of *Cupuladria haidingeri*, and molluscs characteristic of this clay, besides a few otolites, fish teeth, etc. Furthermore, there are in the samples from 9.4–11.4 m. some grains of sand, mainly quartz, but also felspar.

Remarks: The Miocene beds in this boring cannot be in situ. The whole sequence of strata seems to be either included in a glacial floe of Gram Clay embedded in the moraine, or Gram Clay squeezed upwards and surrounded by boulder clay.

2. The Ørnhøj – Spjald – Videbæk Area

A compact area of rather a great extent, in which Gram Clay has been found in a large number of the boreholes made by the Raw Material Department of D.G.U. for lignite, occurs from Ørnhøj in the north to Spjald and Videbæk in the south.

Fossiliferous Gram Clay has been found in 49 boreholes and in two outcrops, one of which is a lignite pit, the other a clay pit of a brickworks.

In order to get a general idea of the large number of single localities it has been necessary to divide the area into four groups, each of which is indicated on its map.

These map-sheets have the numbers M 2403, M 2404, M 2503, and M 2504.

M 2403

On the area of this map-sheet fossiliferous Gram Clay has been found in about eight boreholes and in two outcrops. The localities are mainly grouped in two areas, viz. in the region Grønbjærg – Kjærgårde – Spåbæk, and in the region NW of the railway village of Spjald, between this village and Muldbjerg.

Lille Spåbæk

The locality consists of a lignite pit now abandoned.

Situation: 1.8 km. WSW of the church of Ørnhøj and 2.5 km. NE of the church of Nørre Omme. Fig. 13.

Ground level: about + 57 — + 60 m.

Description: Our knowledge of the locality exclusively originates from PETER INGWERSEN, Cand. Mag., who has kindly placed his notes and collections of fossils at my disposal.

Lignite has been excavated in at least two pits at Lille Spåbæk, but as far as is known, the marine Younger Miocene clay series has only been shown to occur in the easternmost of the pits. This lignite pit has changed shapes as the excava-

Fig. 13. Situation of lignite pit at Lille Spåbæk (Spaabæk) and clay pits near the brickworks of Grønbjerg, and a borehole NW of Kjærgårde: D.G.U. File No. 83.210. (Segment of M. 2403, reduced to a scale of 1:40,000).

tion proceeded, and at the time of INGWERSEN's investigations (29th–30th August and 1st–2nd October 1958) was of an oblong, rather narrow, curved shape.

The greater number of the beds above the lignites consisted of quartz sand, overlain by quartz gravel. In the northeastern part of the pit INGWERSEN observed a depressed space with quartz gravel overlain by Hodde Clay, above which there was Glauconite Clay, and at the top Gram Clay in concordant superposition, but with many faults.

The full succession based on INGWERSEN's notes is seen in the table p. 32.

Level of the surface of the Miocene: about + 54 — + 57 m.

Molluscs have been collected by INGWERSEN in the Gram Clay, mainly in the beds about one metre above the Glauconite Clay. Faunal analysis, see Table 18, p. 230.

	Sediment:	Thickness:
At the top:	Sand and clay, in part dark in colour (Quaternary) . . .	About 3 m.
	Clay, dark grey, fossiliferous (Gram Clay)	About 6–7 m.
	Clay, dark greenish, gritty (Glauconite Clay)	0.5–0.7 m.
	Clay, black – blackish brown, partly fractured, at the bottom perhaps with a bed of silt (Hodde Clay)	1.5–2 m.
	Quartz gravel, resting discordantly on quartz sand and underlying the Hodde Clay with a somewhat uneven limit; grain size in part of more than 1 cm. in diameter	0.10–0.25 m.
	Quartz sand, medium grained-fine, light, with cross-bedding	3–5 m.
	Lignite, here and there with upright stumps of trees . .	About 1 m.
	Mica Clay, in places replaced by more or less fine-grained sand	Rising from a few cm. in the NE to about 0.75 m. in SW
	Lignite	About 0.5 m.

Grønbjærg

The locality includes three clay pits.

Situation: The brickworks of Grønbjærg is situated 800 m. east of the church of Nørre Omme, 400 m. south of the railway station of Grønbjærg and 700 m. west of the hill-top Grønbjærg. The clay pits are situated south and southeast of the buildings. Fig. 13.

Ground level: about + 54 m.

Description: The first information about the existence of the locality is due to a communication to the D.G.U. (in letter of the 1st of December 1957) from Assistant Chief Constable ERIK WESTERBY, Ringkøbing, who at the same time forwarded some mollusc shells and the tooth of a shark. Besides these fossils Mr. WESTERBY found some bones of whales, which he sent to the Zoological Museum in Copenhagen.

On the fifth and sixth of May 1962 I visited the brickworks of Grønbjærg and found three clay pits. The oldest one is situated immediately SE of the buildings, but was water-logged. A younger one was dug immediately south of the buildings and extended several hundred metres southwards. This pit, too, was mainly water-logged. In the southern part of the pit, however, there were a few accessible places where there were Gram Clay, dark green Glauconite Clay, and Hodde Clay. The latter two types of clay were seen in the southernmost part of the pit, whereas Gram Clay could be traced on most of the southern half of the west wall. However, no fresh sections were found, and the only fossil found was a single tooth of a shark.

The youngest clay pit, which is only a few metres deep, is situated about 500 m. SE of the buildings and must have been dug about 1961. In the about 300 m. long digging section we found only Gram Clay without fossils under 1.5 m. of meltwater sand. A sample of the Gram Clay brought home and washed contained only three pyrite casts of *Spiratella atlanta* (MØRCH), but several pyrite casts of larger shells of foraminifera. A dominant feature in the wash residue was ellipsoidal grains of a greyish green colour and numerous pyrite stems.

Position of strata: Because of the partial inaccessibility of the two older clay pits it was not possible to clear up the position of strata, but the three abovementioned types of clay obviously had been carried out of their original position, presumably as a consequence of glacial action.

Level of the surface of the Miocene: about + 52 m.

Molluscs are available partly as collected in a loose state by ERIK WESTERBY at the bottom of the clay pit south of the buildings, partly collected by me from a heap of dug-up Gram Clay found on the ground beside the brickworks. Faunal analysis, see Table 18, p. 230.

Boreholes

1. *Kjærgårde. Borehole D.G.U. File No. 83.210.* Made by D.G.U. in 1944.

Situation: 1.2 km. NW of Kjærgårde, 3.2 km. NW of the church of Nørre Omme and 4.2 km. ESE of the church of Thorsted. Fig. 13.

Ground level: about + 33 m.

Borehole log:

0.0– 2.0 m. Sand with stones
2.0– 3.0 – Clay, grey (Quaternary)
3.0–15.0 – Gram Clay, perhaps reworked.

Level of the surface of the Miocene: about + 30 m.

Fragments of molluscs in a small number are available from a single sample from 3.0–15.0 m. Faunal analysis, see Table 19, p. 230.

Description of the fossiliferous sample. Gram Clay which seems to contain small lumps of dark clay. The wash residue is completely dominated by small grains of quartz and brown grains with a contamination of dark grains of glauconite. Few disintegrated fragments of *Cupuladria haidingeri* and molluscs. The clay seems to have been reworked.

2. *Muldbjerg. Borehole D.G.U. File No. 83.377.* Made by D.G.U. in 1944.

Situation: 600 m. SSE of the railway station of Muldbjerg, close to the Hover river. Fig. 14.

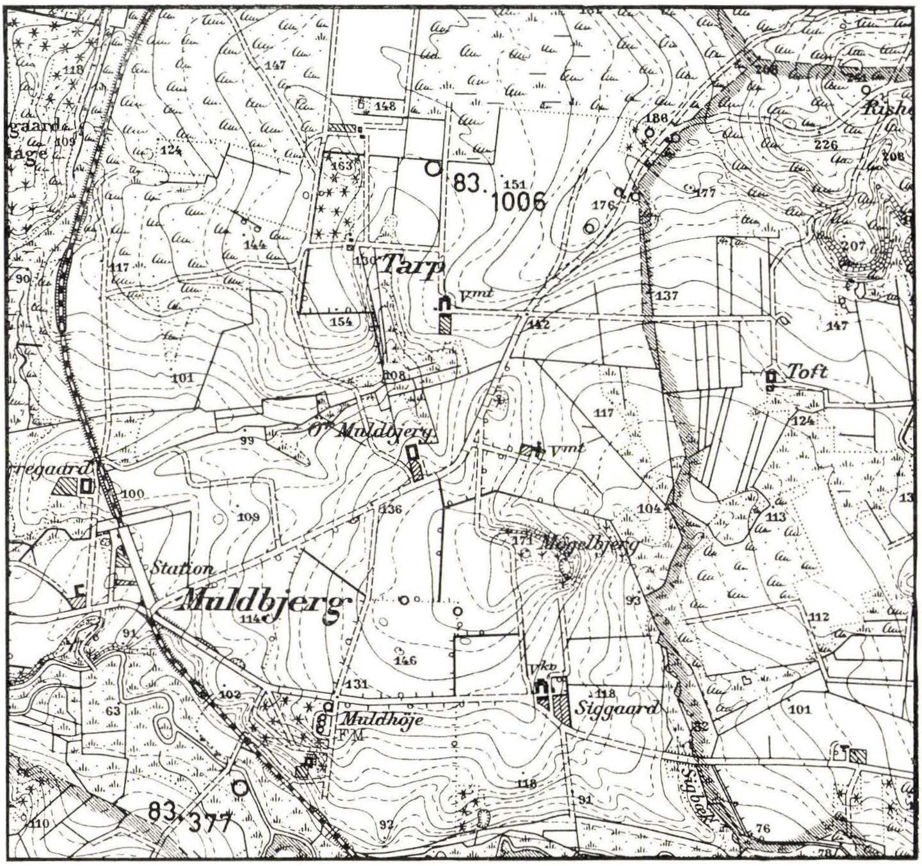

Fig. 14. Situation of boreholes around Muldbjerg: D.G.U. File Nos. 83.377 and 83.1006. (Segment of M 2403 on the scale of 1:20,000).

Ground level: about + 20 m.

Borehole log:

0.0– 0.6 m. Peat mud
0.6– 2.2 – Clay, yellowish, stony
2.2–13.6 – Mica Clay
13.6–15.0 – Gram Clay, fossiliferous.

Level of the surface of the Miocene: about + 18 m.

Molluscs are available in a small number from a single sample from 13.6–15.0 m. Faunal analysis, see Table 19, p. 230.

Description of the fossiliferous sample: Gram Clay, the wash residue of which mainly consists of disintegrated, dark brown grains. Some pyrite. Fragments of *Cupuladria* and molluscs, all somewhat disintegrated.

3. Muldbjerg. Borehole D.G.U. File No. 83.1006. Made by the D.G.U. in 1961.

Situation: 1.4 km. NE of the railway station of Muldbjerg, 3.2 km. SW of the church of Nørre Omme and 4.6 km. ENE of the church of Hover. Fig. 14.

Ground level: about + 45 m.

Borehole log:

0.0– 2.0 m.	Glacio-fluvial sand, fine, yellowish
2.0– 4.0 –	Clay, greyish brown (perhaps Quaternary)
4.0–10.0 –	Gram Clay, in lower part with a concretion bed
10.0–12.0 –	Glauconite Clay
12.0–16.2 –	Hodde Clay, in lower part a little silty
16.2–30.0 –	Mica Silt with quartz gravel, grey.

Level of the surface of the Miocene: about + 41 m.

Molluscs are available from 5.0–6.0 m., 6.0–7.0 m., 7.0–8.0 m., 8.0–9.0 m., and 9.0–10.0 m. Faunal analysis, see Table 20, p. 231.

Description of the fossiliferous samples:

5.0–10.0 m. Gram Clay, typical. The samples washed by means of a screen with a width of meshes of 0.5 mm. Wash residues consisting mainly of pyrite stems and fragments of shells, as well as some fragments of *Cupuladria haidingeri.*

The sample from 9.0–10.0 m. contains numerous concretion fragments.

M 2404

Fossiliferous Gram Clay has been found in eight boreholes. From most of them only a single sample is available, even mostly weathered. Quantitatively valuable material of molluscs is available only from a single boring (File No. 84.1749). It is mentioned apart, whereas the other five boreholes from which material has been examined, are dealt with together. Fig. 15.

1. Kodal-Fjaldene. Borehole D.G.U. File No. 84.1749. Made by D.G.U. in 1961.

Situation: 4.3 km. SSE of the church of Ørnhøj, 3.4 km. west of the church of Tiphede and 300 m. SSE of the farm Hedegård – in the district Fjaldene. Fig. 15.

Ground level: about + 65 m.

Borehole log:

0.0– 0.2 m.	Mould, sandy
0.2– 4.4 –	Glacio-fluvial sand
4.4– 7.1 –	Moraine sand
7.1– 8.5 –	Glacio-fluvial sand
8.5–10.6 –	Boulder clay
10.6–14.6 –	Mica Clay, dark grey (Gram Clay)
14.6–23.6 –	Gram Clay

23.6–25.6 – Clay, greenish grey, glauconitic
25.6–30.0 – Mica Clay, greyish black, with silt and glauconite (Hodde Clay). (Final depth).

Level of the surface of the Miocene: about + 54 m.

Molluscs are available from the following depth intervals: 14.55–15.55 m., 15.55–16.55 m., 16.55–17.55 m., 17.55–18.55 m., 18.55–19.55 m., 19.55–20.55 m., 20.55–21.55 m., 21.55–22.55 m., and 22.55–23.55 m. Faunal analysis, see Table 21, p. 232.

Description of the fossiliferous samples: All the samples mentioned from which molluscs are available, consist of typical Gram Clay. The wash residue, besides micro-ellipsoids, contains numerous pyrite stems and some fragments of *Cupuladria* and molluscs. All the samples contain grains of quartz in considerable quantities, which may be due to contamination of the sample after its being taken. They have all been washed by means of a screen with a width of meshes of 0.5 mm.

2. *Five boreholes in the area of Kodal and in Fjaldene.* Made by D.G.U. in 1944. The situations appear from the map Fig. 15, p. 37.

D.G.U. File No.	Ground level	Quaternary beds at the following depths	Miocene beds		Level of the surface of the Miocene
			Depths	Sediment	
84.763	+55 m.	0.0–3.1 m.	3.1–13.7 m.	Gram Clay	+52 m.
			13.7–15.0 –	Mica Clay	
84.766	+55 –	0.0–0.7 –	0.7– 1.4 –	Clay, grey and yellow	+54 –
			1.4–11.0 –	Gram Clay	
84.770	+58 –	0.0–2.6 –	2.6– 9.3 –	Mica Clay, grey	+56 –
			9.3–15.0 –	Gram Clay, brownish	
84.233	+47 –	0.0–0.6 –	0.6–10.7 –	Gram Clay	+47 –
			10.7–11.8 –	Quartz sand, medium-grained	
			11.8–12.1 –	Lignite	
			12.1–14.5 –	Quartz sand, medium-grained, with coarser grains	
			14.5–15.0 –	Mica Clay	
84.238	+52 –	0.0–1.0 –	1.0–15.0 –	Gram Clay	+51 –

Molluscs are available only as fragments which have been found in all intervals denoted as Gram Clay in the boreholes mentioned. Faunal analysis, see Table 19, p. 230.

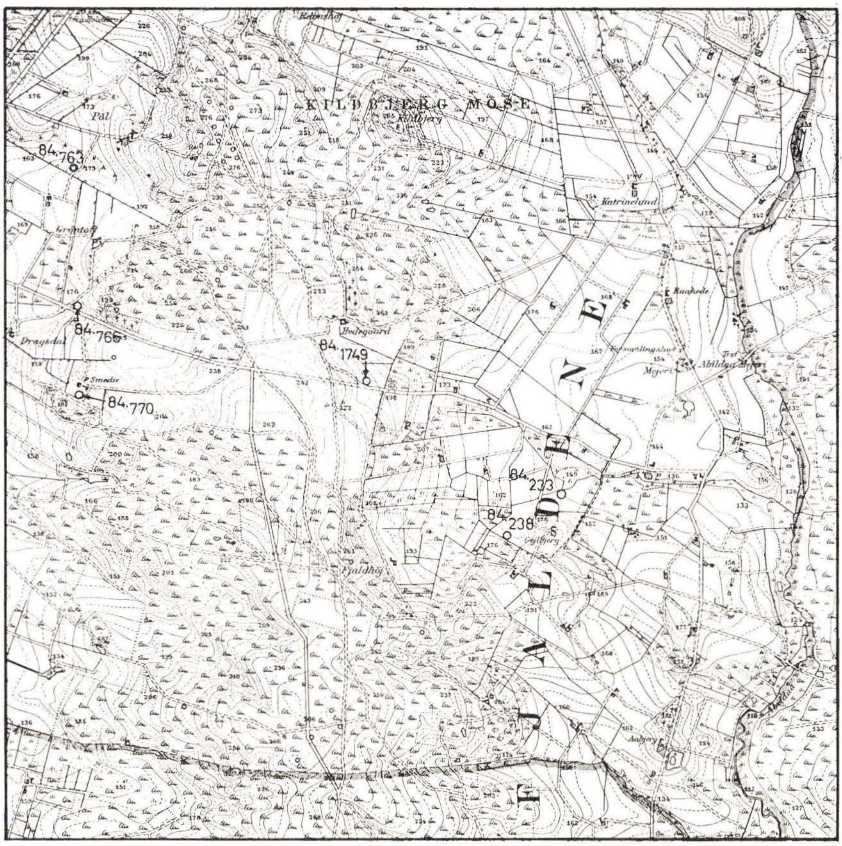

Fig. 15. Situation of boreholes in the area at Fjaldene: D.G.U. File Nos. 84.1749, 84.763, 84.766, 84.770, 84.233, and 84.238.
(Segment of M 2404, reduced to a scale of 1:40,000).

Description of the fossiliferous samples: All the samples of Gram Clay available have the appearance typical of this clay. After washing it appeared that nearly all samples had been weathered, which, however, may be due to their being stored for nearly 20 years. Furthermore they contain some grains of quartz and other contaminations. Therefore it is uncertain whether the deposits are in situ.

M 2503

On this map fossiliferous Gram Clay has been shown to occur in six boreholes, mainly grouped in the area east of the railway village of Spjald, while a single one is situated NW of this town, between Spjald and Muldbjerg, and another has been made at the inn of Brejning south of Brejning. Fig. 16.

Spjald

Two boreholes were made in 1944 by the D.G.U. near Spjald: (1) D.G.U. File No. 83.104 is situated 1.2 km. NW of the railway station of Spjald and (2) D.G.U. File No. 83.127 1 km. E of the station. Fig. 16.

D.G.U. File No.	83.104	83.127	Sediments
Ground level:	+29 m.	+31 m.	
Borehole logs:	0.0– 3.1 m.	0.0– 2.6 m.	Meltwater sand
	3.1–15.0 m.	2.6–15.0 m.	Gram Clay
Level of the Miocene:	+26 m.	+28 m.	

Molluscs are available from the Gram Clay intervals in both boreholes. Faunal analysis, see Table 19, p. 230.

Description of the fossiliferous samples:

Borehole 83.104. 3.1–15.0 m. Weight of sample: 76.47 grammes. Weight of wash residue: 5.99 grammes. Gram Clay, the wash residue of which consists of darkgreen glauconite grains. Some pyrite. Single grains of quartz. Some partly weathered fragments of shells. Foraminifera.

Borehole 83.127. 2.6–15.0 m. Weight of sample: 115.08 grammes. Weight of wash residue: 19.62 grammes of Gram Clay, the wash residue of which mainly consists of dark green or greenish black glauconite grains mixed with irregularly shaped brown grains. Some pyrite. Fragments of *Cupuladria haidingeri* and molluscs. Foraminifera. Otolites.

Randbæk

Three boreholes in the area between Randbæk and Vægerskilde, 3 km. east of the station village of Spjald, are situated as shown on the map fig. 16.

They were all made by the Lignite Department of the D.G.U. in 1944.

D.G.U. File No.	83.591	83.597	83.602	Sediments
Ground level:	+43 m.	+43 m.	+45 m.	
Borehole logs:	0.0– 3.8 m.	0.0– 2.1 m.	0.0– 1.6 m.	Glacio-fluvial sand, stony
	3.8–15.0 m.	2.1–15.0 m.	1.6–15.0 m.	Gram Clay
Level of the surface of the Miocene:	+39 m.	+41 m.	+43 m.	

Molluscs are available from the above-mentioned intervals with Gram Clay. Faunal analysis, see Table 19, p. 230.

Description of the fossiliferous samples:

Borehole 83.591. 3.8–15.0 m. Weight of sample: 233.15 grammes. Weight of wash residue: 9.19 grammes. Gram Clay, the wash residue of which is dominated by quartz grains. Small

Fig. 16. Situation of boreholes around Spjald and at Brejning Kro. D.G.U. File Nos. 83.104, 83.127, 83.591, 83.597, 83.602, and 83.197. (Segment of M 2503, reduced to a scale of 1:40,000).

pieces of flint. Pyrite. Fragments of *Cupuladria*. A few rolled and in part weathered fragments of molluscs.

Borehole 83.597. 2.1–15.0 m. Sample from this interval washed about 1944 at the branch of the D.G.U. at Videbæk. No new sample washed later. The washing made by means of a screen with a width of meshes of 0.5 mm. The wash residue preserved is somewhat weathered after being stored for 20 years. Contains much pyrite and many grains of sand as well as numerous brownish concretion pieces. Some fragments of shells.

Borehole 83.602. 1.6–15.0 m. Weight of sample: 123.28 grammes. Weight of wash residue: 3.45 grammes. Gram Clay, the wash residue of which mainly consists of micro-ellipsoids. Many stems of pyrite. Weathered fragments of molluscs and of *Cupuladria haidingeri.* Foraminifera. Wash residues of another sample, which seems to have been washed as early as 1944 at Videbæk, mainly contain yellowish brown, irregular grains (transformed glauconite?).

Remarks: A fourth borehole D.G.U. File No. 83.609, 800 m. SW of File No. 83.602, according to the log seems to have reached "grey Astarte Clay with shells" at a depth of 13.0–15.0 m. Below the only 2.3 m. thick Quaternary meltwater sand "grey Mica Clay" was found in two intervals (2.3–8.9 m. and 12.0–13.0 m.) separated by quartz sand and gravel from 8.9–12.0 m. It has only been possible to find one sample of the latter bed in the collection of samples of the D.G.U.

Brejning Kro

Borehole D.G.U. File No. 83.197. Made in 1948.

Situation: 3.2 km. south of the Brejning farm and 7.5 km. west of Videbæk, where the highway from Holstebro to Skern crosses the highway between Herning and Ringkøbing. Fig. 16.

Ground level: about + 69 m.

Borehole log:

0.0–19.0 m.	Sand and clay (Quaternary)
19.0–42.0 –	Clay, grey, non-calcareous, without stones. (A sample from 40.5 consists of typical Gram Clay)
42.0–45.0 –	Clay, dark grey, with irregular lighter parts. (The sample is a ditch sample. The original character of the sediment is unknown).
45.0–45.8 –	?
45.8–45.9 –	Quartz sand and gravel, coarse, with pebbles of quartz up to a length of 1.5 cm.
45.9–61.5 –	Mica Clay and silt
61.5–63.0 –	Quartz sand and gravel, marine, fossiliferous
63.0–69.0 –	Mica Silt, brownish grey, fine, marine, fossiliferous
69.0–71.0 –	Mica Clay, silty, brownish, marine, fossiliferous.

Level of the surface of the Miocene: + 50 m.?

Molluscs are available from depths of 40.5 and 42–45 m., but were also found outside the clay series in the quartz sand from 61.5 to 63.5 m. Faunal analysis, see Table 19, 230.

Description of the fossiliferous samples:

40.5 m. Weight of sample: 190.78 grammes. Weight of wash residue: 20.16 grammes. Clay, the wash residue of which mainly consists of brownish irregular grains. Much pyrite. Many foraminifera. Fragments of *Cupuladria haidingeri* and *C. canariensis.* A few quartz grains.

42–45 m. Weight of sample: 440.10 grammes. Weight of wash residue: 55.60 grammes. Clay, the wash residue of which consists of a mixture of numerous glauconite grains and numerous grains of sand, mainly of quartz, but also of flint and felspar. Much pyrite. Many foraminifera. Some fragments of molluscs. Fragments of *Cupuladria.*

Remarks: The fossiliferous sample immediately below the clay consists of quartz sand and gravel with remnants of a molluscan fauna which amongst others contains the following species:

Nucula sp.
Nuculana pygmaea (MÜNSTER)
Yoldia glaberrima (MÜNSTER)
Spisula subtruncata (DA COSTA) (many shells)
Cuspidaria cuspidata (OLIVI)
Haustator eryna (D'ORBIGNY)
Bittium tenuispina SORGENFREI (many shells)
Natica sp.
Nassa tenuistriata (BEYRICH)
Nassa schlotheimi (BEYRICH) (many shells)
Gemmula cf. badensis (R. HÖRNES)
Terebra hoernesi BEYRICH
Chrysallida cimbrica (KAUTSKY)
Odostomia mutinensis (SACCO)
Ringicula buccinea (BROCCHI)
Vaginella depressa DAUDIN

This fauna is too fragmentary for it to be characterized in detail, but the forms found all belong in the faunas of the Arnum Formation, and through the distribution according to frequency a *Spisula subtruncata – Nassa schlotheimi* assemblage is suggested.

The commonest species in the material is *Bittium tenuispina.* Quite the same conditions were also observed in the interval (62.7–62.9 m.) in the borehole at Arnum in North Slesvig, where the assemblage mentioned above occurs.

The clay in the interval 19–45 m. in this borehole is incompletely known as it has only been demonstrated with certainty that Gram Clay is present at a depth of 40.5 m. The level of the surface of the Miocene is therefore uncertain, just as it has not been shown that the whole of the Younger Miocene clay series is present.

M 2504

On this map sheet a total of fourteen boreholes with fossiliferous Gram Clay are known. They all occur on the western half of the sheet, partly in the area between Videbæk and Fjaldene, partly farther SW of Videbæk. Their situation appears from the map segment fig. 17.

The borehole logs are shown together in the table p. 42:

Molluscs are available from all intervals denoted as "Gram Clay" (except from the boreholes 84.441 and 84.473). Faunal analysis, see Table 23, p. 235, Table 24 (84.1727), p. 235, and Table 22 (84.1748), p. 234.

Description of the fossiliferous samples: Good-sized samples of Gram Clay from all borings which in the table p. 42 have been mentioned from No. 84.288 included to No. 84.525 included, were washed with a screen with a width of meshes of 0.5 mm. as early as 1943 at the D.G.U. branch for lignite search at Videbæk at the time by the geologists there. Then the fossils were separated from the wash residues. These have gradually been somewhat weathered, as the large quantity of pyrite found in these residues has been coated

D.G.U. File No.	Ground level	Quaternary beds at the following depths	Miocene beds		Level of the surface of the Miocene
			Depths	Sediment	
84.288	+56 m.	0.0–1.4 m.	1.4–15.0 m.	Gram Clay	+55 m.
84.313	+52 –	0.0–3.5 –	3.5–15.0 –	Gram Clay	+48 –
84.344	+49 –	0.0–5.6 –	5.6–15.0 –	Gram Clay	+43 –
84.358	+45 –	0.0–7.2 –	7.2–15.1 –	Gram Clay	+37 –
84.417	+55 –	0.0–2.2 –	2.2–15.0 –	Gram Clay	+53 –
84.441	+53 –	0.0–1.9 –	1.9–11.0 –	Gram Clay	+51 –
			11.0–14.0 –	Glauconite Clay	
			14.0–15.2 –	Hodde Clay	
84.456	+54 m.	0.0–2.2 m.	2.2–15.0 –	Gram Clay	+52 m.
84.473	+47 –	0.0–1.6 –	1.6–15.0 –	Gram Clay	+45 –
84.483	+60 –	0.0–2.0 –	2.0–14.8 –	Gram Clay	+58 –
84.492	+63 –	0.0–5.1 –	5.1–15.5 –	Gram Clay	+58 –
84.493	+54 –	0.0–5.4 –	5.4– 7.1 –	Mica Clay, grey	+47 –
			7.1– 7.4 –	Sand, grey, with clay	
			7.4–15.0 –	Gram Clay	
84.525	+50 m.	0.0–3.9 m.	3.9– 4.5 –	Mica Sand	+46 m.
			4.5– 6.2 –	Mica Clay brown above, black below	
			6.2– 9.0 –	Gram Clay	
			9.0–12.2 –	Glauconite Clay	
			12.2–15.0 –	Hodde Clay	
84.1727	+51 m.	0.0–7.4 m.	7.4–	Gram Clay	+44 m.
			–15.4 –	Glauconite Clay	
			15.4–19.6 –	Hodde Clay	
			19.6–23.3 –	Mica Silt with a few quartz pebbles	
			23.3–24.5 –	Mica Clay, dark grey, silty	
			24.5–25.5 –	Quartz sand	
			25.5–30.0 –	Mica Silt	
84.1748	+63 m.	0.0–3.0 m.	3.0–25.5 –	Gram Clay	+60 m.
			25.5–28.3 –	Glauconite Clay	
			28.3–30.0 –	Hodde Clay, blackish brown	

with a grey film, just as all remnants of shells of calcite have been attacked. On the various wash residues the following remarks may be made:

84.288. Dominance of grains of quartz which seem to originate from contamination of the sample.

84.313. Dominance of dark grey and greenish grey micro-ellipsoids. Some pyrite. Many fragments of molluscs. Foraminifera. Fragments of *Cupuladria haidingeri.* (Description on the basis of a new washing of a sample of clay).

84.344. Besides stems of pyrite a few pebbles of felspar as well as quartz (contaminations).

84.358. The wash residue not present.

84.417. Exclusively bits of clay-ironstone concretion.

Fig. 17. Situation of boreholes in the area NW and W of Videbæk. D.G.U. File Nos. 84.288, 84.313, 84.344, 84.358, 84.417, 84.441, 84.456, 84.473, 84.483, 84.492, 84.493, 84.525, 84.1727, and 84.1748. (Segment of M 2504, reduced to a scale of 1:40,000).

84.441. The wash residue not present.

84.456. Besides pyrite there are a few bits of clay-ironstone concretion.

84.473. The wash residue not present.

84.483. Consists of pyrite only.

84.492. Besides pyrite there are a few bits of clay-ironstone concretion and some grains of sand and small stones (contaminations).

84.493. Mainly consists of sand and pebbles (granite, quartzite, flint, etc.). Much contaminated.

84.525. Consists of pyrite only.

From the boreholes D.G.U. File No. 84.1727 (the interval 8.4–12.4 m.) and 84.1748 (the intervals 14.95–17.95 m. and 22.95–24.95 m.) largish samples were washed with screens with a width of meshes of 0.5 mm. The wash residues all in the majority of cases consist of pyrite in stems and small lumps. Furthermore there are some fragments of molluscs and *Cupuladria*, especially *C. haidingeri*. The small samples which are otherwise available from these two boreholes, have not been examined in more detail.

3. The Vildbjerg Area

Marine Younger Miocene deposits have been found in eight boreholes in the area around Vildbjerg. Furthermore the Gram Clay crops up at the brickworks of Møltrup, the clay pit of which is the only outcrop in the area.

Møltrup Brickworks

Situation: 600 m. east of the church of Timring, 250 m. west of the Møltrup farm, and 2.5 km. south of Vildbjerg. The clay pit stretches from the brickworks 500 m. towards the west and reaches close to the village of Timring. Fig. 18.

Ground level: about + 44 m. – + 52 m., rising from the east towards the west.

Sequence of strata: The clay pit was visited on the 22th of August 1959 and the 5th of May 1962.

It has gradually reached rather a considerable extent, and digging now takes place in a wall parallel to the highway from Timring to Møltrup in the direction east – west.

The section was about 200 m. long in 1962. In the whole length of the section dark grey Gram Clay was seen under a thin layer of boulder clay. The height of the wall was estimated to be about 8–9 m., 6–7 m. of which cut into the Gram Clay. This is clearly fractured. The mollusc shells in the accessible part of the clay are mainly decomposed and are present as imprints.

In 1959 only a minor part of Gram Clay was found with well preserved mollusc shells, while in 1962 there appeared to be better possibilities of providing intact material from the lowermost part of the eastern portion of the section.

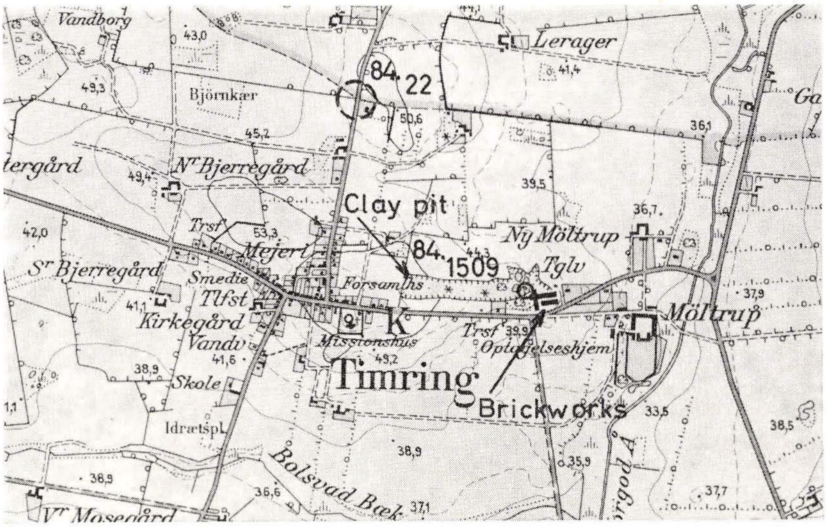

Fig. 18. Situation of the brickworks of Møltrup and the boreholes D.G.U. File No. 84.22 and 84.1509. (Segment of map sheet 1114 I NW on the scale of 1:25,000).

Position of strata: No bedding of the clay could be seen, nor were any beds of concretions found. The position of strata therefore have not been elucidated.

Borings: The Raw Material Department of the D.G.U. in 1946 made a 89 m. deep boring (D.G.U. File No. 84.1509) close to the buildings of the brickworks, at which the following sequence of strata was penetrated (list of strata abridged):

0.0– 0.4 m.	Mould
0.4– 1.8 –	Clay, greyish brown (filling)
1.8– 4.6 –	Mica Clay, grey (Gram Clay)
4.6–18.7 –	Mica Clay, brown, fossiliferous (mainly Gram Clay)
18.7–23.2 –	Mica Clay, brown
23.2–24.6 –	Quartz sand and gravel, grey
24.6–29.6 –	Quartz sand, grey, coarse-grained in the lower part
29.6–47.0 –	Quartz sand, grey, medium-grained
47.0–47.7 –	Quartz sand, grey, fine-grained
47.7–55.7 –	Mica Clay with lignite
55.7–63.5 –	Mica Clay alternating with Mica Sand and quartz sand; a little lignite
63.5–73.1 –	Quartz sand alternating with Mica Clay
73.1–89.0 –	Mica Sand alternating with Mica Clay.

Remarks: No marine fossils were found in the beds below 23.2 m. in this borehole.

Level of the surface of the Miocene: about + 42 – + 50 m.

Molluscs are available partly as collected loose from the clay pit, partly from clay samples taken from the pit at a depth of about 9 m. and from a sample from 4.6–18.7 m. from the borehole. Faunal analysis, see Table 25, p. 236.

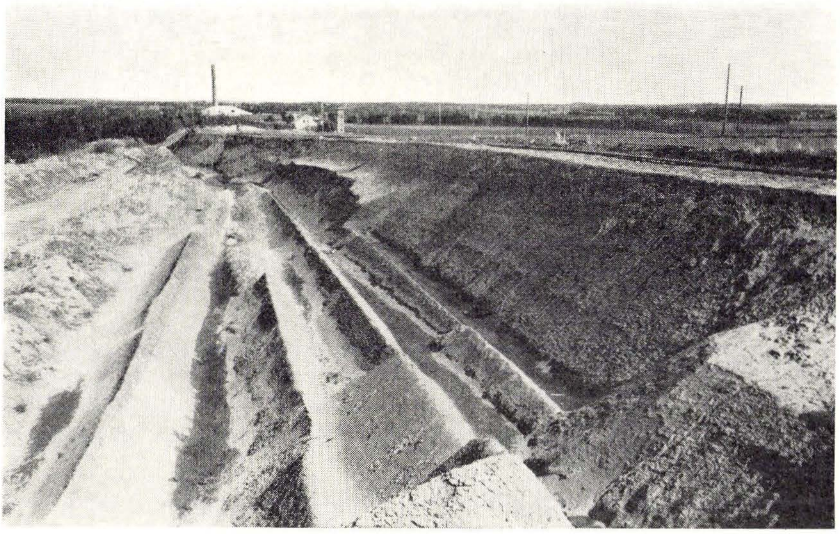

Fig. 19. The clay pit of the brickworks of Møltrup 1962. The direction of the digging wall is west–east. The section is here seen from the west towards the east. The buildings of the brickworks are seen in the background.

Phot. Chr. Westergaard

Description of the fossiliferous samples:

Sample taken from the clay pit. Weight before washing: 4708 g. Weight of wash residue: 83.0 g. The wash residue is dominated by micro-ellipsoids. Furthermore there is very much pyrite, especially in the shape of needles. Numerous foraminifera and fragments of *Cupuladria*, especially *C. haidingeri*. Few fragments of *C. canariensis*. Some fragments of molluscs. Otolites. Fragments of *Ditrupa* tubes.

Timring

Well-digging made about 1934.
D.G.U. File No. 84.22.

Situation: Not exactly localized. According to report from the well-digger (N. Nielsen, Avlum) the digging was made about 700 m. north of the church of Timring. Fig. 18.

Ground level: ?

Borehole log:

0.0– 0.7 m. Mould
0.7– 4.2 – Boulder clay
4.2–11.2 – Gram Clay, dark, fossiliferous.

Level of the surface of the Miocene: ?

Molluscs were found in the Gram Clay together with some remnants of driftwood, viz. two shells of *Astarte reimersi* Semp. and a cast of *Galeodea echinophora* (L.).

4. *The Sunds–Herning Area*

This area comprises the whole region from Sunds Lake in the north to Gjødstrup Lake and Snejbjerg in the SW. Further from there to the region about Frølund in the east.

It seems that Gram Clay was dug up in the clay pits of the brickworks of *Snejbjerg*, but at a visit to the place in 1962 it was only possible to establish the presence of Quaternary beds. According to oral communication from the late State Geologist KELD MILTHERS, Ph. D., "Astarte Clay" was previously accessible in the clay pits.

Gram Clay has furthermore been found in many – 24 in all – boreholes within the area. From each of these boreholes only a single sample is available. These samples have not been closely examined for fossils. On the other hand, there are molluscs from a total of eight borings situated more or less evenly distributed over the area. These borings are mentioned below except for borehole 85.393 at Sunds, from which the molluscs have not been available.

Lille Torup

Borehole made by D.G.U. in 1948.
D.G.U. File No. 85.379.

Situation: 2.1 km. SE of the church of Sunds, half-way between the built-up areas of Torup and Lille Torup. Fig. 20.

Ground level: about + 47 m.

Borehole log:

0.0–13.4 m. Glacio-fluvial sand, stony, in part coarse-grained
13.4–14.2 – Mica Clay, grey, mealy
14.2–16.0 – Sand, grey, medium-grained, with stones
16.0–16.8 – Sand with beds of clay (Quaternary)
16.8–20.0 – Mica Clay, grey, fossiliferous (Gram Clay). At 16.8 m. a 5–10 cm. thick bed of concretions.

Level of the surface of the Miocene: about + 30 m.

Molluscs are available from the interval 16.8 m. – 20.0 m. as a result of washing of a good-sized sample of clay with a screen having a width of meshes of 0.5 mm. The molluscs have been sorted out and sent to the D.G.U. from the branch of the institute at Sunds without further information about the size and weight of the sample. Faunal analysis, se Table 26, p. 237.

Tværmose

Borehole made by D.G.U. in 1948.
D.G.U. File No. 85.381.

Situation: 4.2 km. SE of the church of Sunds, 4.1 km. NE of the church of Gjellerup and immediately on the road from Vrå by way of Tværmose to Tulstrup. Fig. 20.

Fig. 20. Situation of boreholes in the Sunds-Herning area.
D.G.U. File Nos. 85.393, 85.379, 85.381, 85.380, 85.382, and 85.383.
(Segment of M 2407, reduced to a scale of 1:40,000).

Ground level: about + 51 m.

Borehole log:

0.0–11.7 m. Sand, medium-grained; with stones
11.7–14.3 – Clay, grey, mixed with sand; with stones
14.3–17.3 – Sand, grey, medium-grained; with stones
17.3–19.0 – Clay, grey, mixed with sand; with stones
19.0–21.0 – Mica Sand, grey, fine-grained
21.0–22.8 – Mica Clay, grey, fossiliferous (Gram Clay)
22.8–25.0 – Mica Clay, glauconitic.

Level of the surface of the Miocene: about + 31 m.

Molluscs are available from the interval 21.0–25.0 m. After washing the material was sent to the D.G.U. from the branch of the institute at Sunds at the time. Faunal analysis, see Table 26, p. 237. Information of the size and weight of the sample before washing is missing.

Gjellerup

Two boreholes made by the D.G.U. in 1948.

1. Boring D.G.U. File No. 85.380.

Situation: 2.9 km. NNE of the church of Gjellerup and about 100 m. north of the brook of Nybo. Fig. 20.

Ground level: about + 50 m.

Borehole log:

0.0– 1.2 m. Gravel and stones
1.2– 5.5 – Sand, grey, medium-grained; with stones
5.5– 6.3 – Clay, mixed with sand; with stones
6.3– 9.3 – Sand, medium-grained; with stones
9.3–20.0 – Gram Clay, greyish black, fossiliferous.

Level of the surface of the Miocene: about + 41 m.

Molluscs are available from the interval 13–20 m., sent to the D.G.U. from the branch of the institute at Sunds at the time in an sorted-out condition and without information about the size of the original sample. Faunal analysis, see Table 26, p. 237.

2. Boring D.G.U. File No. 85.382.

Situation: 2.4 km. NNE of the church of Gjellerup and 300–400 m. south of the brook of Nybo. The boring was made only 500 m. south of the locality of boring No. 85.380. Fig. 20.

Ground level: about + 52 m.

Borehole log:

0.0– 2.9 m. Sand, medium-grained, grey
2.9– 3.1 – Sand, medium-grained, grey; with stones
3.1– 3.4 – Sand, mixed with clay, grey; with stones
3.4– 4.4 – Sand, medium-grained, grey; with stones
4.4– 5.8 – Clay, blackish brown
5.8– 6.1 – Sand, coarse-grained, yellow; with stones
6.1– 6.2 – Clay, mixed with sand, blackish brown; with stones
6.2– 7.5 – Sand, medium-grained, grey; with stones
7.5– 8.6 – Mica Clay, greyish black, in part mixed with sand
8.6–13.9 – Sand, medium-grained, grey; with stones
13.9–16.8 – Mica Clay, greenish grey
16.8–19.0 – Mica Clay, with shells (Gram Clay).

Level of the surface of the Miocene: about + 38 m.

Molluscs available from 16.8–19.0 m. Faunal analysis, see Table 26, p. 237.

Frølund

Borehole made by the D.G.U. in 1948.
D.G.U. File No. 85.383.

Situation: 5.8 km. SE of the church of Sunds, 3.4 km. NE of the church of Gjellerup and about one km. NNW of the village Frølund. Fig. 20.

Ground level: about + 53 m.

Borehole log:

0.0– 9.2 m. Meltwater sand, mainly coarse-grained; with stones
9.2–17.9 – Gram Clay, grey, with molluscs
17.9–18.3 – Lignite ooze
18.3–20.0 – Mica Sand, greyish brown, fine-grained; with bits of wood at the top.

Level of the surface of the Miocene: about + 44 m.

Molluscs are available from 9.2–17.9 m. They were washed and sorted out at the D.G.U. branch at Sunds at the time and sent to the institute without information of the size of the sample before washing. Faunal analysis, see Table 26, p. 237.

Gjødstrup

Borehole made by the D.G.U. in 1960.
D.G.U. File No. 85.861.

Situation: 300 m. south of Gjødstrup Lake and 2 km. SSW of the church of Tjørring. Fig. 21.

Ground level: about + 47 m.

Borehole log:

0.0– 2.8 m. Moraine sand, greyish-brown, stony
2.8– 8.9 – Boulder clay, brownish grey, sandy, gravelly

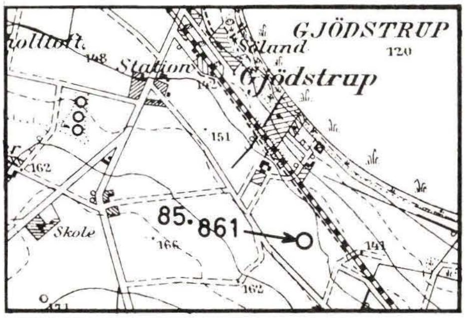

Fig. 21. Situation of borehole D.G.U. File No. 85.861 at Gjødstrup.
(Segment of M 2406 on the scale of 1:20,000).

8.9– 9.6 – Meltwater sand and gravel
9.6–14.0 – Mica Clay, brownish grey, silty, and micaceous silt, brownish grey
14.0–20.2 – Mica Clay, brownish grey, with some silt
20.2–21.1 – Silt, micaceous, brownish grey, fine, mealy
21.1–23.3 – Mica Clay, brownish grey, partly silty
23.3–24.8 – Mica Clay, grey
24.8–27.0 – Mica Clay, grey or greenish grey, more or less conspicuously containing glauconite, silty
27.0–32.3 – Mica Clay, grey – dark grey, partly silty
32.3–36.2 – Mica Clay, greyish green and yellowish brown at the top, then dark greyish green, glauconitic. Fragments of molluscs observed from 35.0–36.2 m.
36.2–36.8 – Mica Clay, light greyish brown, sticky, slightly micaceous
36.2–58 – Mica Clay, dark grey, slightly micaceous, fossiliferous (Gram Clay). At 48.0 m. one shell of *Gemmula annae.* At 55.0 m. one shell of *Gemmula badensis.*
about 58–60.2 m. Clay, containing glauconite, dark-coloured.

Level of the surface of the Miocene: Uncertain, perhaps about + 37 m.

Molluscs have only been sorted out from the samples which looked fairly fresh, taken at the following depths: 45.0 m., 46.0 m., 47.0 m., 48.0 m., 49.0 m., 50.0 m., 51.0 m., 52.0 m., 53.0 m., 54.0 m., 55.0 m., 56.0 m., 57.0 m., 58.0 m. Faunal analysis, see Table 27, p. 239.

Description of the fossiliferous samples: All the samples examined consist of typical Gram Clay. The wash residues all contain many foraminifera, fairly many fragments of molluscs and some fragments of zoaria of *Cupuladria,* especially *C. haidingeri.* In several samples there were also *Ditrupa* tubes, otolites, and ostracods.

The main components of the various samples appear from the Table p. 52.

Remarks: The Tertiary beds above the Gram Clay have not been examined, but at any rate from the depth of about 45 m. and through the rest of the boring, the sequence seems to be normal. Perhaps all the beds have been glacially dislocated, as Glauconite Clay seems to have been found from the depths of 24.8–32.3 m.

Depth	Weight of sample	Weight of wash residue	Main components (the former is dominant)	
45.0 m.	126.42 g	5.22 g	Micro-ellipsoids	Pyrite
46.0 –	147.93 –	2.15 –	Pyrite	
47.0 –	139.89 –	2.41 –	Pyrite	Mica flakes
48.0 –	146.75 –	3.24 –	Micro-ellipsoids	Pyrite
49.0 –	149.80 –	6.15 –	Micro-ellipsoids	Pyrite
50.0 –	126.70 –	5.87 –	Micro-ellipsoids	Pyrite
51.0 –	172.55 –	5.71 –	Pyrite	Micro-ellipsoids
52.0 –	183.51 –	7.03 –	Micro-ellipsoids	Pyrite
53.0 –	179.00 –	2.36 –	Pyrite	
54.0 –	186.75 –	5.35 –	Micro-ellipsoids	Pyrite
55.0 –	195.40 –	2.16 –	Pyrite	
56.0 –	165.02 –	2.80 –	Pyrite	
57.0 –	150.94 –	3.32 –	Glauconite	Pyrite
58.0 –	183.04 –	5.48 –	Glauconite	Pyrite

Snejbjerg

Borehole made by the D.G.U. in 1960.
D.G.U. File No. 85.775.

Situation: 900 m. SE of the church of Snejbjerg, 800 m. south of the brickworks of Snejbjerg and 500 m. south of the highway from Herning to Ringkøbing. Fig. 22.

Ground level: about + 50 m.

Borehole log:

0.0–11.3 m.	Boulder clay and glacial sand, yellowish brown at the top (down to a depth of about 3 m.), then grey, partly stony and gravelly. From 10.3–11.3 m. greenish grey and containing glauconite
11.3–12.3 –	Clay, greenish grey, with a slightly yellow tint
12.3–13.3 –	Clay, yellowish grey
13.3–14.3 –	Clay, presumably Gram Clay, yellowish grey
14.3–15.3 –	Gram Clay, partly glauconitic, grey, with a slightly greyish tint
15.3–30.3 –	Gram Clay, darker grey, typical.

Level of the surface of the Miocene: about + 31 m.?

Molluscs have been taken from the following intervals: 18.25–19.25 m., 19.25–20.25 m., 20.25–21.25 m., 21.25–22.25 m., 22.25–23.25 m., 23.25–24.25 m., 24.25–25.25 m., 25.25–26.25 m., 26.25–27.25 m., 27.25–28.25 m., 28.25–29.25 m., 29.25–30.25 m. Faunal analysis, see Table 28, p. 240.

Description of the fossiliferous samples: All the samples consist of typical Gram Clay. The contents of fossils include foraminifera, mollusca, bryozoa (*Cupuladria haidingeri*, a few fragments of *C. canariensis* and *Lunulites* sp.), a few otolites, and ostracods.

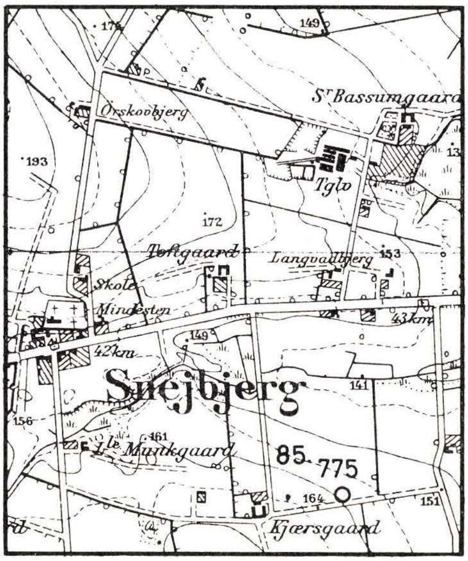

Fig. 22. Situation of borehole D.G.U. File No. 85.775 at Snejbjerg.
(Segment of M 2506 on the scale of 1:20,000).

Depth interval	Weight of sample	Weight of wash residue	Main components (the dominant one is mentioned first)
18.25–19.25 m.	178.37 g	12.95 g	Micro-ellipsoids. Pyrite. Grains of quartz.
19.25–20.25 –	112.77 –	3.39 –	Micro-ellipsoids. Pyrite.
20.25–21.25 –	125.67 –	4.53 –	Micro-ellipsoids. Much pyrite. Mica flakes.
21.25–22.25 –	93.08 –	1.96 –	Micro-ellipsoids. Pyrite.
22.25–23.25 –	124.63 –	3.78 –	Pyrite. Micro-ellipsoids. Mica flakes.
23.25–24.25 –	129.91 –	5.21 –	Micro-ellipsoids. Pyrite.
24.25–25.25 –	103.05 –	7.07 –	Micro-ellipsoids. Less pyrite.
25.25–26.25 –	130.52 –	6.58 –	Micro-ellipsoids. Much pyrite.
26.25–27.25 –	98.12 –	3.32 –	Micro-ellipsoids. Much pyrite.
27.25–28.25 –	121.06 –	2.91 –	Micro-ellipsoids. Grains of quartz.
28.25–29.25 –	124.79 –	3.54 –	Micro-ellipsoids. Very much pyrite.
29.25–30.25 –	156.04 –	3.09 –	Micro-ellipsoids. Much pyrite.

Remarks: As there is Glauconite Clay above the Gram Clay, at any rate the topmost parts of the Miocene in this boring must have been glacially dislocated. In the samples it has been possible to show the occurrence of Quaternary sand down to a depth of 19.25 m. Below that there are no certain signs of contaminations.

5. The Bording Area

The northwesternmost of the localities of marine Younger Miocene strata in Denmark known so far have been shown to occur in the area immediately east and north of Bording. In all cases it is a question of boreholes made by the Raw Material Department of the D.G.U. in 1948. Gram Clay is stated to have been found in eight of these boreholes, and in several of these borings also green Glauconite Clay and Hodde Clay have been penetrated. The most important data of the eight boreholes are given below. In the cases in which the borehole stopped in the layer in question, the indications of thickness are placed in parenthesis.

D.G.U. File No.	Thickness of Gram Clay	Thickness of Glauconite Clay	Thickness of Hodde Clay	Level of the surface of the Miocene
86.174		(5.3 m.)		+60.8 m.
86.177	6.6 m.	10.2 –		+66.8 –
86.178	2.4 –	7.3 m.	1.3 m.	+62.6 –
86.179	?0.7 –	?3.5 –	2.1 –	+64.3 –
86.184		(3.9 –)		+61.2 –
86.213	1.5 –	7.3 –	(1.4 –)	+60.5 –
86.214	(5.3 –)			+59.6 –
86.215	9.7 –	(0.7 –)		+59.9 –

The levels of the surface of the Miocene are in the interval from + 60 m. to + 67 m., which is the highest situation above sea level of this series in Denmark. Even though certain glacial dislocations probably have taken place, conditions in the borings suggest that the area as a whole mainly has the Miocene strata in situ.

Molluscs are available from two of the borings only, and only these borings will be mentioned in more detail.

1. Boring D.G.U. File No. 86.177.

Situation: 1.6 km. north of the church of Bording, 200 m. NNE of the Nørlund farm, in the eastern fringe of the bog of Nørlund. Fig. 23.

Ground level: about + 70 m.

Borehole log:

0.0– 3.2 m. Meltwater sand, coarse, stony
3.2– 9.8 – Gram Clay
9.8–20.0 – Clay, greenish and black (presumably Glauconite Clay and Hodde Clay).

Level of the surface of the Miocene: about + 67 m.

Molluscs were found in the sample from the interval 3.2–9.8 m. Faunal analysis, see Table 29, p. 240.

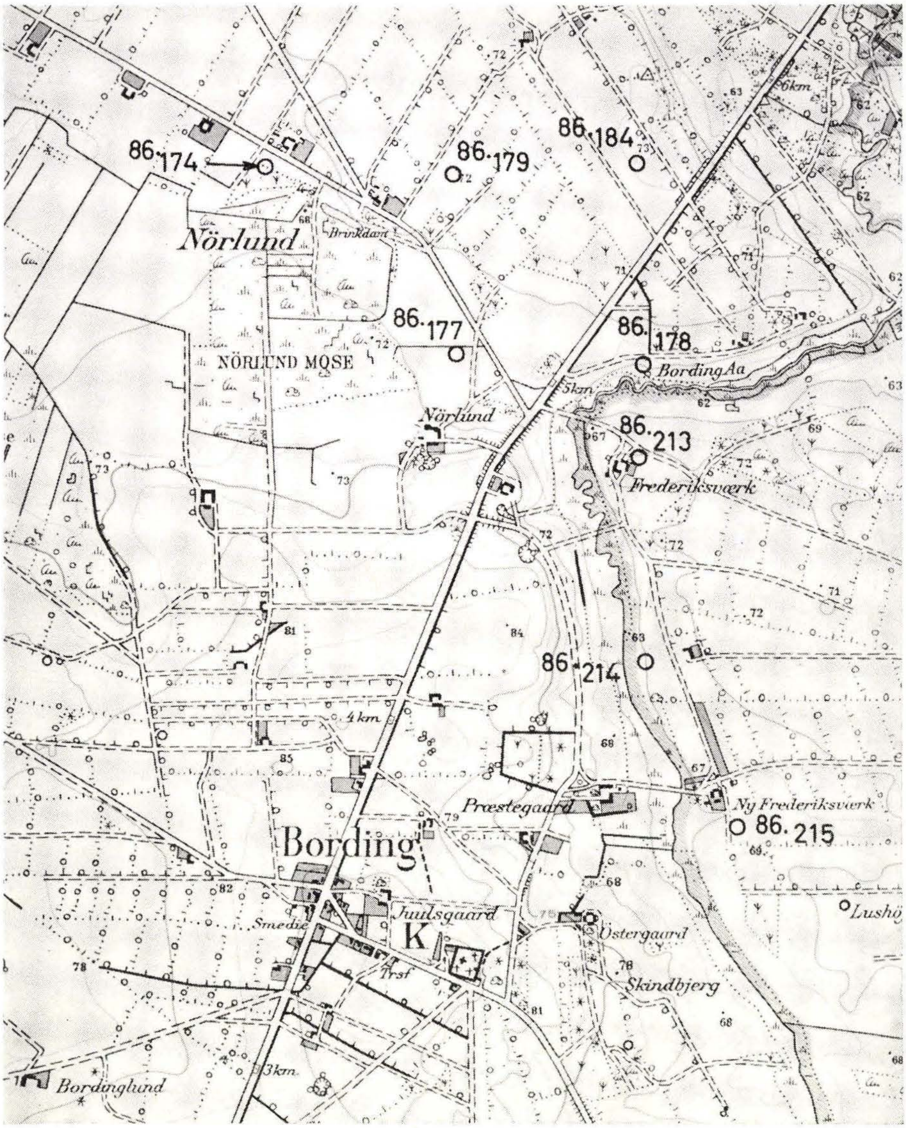

Fig. 23. Situation of boreholes in the Bording area: D.G.U. File Nos. 86.174, 86.177, 86.178, 86.179, 86.184, 86.213, 86.214, and 86.215.
(Segment of M 2408 on the scale of 1:20,000).

2. Boring D.G.U. File No. 86.215.

Situation: 800 m. NE of the church of Bording, 100 m. east of the Bording river. Fig. 23.

Ground level: about + 66 m.

Borehole log:

0.0– 0.4 m. Sand with peat
0.4– 3.0 – Sand, medium-grained, grey, with mica flakes and a few stones
3.0– 6.0 – Mica Clay, mealy, grey. At 6.0 m. a layer of stones
6.0–10.3 – Mica Clay, brownish black, fossiliferous (Gram Clay)
10.3–15.7 – Mica Clay, grey (presumably Gram Clay)
15.7–16.4 – Clay, greenish, with a few pebbles of quartz.

Level of the surface of the Miocene: about + 60 m.

Molluscs were found in the sample from the depth of about 10 m. Faunal analysis, see Table 29, p. 240.

Region II
The Høgild–Brande–Give Area

South of Herning Gram Clay has been shown to occur in a broad region from Rind by way of Arnborg and Brande to Give.

A small compact area has been found through the search for lignite by the D.G.U. in the region at Høgild, while isolated occurrences have been observed at a boring west of the plantation of Fasterholt (south of Søby), at borings west and south of Brande, and in the neighbourhood of Give.

Glacial floes of Gram Clay have been found well over one km. WSW of the church of *Arnborg*. In Mica Clay from a depth of 6.0–11.7 m. there, *Astarte* shells were found at a boring (D.G.U. File No. 95.1267.a) made by the Lignite Department of the D.G.U.

Outcrops are known from Sandfeldbjerg and the area south of there, viz. a minor, now overgrown, clay pit and a few pits of a brickworks, only a single one of which was accessible for examination. All the other localities were boreholes, 14 of which yielded fossiliferous Gram Clay.

Besides this clay Glauconite Clay and Hodde Clay have also been shown to occur in most deposits.

The glacial disturbances of the strata are often radical.

Høgild

In the area between the Fjederholt river and the farm Høgild Overgård, Gram Clay has been found on both sides of the highway from Herning to Brande in a number of boreholes close together made to a depth of only 15 m. A single borehole down to a depth of 152.0 m. throws light on lithological and stratigraphical conditions below the Younger Miocene series, but otherwise the other boreholes as a rule were stopped before this series was penetrated. Molluscs are only available from the deep borehole, for which reason conditions in the smaller boreholes are only mentioned as a supplement in the section "Remarks".

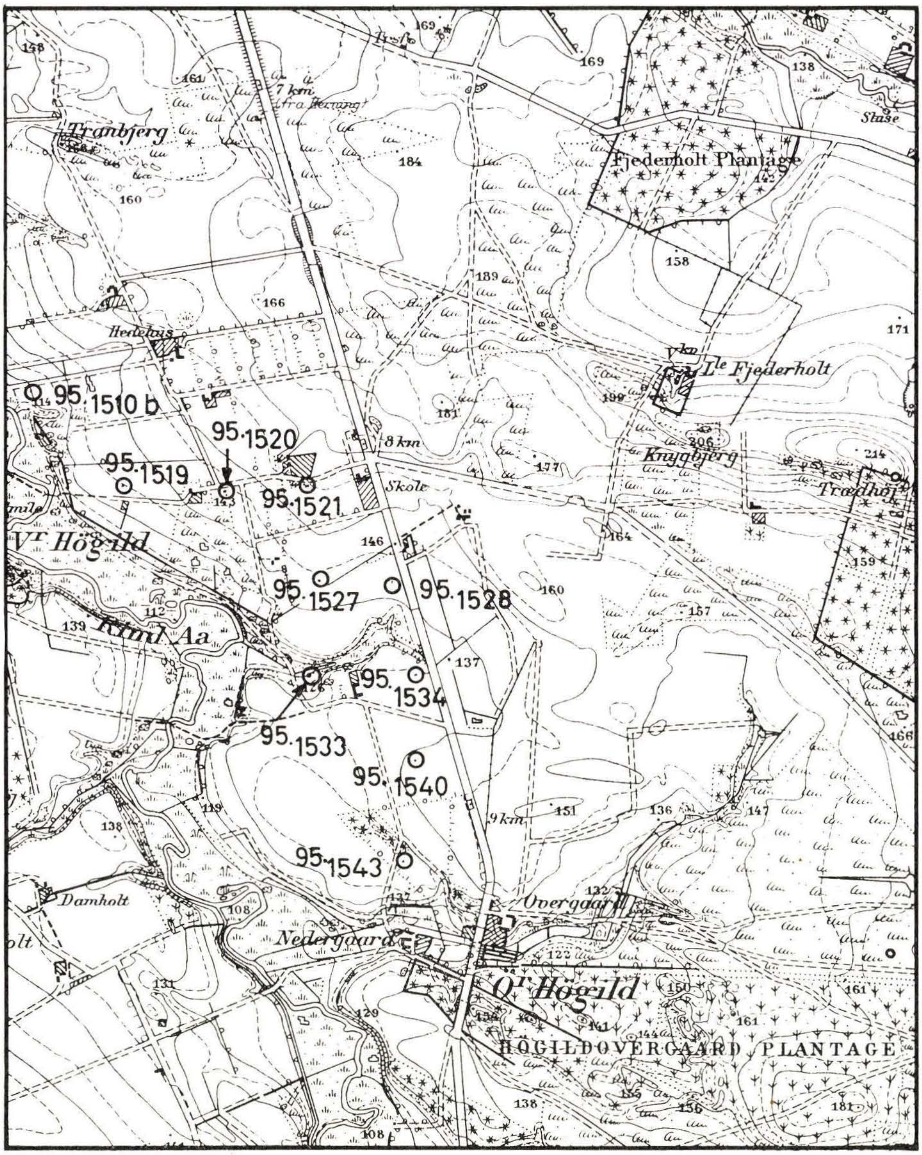

Fig. 24. Situation of boreholes between Vester and Øster Høgild: D.G.U. File Nos. 95.1510. b, 95.1519, 95.1520, 95.1521, 95.1527, 95.1528, 95.1533, 95.1534, 95.1540, and 95.1543. (Segment of M 2606 on the scale of 1:20,000).

Borehole at Høgildgård. D.G.U. File No. 95.1510.b. Made by the D.G.U. in 1947.

Situation: 400 m. NE of the farm Høgildgård, 800 m. west of the highway from Herning to Brande and immediately east of the Rind river. Fig. 24.

Ground level: about + 37 m.

Borehole log:

0.0– 0.6 m. Boulder clay
0.6– 3.9 – Mica Clay, grey (Gram Clay?)
3.9– 5.7 – Gram Clay, fossiliferous
5.7–11.8 – Clay, greenish grey, glauconitic; at 6.3 m. a concretion bed; 10.9–11.8 m. greenish-black Glauconite Clay
11.8–15.4 – Hodde Clay, carboniferous, fractured; at 15.3 m. with pebbles of quartz of up to 2 cm. in length
15.4–16.6 – Quartz sand, coarse, with mica flakes
16.6–22.2 – Quartz sand, medium-grained
22.2–22.9 – Lignite gyttja
22.9–24.6 – Lignite
24.6–152.0 – Mica Clay, Mica Sand, and quartz sand, in places with beds of lignite. All layers below the depth of 15.4 m. probably limnic. Final depth: 152.0 m.

Level of the surface of the Miocene: about + 36 m.

Molluscs are available from the following depths: 3.9 m., 6.3 m., 3.9–5.7 m. Faunal analysis, see Table 30, p. 241.

Description of the fossiliferous samples: All the samples mentioned from which molluscs are available, consist of typical Gram Clay with high contents of pyrite.

Remarks: The borehole mentioned above was made in the middle of an area in which Gram Clay has been found in some boreholes that have been made down to a depth of 15 m.

The samples from these boreholes have not been accessible, for which reason the Miocene strata will be listed here according to the description made by the Lignite Department of the D.G.U. The boreholes are arranged from north to south and from west to east:

D.G.U. File No.	85.274	85.275	85.276	85.288	85.298
Ground level:	+51.4 m.	+48.2 m.	+48.4 m.	+52.6 m.	+53.3 m.
Level of the surface of the Miocene:	+49.6 m.	+45.2 m.	+44.4 m.	+48.6 m.	+46.9 m.
Gram Clay (= "grey Mica Clay"). Depth interval:	1.8–9.5 m.	3.0–8.4 m.	3.5–10.4 m.	4.0–9.8 m.	6.4–13.9 m.
Gram Clay, thickness:	7.7 m.	5.4 m.	6.9 m.	4.2 m.	7.5 m.
Glauconite Clay: Hodde Clay (= "black Mica Clay" or "brown Mica Clay"). Interval: (Not penetrated)	9.5– (15.0 m.)	8.4– (15.0 m.)	10.4– (15.0 m.)	9.8– (15.0 m.)	13.9– (15.0 m.)

D.G.U. File No.	85.299	95.1519	95.1520	95.1521	95.1527
Ground level:	+51.9 m.	+42.7 m.	+45.4 m.	+49.4 m.	+45.6 m.
Level of the surface of the Miocene:	+45.6 m.	+38.4 m.	+40.7 m.	+37.5 m.	+39.6 m.
Gram Clay (= "grey Mica Clay"), depth interval:	6.3– 10.8 m.	4.3– 9.0 m.	4.7– (15.0 m.)	11.9– (15.0 m.)	6.0– 12.7 m.
Gram Clay, thickness:	4.5 m.	4.7 m.			6.7 m.
Glauconite Clay (= "greyish green Mica Clay") depth interval:		9.0– (15.0 m.			12.7– (15.0 m.)
Glauconite Clay, thickness:					
Hodde Clay (= "black Mica Clay" or "brownMica Clay"), interval: (Not penetrated)	10.8– (15.0 m.)				

D.G.U. File No.	95.1528	95.1533	95.1534	95.1543	95.1540
Ground level:	+45.2 m.	+38.1 m.	+43.3 m.	+43.3 m.	+44.7 m.
Level of the surface of the Miocene:	+40.8 m.	+37.2 m.	+40.2 m.	+31.3 m.	+33.7 m.
Gram Clay (= "grey Mica Clay"), depth interval:	4.4– 8.0 m.	0.9– 12.0 m.	3.1– 10.2 m.	12.0– (15.0 m.)	11.0– (15.0 m.
Gram Clay, thickness:	3.6 m.	11.1 m.	7.1 m.		
Glauconite Clay (= "greyish green Mica Clay") depth interval:	8.0– 13.2 m.		10.2– (15.0 m.)		
Glauconite Clay, thickness:	5.2 m.				
Hodde Clay (= "black Mica Clay" or "brown Mica Clay"), interval: (Not penetrated)	13.2– (15.0 m.)	12.0– (15.0 m.)			

The term which is given in inverted commas, is that of the Lignite Department.

The levels of the surface of the Gram Clay according to the information given above range from + 37 m. to + 51 m., the boreholes with the highest level of Gram Clay being grouped farthest north in the area.

The thicknesses of the Gram Clay mainly range from 4 m. to 8 m.

The basal Glauconite Clay was observed in four of the boreholes, but may have been overlooked in some of the others. Hodde Clay was observed in at least eight of the boreholes.

It was remarked in the descriptions of samples for D.G.U. File No. 95.1540 that in the interval 11.0–15.0 m. there was "grey clay with mica and shells." The shells in question have not been found in the collections of the D.G.U.

Fasterholt Plantage

Borehole made by the D.G.U. in 1943.
D.G.U. File No. 95.849.

Situation: 3 km. SW of Søby Lake, 3 km. NE of Gl. Arnborg and 400 m. west of the plantation of Fasterholt. The lignite pits of Søby is situated only about 1.4 km. east of the locality. Fig. 25.

Ground level: about + 46 m.

Fig. 25. Situation of borehole D.G.U. File No. 95.849 west of the plantation of Fasterholt. (Segment of M 2607, reduced to the scale of 1:40,000).

Borehole log:

0.0– 0.2 m. Loam
0.2– 0.3 – Hard Pan
0.3– 4.1 – Sand, mixed with clay, yellowish grey, stony
4.1–14.0 – Gram Clay, fossiliferous
14.0–16.0 – Clay, greenish (Glauconite Clay)
16.0–21.0 – Mica Clay, black (presumably Hodde Clay).

Level of the surface of the Miocene: about + 42 m.

Molluscs are available from a depth of 4.1–14.0 m. Faunal analysis, see Table 30, p. 241.

Description of the fossiliferous sample:

4.1–14.0 m. Weight of sample: 91.20 grammes. Weight of wash residue: 3.59 grammes. The wash residue is dominated by grey, greenish, and brownish grains. Some pyrite. Grains of quartz. Some fragments of molluscs and foraminifera. The sample in part weathered.

Sandfeldbjerg

Situation: Pit 900 m. SW of the highest point of Sandfeldbjerg, at the foot of the ridge itself. Fig. 27.

Ground level: about + 44 m.

Description: The locality was found by E. DALGAS in 1869, and the place is known practically only through DALGAS's description, which is found in a letter to Professor JOHNSTRUP, dated at 17th September 1869, in which it says:

"The marl pit was found at the investigations of the Heath Society at the foot of the small hill island called Sandfeldbjerg. When I saw the pit, the whole of the lower part was covered by earth cleared away, so that I did not get any opportunity to examine the strata and their direction. Only the uppermost 3 Danish ells were open and at this depth only outwash sand ("fladesand") was found, as usual, occurring in thin horizontal streaks. The owner said that the marl began at a depth of 3 Danish ells. Then, according to his report the following layers were found:

A yellow layer of clay a few metres thick (No. 1). A dark layer of marl (No. 2) of very different depths with the large double-valved mussels, which were sometimes found abundantly.

Under that a thin layer of Mica Sand.

Under that marl No. 3, in which the other fossils."

At the same time as this letter sediment samples as well as fossils were sent.

The fossils were determined by O. MØRCH, who published their names in 1873. Later J. P. J. RAVN (1907) described the same fossils and at the same time gave a description of the sediment samples sent (*loc. cit.* p. 231):

"The layer of marl No. 2 with *Cyprina tumida* is grey Mica Clay; the layer of marl No. 3 is also grey Mica Clay, which, however, has a more yellowish tint and is rather much mixed with sand."

The interpretation of the section communicated by DALGAS is perhaps as follows:

At the top: Meltwater Sand
Weathered Mica Clay
Gram Clay
Mica Sand?
At the bottom: Greenish grey Glauconite Clay.

The locality itself has caved in long ago. During a visit to the place on the 3rd of August 1947 no Tertiary sediments were found. On the other hand, weathered Mica Clay was found beside a clay pit situated 100 m. farther north, also overgrown. Both pits are mentioned in detail by V. MILTHERS (1939, p. 23), who, however, did not find any fresh sections in any of the places, either.

Level of the surface of the Miocene: about + 42 m.

Remarks: A good deal of uncertainty prevails as regards this locality, both concerning the sequence of strata and bedding conditions. It is, however, of great palaeontological interest because of the large number of specimens of *Pygocardia rustica (= Cyprina tumida)* found there, a species which is otherwise very rare in the Gram Clay.

Molluscs apart from those submitted by DALGAS are not available from the locality (see Table 30, p. 241).

Brande Brickworks

Situation: Pits at brickworks 4.5 km. NW of Brande, 2.2 km. SE of Sandfeldbjerg, and 200 m. west of the Studsgård farm. The brickworks is called "Brande Brickworks" in spite of the fact that it is situated at some distance from the town of Brande. Fig. 27.

Ground level: about + 55 m.

Description: The locality was first mentioned by V. MILTHERS (1939, p. 24), but at any rate existed in 1918, when the D.G.U. made borings in the near environs of the brickworks and established the occurrence of Tertiary clay below 0.6–2.7 m. of glacio-fluvial sand. The clay pit first dug, which is now water-logged, is situated close to the buildings of the brickworks. From this pit originates the photograph rendered in V. MILTHERS (1939, p. 25, fig. 2).

The new clay pit has been visited by me repeatedly: 20/7, 21/7, 22/7, and 2/8 1947, as well as 30/5 1961 and 5/5 1962. It is situated immediately NW of the buildings. Originally the clay was dug by hand, down to a depth of more than 10 m. Even at that depth the clay was somewhat sandy and as a rule little calcareous. Most of the shells then were dissolved. In places calcareous parts or even concretions with fairly well-preserved shells were found. In 1962 they began digging with an excavator at a lower level. There the clay is sticky and calcareous.

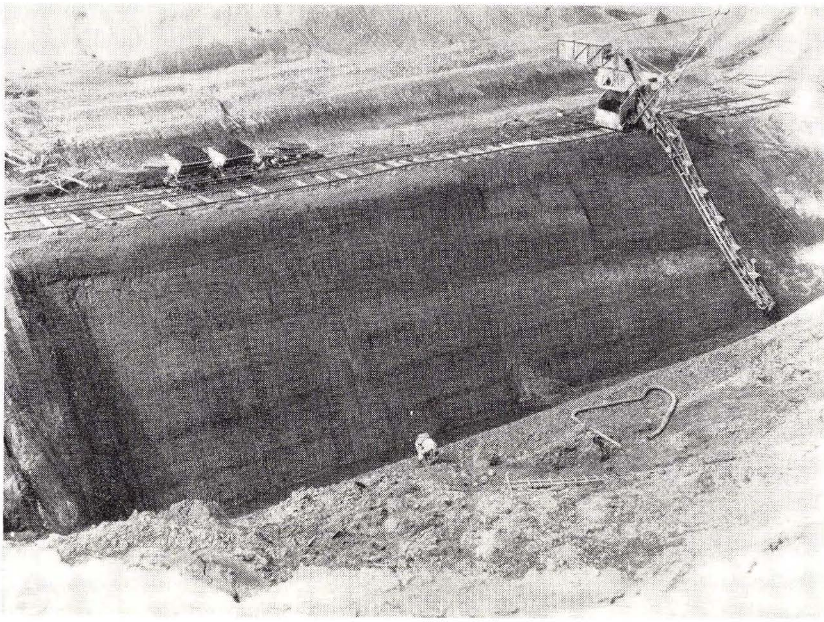

Fig. 26. Digging face in the clay pit of the brickworks of Brande 1963. The wall faces north and strikes east-west. A pale bed is seen a little below the middle of the wall close to the excavator. It rises somewhat towards the east.

Phot. Chr. Westergaard

The Gram Clay is overlain by up to 2 m. meltwater sand, in which floes of Mica Sand has sometimes been observed. The clay immediately below the sand is of an intense yellow colour. In 1962 it was observed in the north wall how the clay is dipping slightly towards the west. In 1947 the Lignite Department of the D.G.U. immediately north of the farm Staldgård, 300 m. ESE of the brickworks, made a boring (D.G.U. File No. 95.325.b) on the ground level + 54 m. The log looks like this:

0.0– 0.2 m.	Loam
0.2– 0.3 –	Brown Hard Pan
0.3– 2.1 –	Meltwater sand, yellow, coarse-grained, stony
2.1– 2.4 –	Clay, yellow (weathered Gram Clay)
2.4–15.8 –	Gram Clay, fossiliferous
15.8–23.1 –	Gram Clay, paler grey, alternating with darker grey beds
23.1–23.2 –	Gram Clay, paler grey, silty, with beds of concretions
23.2–27.9 –	Clay, greenish grey, glauconitic; at 27.4–27.5 m. some bits of wood
27.9–32.7 –	Hodde Clay
32.7–34.4 –	Quartz sand, medium-grained; with gravel of quartz, pea-sized
34.4–35.7 –	Quartz sand and gravel
35.7–36.3 –	Quartz sand, medium-grained (Final depth).

Previously, in 1942, the D.G.U. had made a boring (D.G.U. File No. 95.325.a) to a depth of 17.5 m. at the old pit of the brickworks and found the following section:

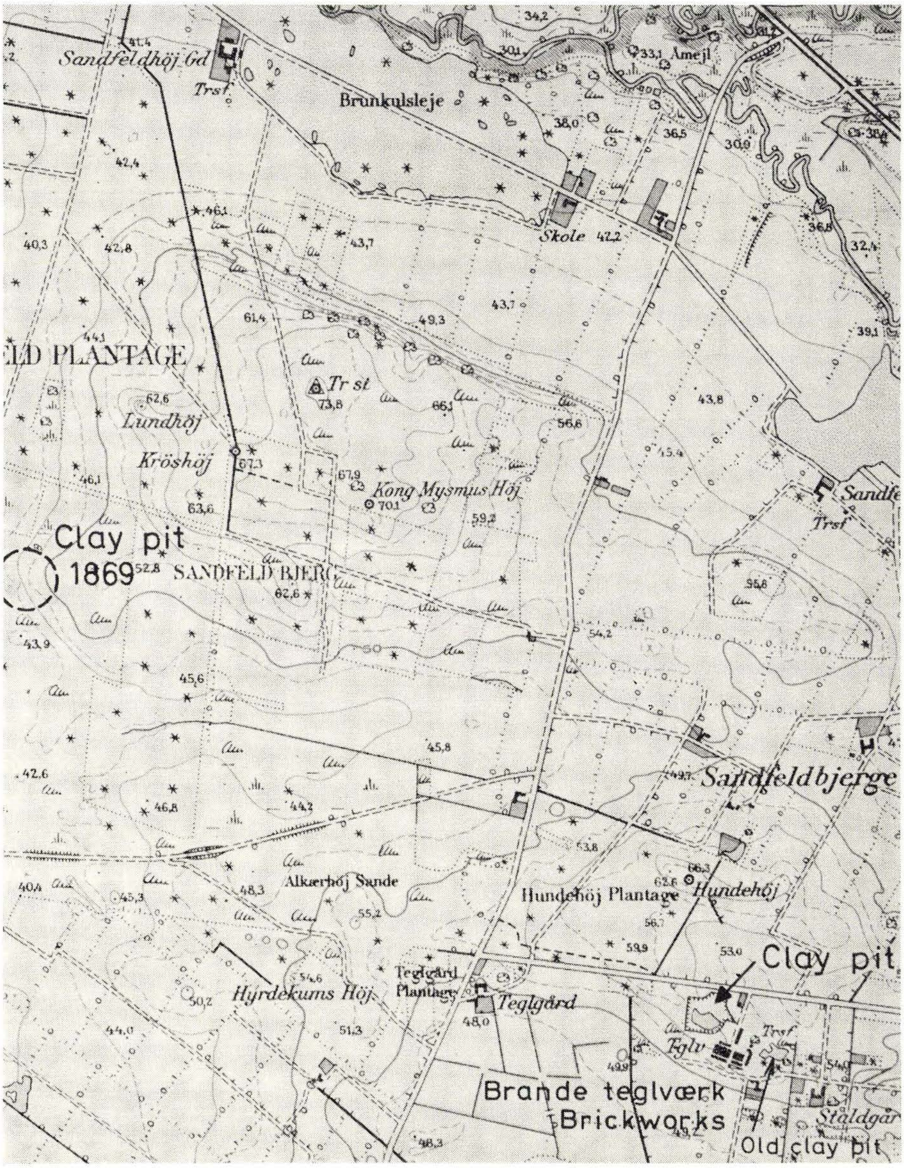

Fig. 27. Situation of the clay pits at Brande Brickworks and the supposed situation of the clay pit at the foot of Sandfeldbjerg mentioned by DALGAS in 1869. The face of the digging rendered on fig. 26 is found at the extreme point of the arrow from the word "clay pit". The old clay pit is identical with the pit mentioned and pictured by V. MILTHERS (1939, p. 24 and fig. 2, p. 25).

(Segment of M 2707 on the scale of 1:20,000).

0.0– 0.6 m. Meltwater sand, medium-grained, stony
0.6– 7.2 – Clay, greenish grey, with much mica
7.2–17.5 – Mica Clay, brownish grey, here and there with shells.

The samples have not been available.

Position of strata: The upper part of the Miocene strata are clearly influenced by glacial deformation. A fold in the Gram Clay was observed in the north wall in 1962, and the boring No. 95.325.a (see above) suggests that Glauconite Clay in places occurs immediately below the meltwater sand.

From the borehole logs it is difficult to see how radical the deformation is. The Gram Clay in the borehole No. 95.325.b is 21.1 m. thick. The upper part of the clay is perhaps deformed, but the disturbances perhaps do not go down under 20 m. below ground level, as the Miocene strata below this depth show normal conditions of thickness. However, it cannot be excluded that the whole sequence has been brought out of its original spatial situation.

Level of the surface of the Miocene: about + 53 m.

Molluscs are available partly as collected loose in the new clay pit, partly in the form of imprints in concretionary clay round bones of whales found in 1919 in the old clay pit. These imprints were determined by H. ØDUM and the determinations published by V. MILTHERS (1939, p. 24). In 1947 concretionary clay was also found in connexion with a number of vertebrae of a whale and other bones belonging to the same animal. These pieces of concretions also contained numerous molluscs the shells of which were well-preserved, but difficult to mount. Faunal analysis, see Table 31, p. 241.

In the samples from borehole No. 95.325.b molluscs are available from the depths 8.5 m. and 13.1 m.

Remarks: Besides the two clay pits at the brickworks of Brande, there have formerly been pits and brickworks at *Hundehøj*, 600 m. north of the brickworks of Brande, and at *Teglgård*, 700 m. west of the brickworks. According to N. HARTZ (1909, p. 75) there were in both places clay pits in "Mica Clay with shells", under which lignite has been found. Fossils or samples of clay do not seem to be available in accessible collections, but probably there have in the places mentioned been diggings of Gram Clay, which obviously is found in a fairly connected area S and SE of the ridge Sandfeldbjerg.

Drantum

Borehole made by the D.G.U. in 1960.
D.G.U. File No. 104.1241.

Situation: 1 km. NNE of the railway station of Drantum, 2.6 km. SW of Brande and 1.5 km. south of Brandlund. Fig. 28.

Ground level: about + 64 m.

Borehole log:

0.0– 1.8 m.	Glacio-fluvial sand
1.8– 6.3 –	Boulder clay
6.3– 9.6 –	Moraine sand
9.6–14.2 –	Meltwater silt
14.2–18.0 –	Meltwater silt, yellowish, micaceous
18.0–21.4 –	Mica Silt, dark, brownish grey, fine
21.4–27.7 –	Mica Clay, silty, dark grey
27.7–33.4 –	Mica Clay, grey to dark grey, with beds of silt, hard
33.4–51.8 –	Gram Clay, fossiliferous; in lower part with beds of concretions
51.8–57.7 –	Clay, dark green, glauconitic
57.7–59.8 –	Hodde Clay, hard
59.8–59.9 –	Quartz sand, medium-grained, greyish brown. (Final depth)

Level of the surface of the Miocene: about + 46 m.

Molluscs are available from large samples taken at the following depths: 36.0–40.0 m., 40.0–44.0 m., 46.0–50.0 m., 51.4–51.8 m. These samples were not weighed before washing, which was made with screens having a width of meshes of 0.5 mm. Faunal analysis, see Table 32, p. 243.

Description of the fossiliferous samples: All the four samples examined consist of typical Gram Clay. The wash residues of the samples from 36.0–40.0 m., 40.0–44.0 m., and 46.0–50.0 m. mainly consist of larger or smaller pieces of pyrite and stems of pyrite. A few grains of quartz. Furthermore, numerous fragments of molluscs and fragments of *Cupuladria haidingeri.* The sample from 51.4–51.8 m. chiefly contains yellowish brown pieces of concretions and some fragments of molluscs.

Remarks: The samples often seem to originate from two different beds apparently squeezed into each other, which suggests glacial dislocation of the strata.

In a sample from the depth of 46.0–50.0 m. there were large quantities of dark grains, which caused the sample to be of comparatively great weight.

For the sake of orientation BIRTHE DINESEN, B. Eng., kindly undertook to make a chemical analysis of the dark ellipsoidal grains. She offers the following comments:

"The grains seem broadly to consist of ferric oxides with a silicate decomposable by acid (probably an iron silicate) and/or free amorphous silicic acid. A certain content of sulphate may be due to weathering of pyrite. No phosphorite was found. On the basis of the chemical analyses it cannot be decided whether the grains are weathered glauconite. It seems that they might otherwise be primarily formed grains consisting of a nucleus of silicic acid surrounded by alternating layers of ferric oxides and silicic acid."

Nyholm

Borehole made by the D.G.U. in 1960.
D.G.U. File No. 104.1166.

Situation: 200 m. north of the farm Nyholm, 1.4 km. NE of the railway station of Drantum, and 2.2 km. SSW of the church of Brande. Fig. 28.

Fig. 28. Situation of the boreholes D.G.U. File Nos. 104.1258 (Brandlund), 104.1241 (Drantum), 104.1158 (Store Langkjær), 104.1166 (Nyholm), and 104.1165 (Skjerris gårde). (Segment of M 2807, reduced to the scale of 1:40,000).

Ground level: about + 61 m.

Borehole log:

0.0– 0.3 m. Clay, brownish grey
0.3– 1.2 – Mica Clay, reddish yellow and brownish grey, sandy, weathered
1.2– 5.2 – Gram Clay, silty
5.2–19.2 – Gram Clay; the last metre with transformed grains of glauconite
19.2–20.2 – Gram Clay, dark brownish grey and greenish grey, gritty clay
20.2–20.9 – Clay, greenish grey, glauconitic
20.9–21.6 – Clay, yellowish green, gritty, glauconitic
21.6–23.5 – Gram Clay (typical)
23.5–26.6 – Clay, slightly yellowish green, gritty, glauconitic
26.6–30.0 – Clay, dark greenish grey, gritty, glauconitic
(Final depth)

Level of the surface of the Miocene: about + 60 m.

Molluscs are available from 4.2–20.2 m. (from each meter), and 22.6–23.5 m. Faunal analysis, see Table 33, p. 244.

Description of selected fossiliferous samples:

7.2–8.2 m. Weight of sample before washing: 93.18 g; after washing: 2.54 g. Silty Gram Clay. The wash residue is highly marked by numerous pale mica flakes, but otherwise is dominated by micro-ellipsoids. Some grains of quartz. Very few pyrite stems. Numerous foraminifera and many fragments of shells. No fragments of bryozoa were observed.

13.2–14.2 m. Weight of sample before washing: 74.94 g; after washing: 1.62 g. Silty Gram Clay. The wash residue contains conspicuous quantities of pale mica flakes. Dominated by micro-ellipsoids. Some, but *relatively* few pyrite stems. A single small *Cupuladria* fragment. Many foraminifera. Some thin-shelled fragments of molluscs.

14.2–15.2 m. Weight of sample before washing: 80.99 g; after washing: 3.98 g. Gram Clay. The wash residue dominated by micro-ellipsoids. Furthermore numerous small pale mica flakes. A few fragments of *Cupuladria* and some foraminifera and fragments of molluscs.

15.2–16.2 m. Weight of sample before washing: 116.09 g; after washing: 4.65 g. Typical Gram Clay. The wash residue dominated by micro-ellipsoids. Pyrite is present in large quantities, in the shape of stems as well as small lumps. Some grains of quartz. Many *Cupuladria* fragments and foraminifera.

17.2–18.2 m. Weight of sample before washing: 98.74 g; after washing: 4.62 g. Typical Gram Clay. The wash residue is of completely the same character as the sample from 15.2–16.2 m.

18.2–19.2 m. Weight of sample before washing: 100.85 g; after washing: 6.54 g. Gram Clay containing glauconite. The wash residue mainly consists of numerous transformed grains of glauconite of a dark brown colour. Furthermore some pyrite. Numerous grains of quartz. Numerous foraminifera, but few remnants of molluscs.

22.6–23.5 m. Weight of sample before washing: 115.55 g; after washing: 6.15 g. Gram Clay. Wash residue mainly consisting of grains of quartz and numerous small mica flakes, which, however, are not dominant. Some stems and lumps of pyrite. Furthermore numerous micro-ellipsoids are seen. Numerous foraminifera, many fragments of *Cupuladria*. Some spines of spatangids.

Remarks: The log shows that the Miocene sequence has been disturbed, as Gram Clay was found in two intervals.

Skjerris gårde

Borehole made by the D.G.U. in 1960.
D.G.U. File No. 104.1165.

Situation: 600 m. SSW of the westernmost of the Skjerris farms, 2.3 km. SE of the church of Brande and 800 north of the built-up area Store Langkjær. Fig. 28.

Ground level: about + 56 m.

Borehole log:

0.0– 3.5 m. Meltwater sand
3.5–15.5 – Gram Clay; from 12.5 m. dominated by transformed grains of glauconite
15.5–20.5 – Clay, greenish grey, glauconitic
20.5–24.4 – Hodde Clay, with quartz gravel below
24.4–30.0 – Quartz sand; fine above, coarser below; micaceous in the whole interval.

Level of the surface of the Miocene: about + 53 m.

Molluscs are available from 8.5–9.5 m., 9.5–10.5 m., 10.5–11.5 m., and 11.5–12.5 m. From 7.5 to 8.5 m. and from 12.5 m. to 14.5 m. only a few fragments. Faunal analysis, see Table 35, p. 245.

Description of the fossiliferous samples:

8.5–9.5 m. Weight of sample before washing: 95.47 g; after washing: 3.61 g. Gram Clay. The wash residue is dominated by micro-ellipsoids and is furthermore marked by the presence of numerous pale mica flakes. Many small grains of quartz. Some stems of pyrite. Many foraminifera and fragments of shells. Ostracods. A single otolite. Fragments and whole zoaria of *Cupuladria haidingeri.*

9.5–10.5 m. Weight of sample before washing: 70.24 g; after washing: 1.71 g. Gram Clay. The wash residue is dominated by micro-ellipsoids. Furthermore highly marked by numerous pale mica flakes. Much pyrite in the form of fragments as well as stems. Many small grains of quartz. Numerous foraminifera. Many fragments of *Cupuladria haidingeri* and of shells.

10.5–11.5 m. Weight of sample before washing: 61.82 g; after washing: 1.14 g. Gram Clay. The wash residue is dominated by numerous pale mica flakes. Furthermore numerous micro-ellipsoids are seen. Some stems of pyrite. Numerous foraminifera. Some ostracods. Many fragments of shells and of *Cupuladria haidingeri.*

11.5–12.5 m. Weight of sample before washing: 104.09 g; after washing: 2.72 g. Gram Clay. The wash residue is dominated by micro-ellipsoids. Smaller contents of pale mica. Much pyrite. A few grains of quartz. Numerous foraminifera. Numerous fragments of *Cupuladria.* Many fragments of shells.

Store Langkjær

Borehole made by the D.G.U. in 1960.
D.G.U. File No. 104.1158.

Situation: In the southeastern part of the village of Store Langkjær, 700 m. SW of the water mill of Langkjær and 3.6 km. SE of the church of Brande. Fig. 28.

Ground level: about + 62 m.

Borehole log:

0.0– 8.1 m.		Meltwater sand
8.1–14.1	–	Gram Clay
14.1–19.1	–	Clay, greenish grey, glauconitic; down to 16.1 m. in part transformed (weathered); below that more unchanged
19.1–20.1	–	Hodde Clay, fractured
20.1–21.1	–	Hodde Clay, with quartz sand and a little quartz gravel
21.1–22.1	–	Hodde Clay, with smaller contents of quartz sand
22.1–22.9	–	Hodde Clay, with little quartz sand
22.9–30.0	–	Quartz sand, brownish grey; from 27.9 m. paler grey, with quartz gravel; the whole micaceous.

Level of the surface of the Miocene: about + 54 m.

Molluscs are available in a small number from the samples from 10.1–11.1 m., 12.1–13.1 m., 13.1–14.1 m. and 19.1–20.1 m. Faunal analysis, see Table 4, p. 208 and Table 34, p. 245.

Description of the uppermost fossiliferous sample:

10.1–11.1 m. Weight of sample before washing: 68.96 g; after washing: 1.30 g. Gram Clay, dark grey with a slightly brownish tint. The wash residue is dominated by pyrite and micro-ellipsoids. Furthermore there are some mica flakes and numerous grains of quartz (contaminations?). Numerous foraminifera and spines of spatangids. Ostracods. Otolite. Fragments of shells of molluscs.

Hjortsballe

Borehole made by the D.G.U. in 1950.
D.G.U. File No. 105.320.

Situation: 2.7 km. NNW of the church of Give, 1.2 km. WNW of Hjortsballe and about 300 km. west of the highway Vejle–Herning. Fig. 29.

Ground level: about + 72 m.

Borehole log:

0.0– 0.2 m.		Mould
0.2– 0.4	–	Sand, mixed with hard pan, brown
0.4– 0.9	–	Meltwater sand, medium-grained, stony, yellow
0.9– 2.2	–	Meltwater sand, partly coarse, stony
2.2– 2.8	–	Gravel and stones
2.8– 2.9	–	Clay, rust-coloured, micaceous, with zones of silt, yellowish
2.9– 3.3	–	Meltwater gravel
3.3– 3.4	–	Mica Clay, rust-coloured, silty (probably weathered Gram Clay)
3.4– 8.2	–	Gram Clay
8.2–12.4	–	Clay, greyish green, fossiliferous
12.4–13.6	–	Hodde Clay, black

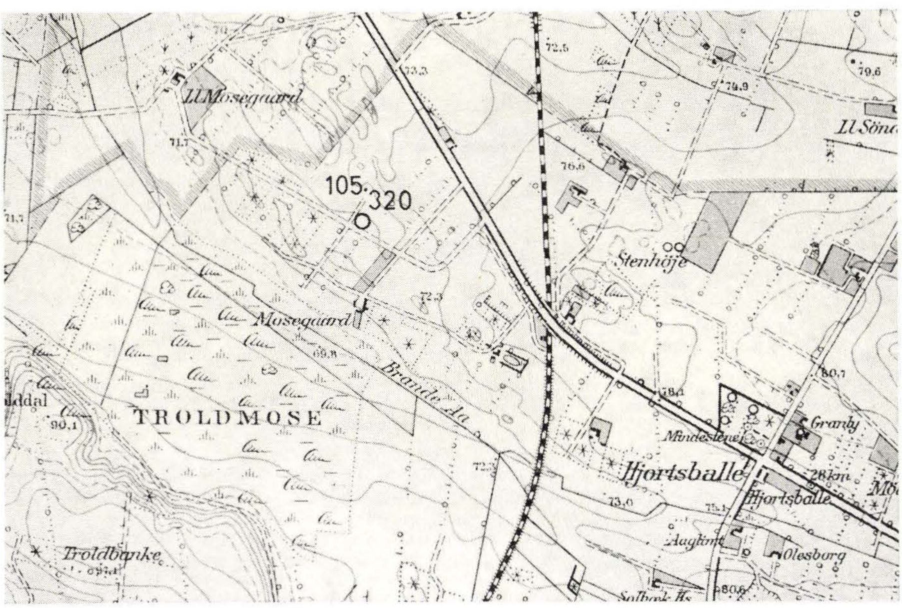

Fig. 29. Situation of borehole D.G.U. File No. 105.320 at Hjortsballe. (Segment of M 2908 on the scale of 1:20,000).

13.6–15.1 – Hodde Clay, brown
15.1–15.3 – Quartz sand and gravel, dark grey, with a few lumps of Mica Clay
15.3–20.8 – Mica Sand, grey, mainly fine-grained. This is followed by quartz sand, Mica Sand and Mica Clay down to the final depth of the drilling, 127.7 m.

Level of the surface of the Miocene: about + 69 m.

Molluscs are available from the interval 3.4–8.2 m. Faunal analysis, see Table 34, p. 245.

Description of the fossiliferous sample: The sample, which consisted of typical Gram Clay, was washed with a screen having a width of meshes of 0.5 mm. The wash residue mainly consists of pyrite, which is sometimes found in bits a few cm. long. Numerous grains of gravel and sand from the Quaternary strata (contaminations the occurrence of which is due to the contact of the sample with the surface of the ground). Numerous fragments of *Cupuladria* and *Lunulites*.

By a mistake in the laboratory the sample unfortunately was treated with H_2O_2 before being washed, through which the surface of nearly all the shells – because of the high content of pyrite in the sample – was transformed into limonite.

Region III

The Skern–Ølgod–Ansager Area

Marine Younger Miocene deposits occur evenly distributed over the whole area of the region, but the occurrences are all glacially dislocated.

Perhaps the area stretches as far NW as Ringkøbing, for N. Hartz (1900, p. 40) mentions a previous brickworks at *Rydbjerggård* where marine Miocene clay was dug, and from where teeth of sharks and bones of whales are available. Considering the utility of the marine Younger Miocene strata for the production of bricks, the greatest probability is that there was an occurrence of Gram Clay. Vertebrae of whales have furthermore been found in Mica Clay at a brickworks now closed down at *Sæding* (see Nordmann 1905, p. 18). Perhaps Gram Clay was also dug there.

The area is a direct continuation towards the south of Region I. The Hodde Clay is underlaid now by limnic, now by marine strata (see e. g. the localities at Odderup and Hodde; cf. Rasmussen 1961, pp. 14–15).

The number of localities in the region amounts to 14, 5 of which are boreholes, 7 clay pits at brickworks, 1 a lignite pit, and 1 a canal system. The last-mentioned locality actually includes two separate occurrences, and as borings have been made in connexion with several of the outcrops, the total number of observation points is 20 in all.

Leding

Borehole at Frost Andersen's farm. Made in 1961.
D.G.U. File No. 93.155.

Situation: 2 km. NNE of the brickworks of Alkærsig, 5 km. NNW of the railway station of Skern and 3.2 km. SE of the church of Dejbjerg. Fig. 30.

Fig. 30. Situation of borehole D.G.U. File No. 93.155 at Leding.
(Segment of M 2703 in 1:20,000).

Ground level: about + 33 m.

Borehole log:

0– 1 m. ?
1– 5 – Mica Clay, dark grey, silty
5–10 – Mica Clay, black, apparently carboniferous
10–12 – Mica Clay, grey – dark grey
12–14 – Mica Clay, with fragments of shells
14–15 – Clay, greenish black – greenish, containing glauconite
15–16 – Clay, yellowish grey, sticky
16–17 – Mica Clay, dark grey – black, silty
17–19 – Mica Clay, dark grey, sticky; with fossil fragments (*Cupuladria*) (Gram Clay)
19–27 – Mica Silt, brownish black
27–28 – Mica Silt, with fragments of shells
28–32 – Mica Silt, fine, brownish black, slightly calcareous, with a few fragments of shells.

Level of the surface of the Miocene: about + 33 m. (?)

Molluscs are available from 10–12 m., 12–14 m., 16–17 m., 17–18 m., 18–19 m., 19–27 m., 27–28 m., 31 m., and 28–32 m. Faunal analysis, see Table 5, p. 208 and Table 36, p. 246.

Description of the samples:

1–5 m. Weight of sample: 122.81 g. Weight of wash residue: 5.42 g. Dominance of numerous grains of quartz of varying sizes. Numerous lumps of clay not washed. Much pyrite. A small piece of flint. Fossils only present in the shape of casts of pyrite.

5–10 m. Weight of sample: 134.64 g. Weight of wash residue: 5.05 g. Dominance of pyrite, mostly of a slag-like appearance. Many stems of pyrite. Numerous grains of quartz. Small pieces of flint of a yellow colour. No fossils.

10–12 m. Weight of sample: 185.77 g. Weight of wash residue: 13.16 g. Dominance of quartz sand. Some pyrite. Fragments of *Cupuladria canariensis* and *C. haidingeri*. A few fragments of molluscs and of foraminifera.

12–14 m. Weight of sample: 128.90 g. Weight of wash residue: 6.59 g. Dominance of quartz sand and bits of pyrite. Numerous fragments of *Cupuladria haidingeri*. Foraminifera. A few fragments of molluscs.

14–15 m. Weight of sample: 140.24 g. Weight of wash residue: 44.45 g. The wash residue exclusively consists of yellowish brown grains, which presumably are transformed glauconite. Some pyrite. Pieces of yellow-violet-brown clay ironstone concretions.

15–16 m. Weight of sample: 83.97 g. Weight of wash residue: 18.45 g. Dominance of pieces of brown concretions. Numerous yellowish brown and some green grains (in part transformed glauconite). No fossils.

16–17 m. Weight of sample: 151.19 g. Weight of wash residue: 5.62 g. The wash residue consists of a mixture of bits of pyrite, quartz sand, and small particles of clay. Many fragments and a few whole zoaria of *Cupuladria haidingeri.* A small tooth of a shark. A few foraminifera. A few fragments of shells. Some yellowish brown "flakes of clay".

17–18 m. Weight of sample: 133.75 g. Weight of wash residue: 4.65 g. The wash residue has the same appearance as the preceding one. Numerous fragments of *Cupuladria haidingeri.* Many fragments of molluscs.

18–19 m. Weight of sample: 76.98 g. Weight of wash residue: 2.05 g. Wash residue of the same appearance as the two preceding ones. Some fragments of *Cupuladria haidingeri.* Many foraminifera. Somewhat more fragments of molluscs than in the preceding sample.

19–27 m. Weight of sample: 103.60 g. Weight of wash residue: 6.54 g. Dominance of quartz sand and mainly greenish particles of clay (some of these are yellowish brown). Numerous fragments of shells.

27–28 m. Weight of sample: 193.00 g. Weight of wash residue: 14.73 g. Dominance of quartz sand and numerous mica flakes. Numerous fragments of molluscs and fragments of *Lunulites* sp.

28–32 m. Weight of sample: 128.39 g. Weight of wash residue: 18.88 g. Dominance of mainly indeterminable fragments of molluscs and quartz sand and gravel. A few fragments of *Lunulites* sp.

31 m. Weight of sample: 63.14 g. Weight of wash residue: 3.90 g. Dominance of quartz sand, mica flakes, and dark grey-black-greenish micro-ellipsoids, and numerous fragments of molluscs. Many small grains of glauconite.

Remarks. The uppermost strata in the borehole, viz. from 1 to 14 m., seem to consist of a mixture of Hodde Clay and Gram Clay, whereas the strata from 14–16 m. clearly are Glauconite Clay. The underlying strata from 16 to 19 m. are Gram Clay contaminated by quartz sand. From 19 to 27 m. conditions are only partially known. The only sample from this interval seems to show the presence of Glauconite Clay. The lowermost strata from 27 to 32 m. are most marked by Hodde Clay and silt with shelly beds, analogously with conditions around Shell Bed I at Hoddemark (se page 100).

All the samples are more or less contaminated by quartz sand, and the abnormal order of the clay beds suggests glacial deformation of the sequence.

Alkærsig

The occurrence of Gram Clay at Alkærsig has been known for a very long time. N. HARTZ (1900, p. 40) seems to have been the first geologist to have mentioned the locality (under the name of "Dejbjerg Brickworks"). A few years later

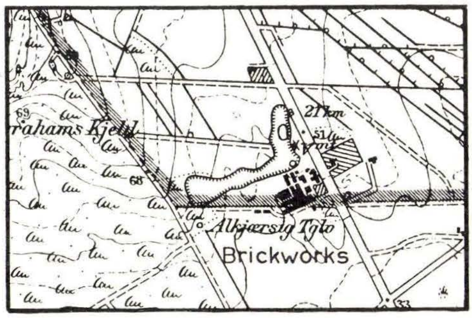

Fig. 31. Situation of the clay pit of the brick-
works of Alkærsig about 1911.
(Segment of M 2703 in 1:20,000).

RAVN (1907, p. 232) described it, and E. M. NØRREGAARD in 1909 communicated interesting details from the sections of the pit of the brickworks.

In 1956 the D.G.U. executed a 92 m. deep boring at the pit. A detailed log has been published by RASMUSSEN (1961, pp. 16–19).

1. The pit of the brickworks.

Situation: 3.9 km NW of the church of Skern and immediately west of the highway Skern – Ringkøbing (close to the 21 km. stone). Figs. 31 og 33.

Ground level: + 14 m.—+22 m.

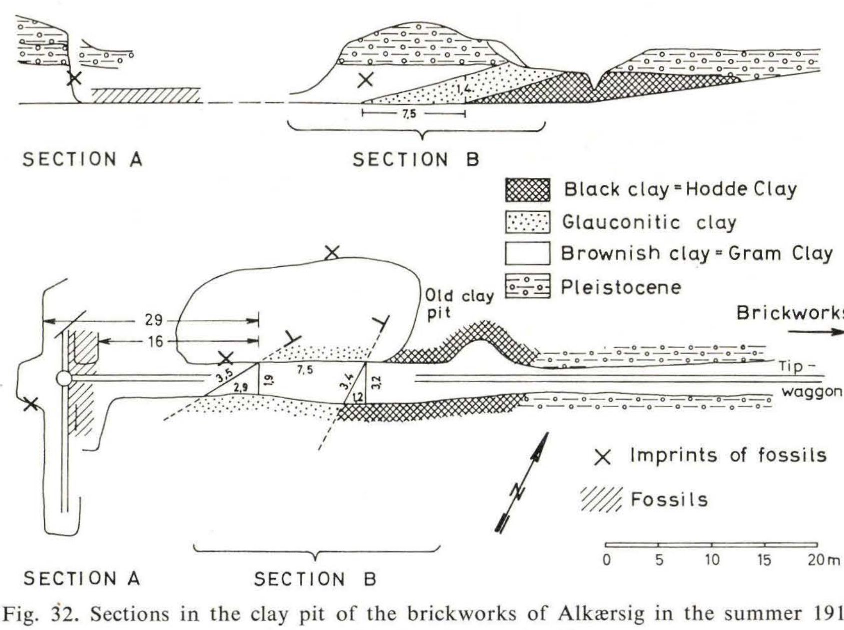

Fig. 32. Sections in the clay pit of the brickworks of Alkærsig in the summer 1919.
(From H. ØDUM's note-book).

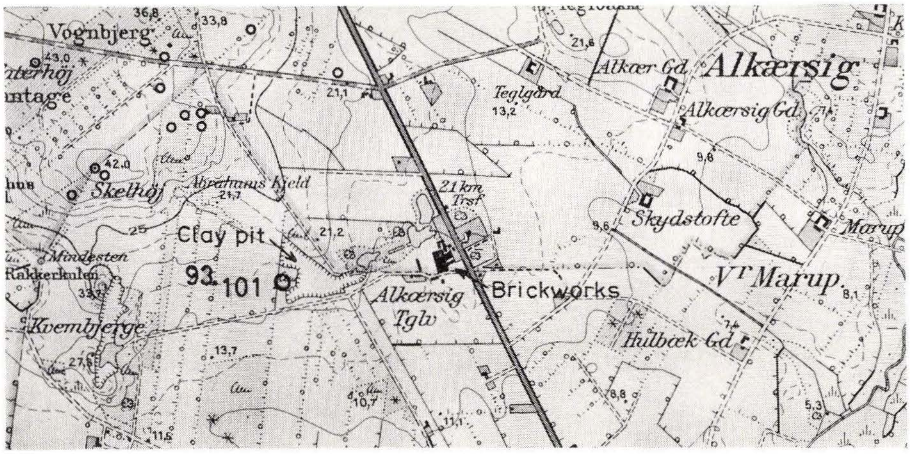

Fig. 33. Situation of the new clay pits at the brickworks of Alkærsig down to about 1962, and borehole D.G.U. File No. 93.101.
(Segment of map sheet 1114 III NØ on the scale of 1:25,000).

Description: The pit of the brickworks is situated north and west of the buildings, the oldest part facing north. It appears from RAVN's mention of the place (*loc. cit.*) that "typical Upper Miocene Mica Clay, which, however, in some places contained fairly much glauconite" was found there. This shows that besides Gram Clay probably also Glauconite Clay (the basal layer of the Gram Clay) was present.

The northern part of the clay pit seems to have been abandoned shortly before 1909 and a new pit started west of the brickworks, to which there was access through a long canal, which in part was dug in meltwater sand and among other things crossed a late-Glacial river bed filled with layers of sand and peat (see NØRREGAARD *loc. cit.*).

NØRREGAARD as regards Miocene layers in the new clay pit, only mentions "dark brown Mica Clay with a thick layer of green, pyritous clay."

In 1919 the clay pit was visited by H. ØDUM, who in his note-book (kindly placed at my disposal) makes the following note about the sequence of strata then found in the sections:

"(a) Black, sticky clay, highly fractured, stinking. No fossils were found.
(b) Glauconite Sand. The boundary towards (a) is not very sharply defined, but still more or less distinct. On the other hand (b) is evenly merged into (c). There are no fossils here, either. The layer is about 1.35 m. thick.
(c) Ordinary brownish-grey Mica Clay."

During my first visit to the locality on the 15th of August 1948 I only found Gram Clay and did not make any notes concerning the sequence of strata and the bedding features. An examination of rather short duration on the 10th of August 1956 showed that in a large new digging area in a northerly direction

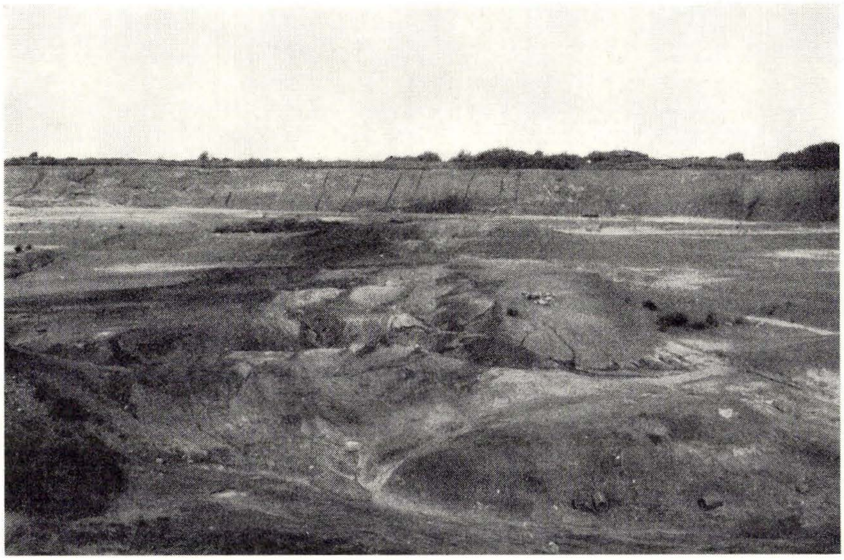

Fig. 34. The clay pit of the brickworks of Alkærsig photographed towards the NE from the place in fig. 33, where the arrow from the word "clay pit" ends. The dark shadow across the picture on the left is a fold of Hodde Clay underlain by pale quartz sand with numerous pebbles of quartz. These last layers are left as large hills to the right of the Hodde Clay. On both sides of the layers mentioned there is fossilfree Gram Clay.

Phot. Chr. Westergaard 1962

there was little Gram Clay, but in return large parts of grey Mica Sand with numerous thin beds of dark Mica Clay (see fig. 2, p. 13), furthermore quartz gravel, Hodde Clay, and Glauconite Clay. Unfortunately the sections were not fresh the day in question. The same was the case during my visit on the 6th of May 1962, when the digging area in question proved to have been abandoned and a new clay pit was being started farther west. On a visit to the locality in June 1963 what was found in this pit was only partially reworked and "impure" Gram Clay, which did not contain any fossils, apart from a few, in part weathered shells of molluscs, especially of *Limopsis aurita.*

One more clay pit was being worked about 20 years ago in the hilly area *Kvembjerge* (see fig. 33), 1.1 km. west of the brickworks. I do not know that clay pit from personal inspection.

The sequence of strata in the clay pits of the brickworks at Alkærsig is as follows:

5. Gram Clay
4. Glauconite Clay
3. Hodde Clay
2. Quartz gravel
1. Grey Mica Sand with thin beds of dark Mica Clay.

The Miocene strata are overlain by meltwater sand with podsols in the uppermost layers. In a few places boulder clay has been observed below this sand (NØRREGAARD *loc. cit.* p. 318).

Position of strata: The Miocene layers are clearly dislocated. H. ØDUM's observations from the summer of 1919 show that the layers in the place in question dip towards the NW (cf. fig. 32, p. 74, drawn from a sketch in ØDUM's note-book). In 1956 and 1962 the layers in the digging section of the time were seen to be partly folded, partly smeared out. Thus, there has undoubtedly been a glacial deformation (cf. fig. 34).

Level of the surface of the Miocene: + 12—+ 20 m.

Molluscs are available only from the Gram Clay. Collections were made from the floor and walls of the clay pit. In the collections of the Mineralogical Museum there is material collected by HARTZ, NØRREGAARD, and others. In those of the D.G.U. there are fossils collected by ØDUM and others. My own collections mainly originate from the visit of the 15th of August 1948. Later I did not succeed in finding any fossils apart from the above-mentioned half dissolved shells in the newest clay pit. All collections are disconnected findings, and samples have not been taken for quantitative faunal analysis. Faunal analysis, see Table 37, p. 246.

2. The borehole at the pit of the brickworks.

D.G.U. File No. 93.101. Made by the D.G.U. in 1956.

Situation: Immediately west of the western end of the clay pit at the time. Fig. 33.

Ground level: + 20 m.

Borehole log:

0.0– 3.2 m.	Meltwater sand; podsols at the top
3.2– 4.2 –	Hodde Clay, below with numerous fragments of shells
4.2– 6.3 –	Glauconite Clay, dark green
6.3–10.6 –	Gram Clay
10.6–13.4 –	Glauconite Clay, dark green
13.4–15.9 –	Hodde Clay, fractured at the top, farther down silty, and at the bottom with quartz gravel
15.9–92.0 –	Mica Silt alternating with Mica Clay and quartz sand (Concerning details see RASMUSSEN 1961, pp. 17–19).

Level of the surface of the Miocene: about + 17 m.

Molluscs are available from 7.0 m., 8.0 m., 8.5 m., 9.0 m., and 10.0 m. Faunal analysis, see Table 37, p. 246.

Description of the fossiliferous samples: All the samples consist of typical Gram Clay. They have been washed with a screen having a width of meshes of 0.1 mm.

7.0 m. Weight of sample: 108.63 g. Weight of wash residue: 1.14 g. Dominance of slightly weathered micro-ellipsoids. Some glauconite. Numerous bits of pyrite. A few small pieces of flint and grains of quartz. No shells. A single pyrite cast of *Spiratella atlanta.*

8.0 m. Weight of sample: 176.15 g. Weight of wash residue: 5.32 g. Dominance of irregular particles of clay, some of which are pale green and seem to be glauconite. Many bits of pyrite. Numerous foraminifera and fragments of *Cupuladria haidingeri.* Many fragments of molluscs. Remnants of spatangids. Ostracods.

8.5 m. Weight of sample: 148.92 g. Weight of wash residue: 6.10 g. Dominance of irregular particles of clay. Some stems of pyrite. Many foraminifera, fragments of molluscs, of *Cupuladria haidingeri,* and of *Lunulites* sp.

9.0 m. Weight of sample: 165.43 g. Weight of wash residue: 3.72 g. Appearance as the preceding sample, but with considerably higher contents of quartz sand. Many fragments of molluscs and foraminifera. Fragments of *Cupuladria haidingeri* and *Lunulites* sp.

10.0 m. Weight of sample: 264.30 g. Weight of wash residue: 18.79 g. Dominance of glauconite. Many stems of pyrite. Many grains of quartz. Numerous fragments of molluscs (especially from a shell of *Galeodea echinophora*) and *Cupuladria haidingeri.*

Remarks: The Upper Miocene beds in the boring are evidently dislocated, as the sequence of strata is inverse from 3.2 to about 8 m., and below that in the correct succession. The deformations are most probably glacigenous.

Lønborg

Borehole made by the D.G.U. in 1959.
D.G.U. File No. 102.55.

Situation: 500 m. west of the church of Lønborg and 1 km. south of the present bed of the Skern river. Fig. 35.

Ground level: about + 3 m.

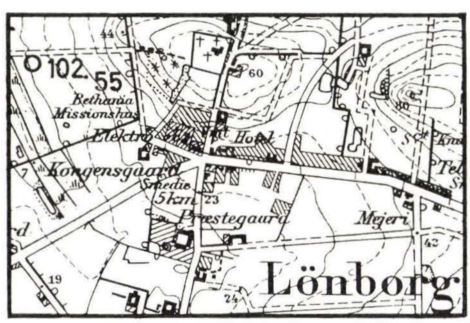

Fig. 35. Situation of borehole D.G.U. File No. 102.55 at Lønborg.
(Segment of M 2803 in 1:20,000).

Borehole log:

0.0– 0.9 m. Meltwater sand
0.9– 3.3 – Boulder clay
3.3–12.3 – Gram Clay
12.3–16.3 – Green glauconitic clay
16.3–21.3 – Hodde Clay
21.3–22.3 – Hodde Clay, with beds of Mica Silt
22.3–25.1 – Mica Silt, grey, with concretions and numerous shells of molluscs
25.1–27.9 – Mica Clay, brownish grey, with layers of silt
27.9–30.0 – Mica Silt, grey.

Level of the surface of the Miocene: about 0 m.

Molluscs are available from the following depth intervals: 6.3–7.3 m., 7.3–8.3 m., 8.3–9.3 m., 9.3–10.3 m., 10.3–11.3 m., 11.3–12.3 m. and 12.3–13.3 m. Furthermore, some indeterminable fragments of molluscs were found in the sample from 16.3–17.3 m., whereas the interval 21.3–22.3 m. contained some fragments of partly determinable molluscs. Faunal analysis, see Table 6, p. 210 and Table 38, p. 247.

Description of the fossiliferous samples:

6.3–7.3 m. Typical Gram Clay. Weight of sample: 95.13 g. Weight of wash residue: 2.11 g. The wash residue mainly consists of micro-ellipsoids and few stems of pyrite and pale mica flakes. Scattered small grains of quartz. Some fragments of *Cupuladria* and few fragments of molluscs, especially pelecypods. Many foraminifera.

7.3–8.3 m. Typical Gram Clay. Weight of sample: 94.31 g. Weight of wash residue: 2.76 g. The wash residue is of the same character as the preceding one. The stems of pyrite and the fragments of *Cupuladria* have increased in number. Pieces of fishbones (i.a. vertebrae). Few pale mica flakes and rather few fragments of molluscs. Many foraminifera.

8.3–9.3 m. Typical Gram Clay. Weight of sample: 86.21 g. Weight of wash residue: 7.21 g. The wash residue is to a higher degree dominated by micro-ellipsoids than that of the previous samples. Very few pale mica flakes. Stems of pyrite are rare. Few fragments of *Cupuladria*. A few grains of quartz. Some foraminifera, but few fragments of shells.

9.3–10.3 m. Typical Gram Clay. Weight of sample: 90.90 g. Weight of wash residue: 2.41 g.

10.3–11.3 m. Typical Gram Clay. Weight of sample: 92.14 g. Weight of wash residue: 1.76 g.

11.3–12.3 m. Typical Gram Clay. Weight of sample: 107.95 g. Weight of wash residue: 1.38 g. The wash residues in the three samples mentioned above dominated by micro-ellipsoids, but now containing many stems of pyrite and fragments of *Cupuladria*. Numerous foraminifera and many fragments of shells.

16.3–17.3 m. Hodde Clay containing glauconite. Weight of sample: 84.25 g. Weight of wash residue: 2.98 g. The wash residue dominated by dark green grains of glauconite, but also containing many bits of pyrite and some grains of quartz. Some foraminifera and fragments of shells (corroded fragments of *Dentalium sp.* and *Yoldia sp.*).

21.3–22.3 m. Weight of sample: 153.21 g. Weight of wash residue: 6.29 g. The wash residue is dominated by grains of quartz, to which should be added numerous grains of glauconite and fragments of shells. Furthermore some small bits of pyrite and many mica flakes. Numerous foraminifera.

Forsom

Situation: Clay pits north of the brickworks of Forsom (or Foersum), which is situated 1.8 km. SSW of the church of Egvad, 4.4 km. south of the railway station of Tarm and 700 m. east of the highway from Tarm to Varde. Fig. 36.

Ground level: about + 21 m.

Sequence of strata: The occurrence was first mentioned by N. HARTZ (1900, p. 40) and some years later by RAVN (1907, p. 232).

The oldest pit of the brickworks was situated E and NE of the buildings. Apparently only Gram Clay was dug. RAVN (*loc. cit.*) made the following statement: "The uppermost part of the Mica Clay during my visit in 1902 seemed to have been kneaded together with boulder clay and to form a kind of glacial floe." See fig. 37.

During short visits to the locality on 15/8 1948 and 10/8 1956 I only, apart from Gram Clay without fossils, observed detached pieces of concretions with imprints of *Astarte*, *Nucula*, and *Isocardia*.

In 1960–61 they started digging clay about 200 m. west of the old clay pit, which is situated east of the brickworks and stretches 400 m. in a northerly direction.

In the new clay pit, which is situated 300 m. due north of the brickworks, there are, besides Gram Clay, Glauconite Clay and Hodde Clay. The boundary between the layers dips towards W or SW. See fig. 38. When on 7/5 1962 I visited the clay pit, it had just been emptied of water, and the clay was still covered by ooze, which prevented detailed studies. The Miocene beds are overlain by some one or two metres of stony meltwater sand, in which a 3–4 m.

Fig. 36. Situation of the new and the old clay pits of the brickworks of Forsom. (Segment of map sheet 1114 III SØ on the scale of 1:25,000).

Fig. 37. The old clay pit of Forsom (or Foersum) in 1956, photographed from its northeastern end towards the southwest.

Phot. L.B.R. 1956

deep pit has been started immediately east of the clay pit. The clay beds thus seem to be situated more deeply towards the east.

Position of strata: As the Miocene beds have clearly been dislocated, it is probable that they have been exposed to glacial deformation. Apart from the above-mentioned observation of the dips in the new clay pit, it has not been possible to make detailed observations as regards the position of the beds.

Level of the surface of the Miocene (in the new clay pit): about + 19 m.

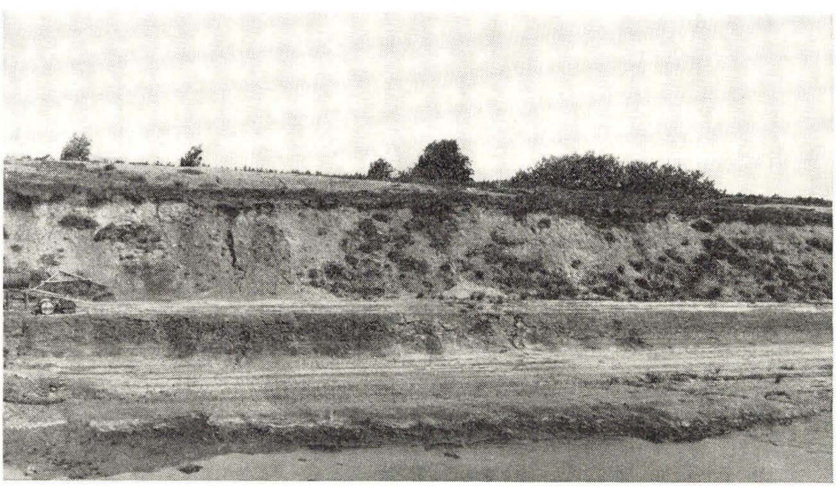

Fig. 38. The new clay pit at the brickworks of Forsom. Part of the north wall. In the slope to the ledge in the middle of the wall steep layers of Hodde Clay (dark) are seen on the left, then the paler Glauconite Clay, and finally on the right, Gram Clay.

Phot. Chr. Westergaard 1962

Molluscs have, as mentioned above, been found in concretions. In the new clay pit some badly preserved shells were found in samples of Gram Clay taken on 7/5 1962. Faunal analysis, see Table 39, p. 248.

Description of the fossiliferous sample:

Sample taken at the floor of the clay pit (about 7–8 m. below the ground level). Weight: 2748 g. Weight of wash residue: 223.61 g. It consists of partly weathered Gram Clay. The wash residue is dominated by micro-ellipsoids. Furthermore, there are many stems of pyrite. The fossils (foraminifera and molluscs) are in part dissolved.

Odderup

In the region north of the built-up area Odderup, Gram Clay is dug in the pit of a brickworks, close to which the D.G.U. in 1957 made a boring 82 m. deep.

The occurrence has been known for a large number of years, it being mentioned in the literature (H. WINGE 1904, p. 295) that in 1885 findings of teeth and pieces of bones of whales (*Hoplocetus*) were made in Miocene Mica Clay at the brickworks of Odderup. Other findings of bones of whales (*Plesiocetus*) were made in 1908 (H. WINGE 1910, p. 2), but molluscs are not mentioned in the literature from this locality.

Fig. 39. Situation of the clay pit of the brickworks of Odderup and borehole D.G.U. File No. 103.150 close to the northeastern corner of the pit. (Segment of map sheet 1114 II SV on the scale of 1:25,000).

1. The brickworks.

Situation: 2 km. ESE of the church of Ådum (= Oddum) and about 1 km. north of the built-up area Odderup. Fig. 39.

Ground level: about + 26 m.

Sequence of strata: The old pit of the brickworks was full of water when I visited the locality on 7/5 1962. A new section was being dug immediately NW of the buildings of the brickworks. Gram Clay was seen there, overlain by meltwater sand, but because of removal of overburden and covering of the slope in older parts excavated, it was not possible to obtain a clear impression of the sequence of strata.

Molluscs are not available from the pit of the brickworks, apart from a cast with attached layer of mother-of-pearl of a double valve of *Nucula georgiana* SEMPER, collected by the owner of the brickworks and presented to KELD MILTHERS, Ph. D., in 1957.

2. The borehole D.G.U. File No. 103.150. Made by the D.G.U. in 1957.

Situation: Immediately north of the northeastern corner of the brickworks. Fig. 39.

Ground level: about + 25 m.

Borehole log:

0.0– 8.3 m.	Boulder clay
8.3– 9.6 –	Meltwater sand, coarse, stony
9.6–22.0 –	Gram Clay, fossiliferous
22.0–23.1 –	Clay, greenish, glauconitic
23.1–27.8 –	Hodde Clay, black, fossiliferous
27.8–28.2 –	Quartz gravel, with flint nodules
28.2–29.8 –	Lignite
29.8–37.5 –	Quartz sand, rather coarse, with quartz gravel
37.5–38.2 –	Quartz sand, micaceous
38.2–40.3 –	Quartz gravel, with fine Mica Sand and lignite wood
40.3–82.0 –	Alternating beds of Mica Clay and Mica Sand, in places with shelly beds (57–59 m. and 81.7 m.) or with quartz gravel (59.8–61.7 m. and 64.6–65.0 m.).

Final depth: 82.0 m.

Level of the surface of the Miocene: about + 15 m.

Molluscs are available from large samples taken in the intervals 14.5–20.0 m., 20.0–21.0 m., and 24.8–25.6 m. Faunal analysis, see Table 7, p. 210, and Table 40, p. 249.

Description of fossiliferous samples:

The wash residues mainly consist of pyrite with numerous fragments of molluscs and *Cupuladria*.

Oddum

In the region of Oddum (=Ådum), 6 km. SE of Tarm, Miocene beds immediately below the ground have been shown to occur partly in a lignite pit and a borehole north of the village at Lundsby, partly in a borehole in Oddum itself. The borehole at Lundsby, however, does not show any Younger Miocene layers.

1. Lignite pit at Lundsby.

Situation: 1.4 km. NNW of the church of Oddum (= Ådum) and 4 km. east of the church of Egvad, 500 m. NE of the Lundsby farm. Fig. 40.

Ground level: about + 15—+ 20 m.

Sequence of strata: Digging of lignite was started in this place in the years before 1956 and continued for few years. Only a rather short stretch was dug at a time, and the material dug out was removed into the digging areas abandoned. The total length of the area dug amounts of 600 m. There seem to have been two separated pits, which, however, hardly were worked at the same time.

The stratigraphical conditions in the lignite pit are difficult to elucidate because of the rather complicated dislocations of the layers.

I visited the locality twice in August 1956, the first time during the excursion of the Dansk Geologisk Forening to Southwest Jutland, in the report on which a brief outline of the geological conditions in the lignite pit was published (V. Milthers a. o. 1957, p. 260). In September of the same year and in June 1957, the locality was examined by P. Ingwersen, who kindly has placed material from his diary and the fossils collected by him at my disposal.

P. Ingwersen's and my own observations show that the following sequence occur in the lignite pit:

	Thickness (according to Ingwersen)
Glacio-fluvial sand, stony, bedded	
Gram Clay	> 2 m.
Glauconite Clay	About 0.6–1.0 m.
Hodde Clay	About 0.5 m.
Quartz silt alternating with thin beds of dark clay	About 0.5 m.
Quartz silt Quartz sand, coarse and gravelly	About 0.4 m.
Quartz sand, medium- to coarse-grained	About 0.7 m.
Lignite, in places with stumps in situ	About 3 m.
Quartz sand	

The thicknesses stated are hardly quite identical with the original ones from before the deformation of the beds, as there is a fairly great variation of the

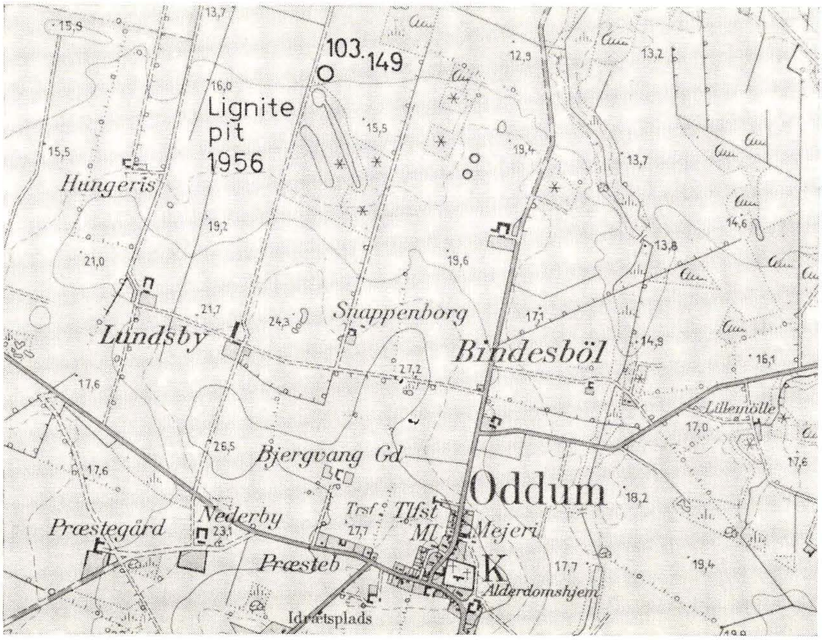

Fig. 40. Situation of lignite pit at Oddum and borehole D.G.U. File No. 103.149 immediately north of the pits. The conditions mentioned in the text p. 84 were observed at the southern end of the western pit.
(Segment of map sheet 1114 II SV on the scale of 1:25,000).

measures from section to section. In many places the clay beds above the quartz sand have not been preserved.

At the excursion mentioned above, a large tooth of a *Carcharodon* and the imprint of an *Astarte* were found in the Hodde Clay. Other fossils have not been kept from this layer.

The Gram Clay, on the other hand, was fossiliferous in certain parts; according to INGWERSEN especially in the southern parts of the outcrop.

In places the Glauconite Clay reached into the oxydation zone, where it was transformed into limonite.

Position of strata: The dislocation of the beds is fairly radical everywhere in the occurrence, especially as regards the upper series of layers. The layer of lignite and the surrounding quartz sand have been folded downwards in a large syncline, so that the lignite bed is vertical towards the east, bends strongly at the bottom of the trough, and then slopes evenly upwards towards the west. Inside the fold there is quartz sand below and above that Hodde Clay, Glauconite Clay, and Gram Clay, often crushed, smeared out, or kneaded together.

The deformations are undoubtedly due to an ice-thrust or other glacially conditioned actions.

Molluscs are available from the Gram Clay, having been collected by P. INGWERSEN in two different places in the lignite pit, respectively in the east and west wall of the southernmost part of the pit in 1956. A single small sample from each of these points has been washed. Faunal analysis, see Table 41, p. 250.

Description of the fossiliferous samples: Both samples consist of typical Gram Clay.

Remarks: In 1957 the D.G.U. (File No. 103.149) made a 100.2 m. deep borehole immediately north of the lignite pit. The Quaternary layers in this borehole go down to a depth of 13.2 m., after which quartz sand and gravel continue down to 17.2 m. In the rest of the borehole there are alternating beds of marine fossiliferous Mica Clay and Mica Silt, in places with shelly beds (48.7–49.0 m. and 56.1–59.0 m.), concretions (30.0–31.0 m.; 32.4–32.6 m.; 36.0–37.0 m., and 70.0 m.), and quartz gravel (thus 94.2–94.3 m.).

The level of the surface of the Miocene is here about + 2 m. The whole of the Younger Miocene series, i.e. the Gram Formation and the Hodde Formation, has been removed in this place, while the Arnum Formation or perhaps the Odderup Formation is situated immediately below the Quaternary beds.

Ålbæk Eng

Borehole made by the Raw Material Department of the D.G.U. in 1959.
D.G.U. File No. 102.59.

Situation: 2.6 km. east of the church of Hemmet, 1.2 km. west of the inn of Brosbøl, in the area "Østerhede". Fig. 41.

Ground level: about + 22 m.

Borehole log:

0.0– 1.7 m. Meltwater sand (Quaternary)
1.7– 3.8 – Boulder clay (Quaternary)
3.8– 8.6 – Meltwater sand (Quaternary)
8.6– 9.0 – Meltwater clay (Quaternary)
9.0–10.8 – Meltwater sand (Quaternary)
10.8–11.8 – Meltwater clay (Quaternary)
11.8–13.8 – Gram Clay mixed with dark grey clay containing glauconite, reworked
13.8–15.8 – Gram Clay and Hodde Clay mixed, reworked
15.8–18.8 – Clay, glauconitic, sandy and with pieces of concretions, probably reworked
18.8–26.8 – Gram Clay
26.8–27.8 – Clay, dark green with a yellow tint (contents of slightly weathered glauconite)
27.8–30.0 – Clay, dark green, glauconitic.
(Final depth).

Level of the surface of the Miocene: about + 3 m.

Molluscs are available from the following depths: 18.8–19.8 m., 19.8–20.8 m., 20.8–21.8 m., 21.8–22.8 m., 22.8–23.8 m., 23.8–24.8 m., 24.8–25.8 m., and 25.8–26.8 m. Faunal analysis, see Table 42, p. 250.

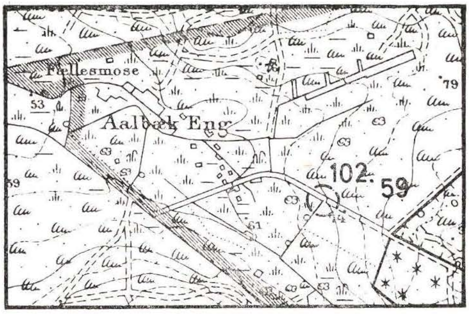

Fig. 41. Situation of borehole D.G.U. File No. 102.59 in Ålbæk Eng.
(Segment of M 2903 on 1:20,000).

Description of the fossiliferous samples:

18.8–19.8 m.	Weight of sample before washing:	76.20 g;	after washing:	2.45 g
19.8–20.8 –	– – – – –	83.12 –	– –	2.76 –
20.8–21.8 –	– – – – –	85.85 –	– –	2.94 –
21.8–22.8 –	– – – – –	94.13 –	– –	1.79 –
22.8–23.8 –	– – – – –	84.86 –	– –	1.74 –
23.8–24.8 –	– – – – –	69.22 –	– –	1.72 –
24.8–25.8 –	– – – – –	89.49 –	– –	2.48 –
25.8–26.8 –	– – – – –	77.62 –	– –	3.69 –

18.8–26.8 m. Typical Gram Clay, the wash residue of which contains the components characteristic of this clay: dominance of micro-ellipsoids. Many stems and small bits of pyrite. Numerous foraminifera. Some small fragments of shells of molluscs. Many fragments and a few whole zoaria of *Cupuladria haidingeri*. Ostracods. Spines of spatangids. A few small grains of quartz.

Harkes

Situation: 2.4 km. east of the church of Ølgod and immediately south of the road from Ølgod to Hoven. The brickworks, which has been closed down, was situated 600 m. east of the brickworks of Østbæk. The pit of the brickworks, which is now water-logged, is situated immediately south of the site of the brickworks. Fig. 42.

Ground level: about + 39 m.

The locality has been mentioned in the literature (V. NORDMANN 1905, p. 18) as a finding-place of bones of whales.

Sequence of strata: In 1919 the locality was visited by H. ØDUM, who in his diary, p. 81, offers the following information:

"Towards the west in the pit of the brickworks (immediately west of the

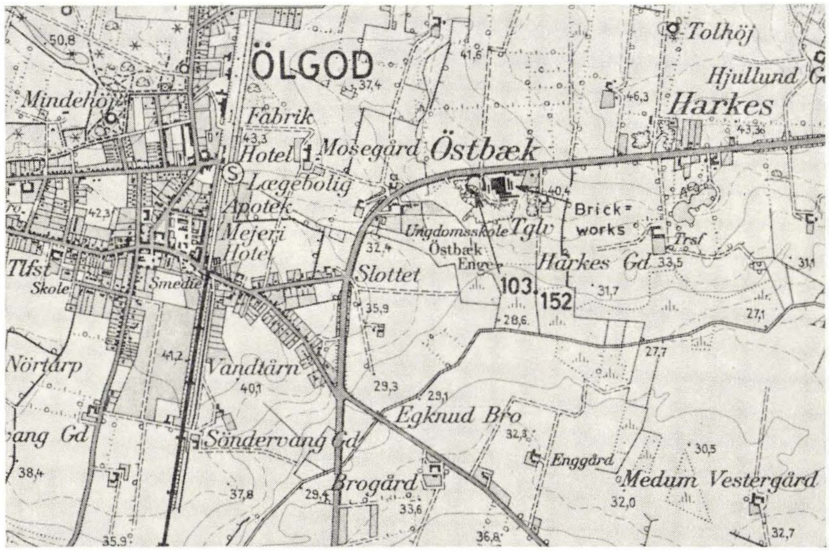

Fig. 42. Situation of the brickworks of Østbæk and the borehole D.G.U. File No. 103.152 west of the brickworks. Farther east the old clay pits of Harkes are seen. (Segment of map sheet 1114 II SV on the scale of 1:25,000).

sloping approach to the brickworks) the following greatly disturbed sequence was found:

(a) Black clay, fractured (= Hodde Clay)

(b) Glauconite Sand

(c) Ordinary Mica Clay, grey; the weathered part was brown. In one place it was highly impregnated with iron compounds in its upper strata. In this Mica Clay, which must with certainty be interpreted as Gram Clay, there were some badly preserved molluscs."

In the north wall of the clay pit ØDUM observed the same strata in a highly dislocated state.

In the east end of the pit ordinary Mica Clay (i.e. Gram Clay) in various varieties was observed: ordinary grey Mica Clay, more plastic Mica Clay, and a more glauconitic part. Furthermore there were a number of concretions arranged in a bed dipping in a westerly direction.

Position of strata: The above-mentioned information from H. ØDUM's notebook clearly shows that the Miocene strata were deformed. Probably this was due to glacial disturbances.

Molluscs were collected by H. ØDUM and are found in the collection of the D.G.U. Faunal analysis, see Table 41, p. 250.

Østbæk

Borehole at the brickworks. Made in 1957.
D.G.U. File No. 103.152.

Situation: 1.7 km. east of the church of Ølgod, immediately south of the road from Ølgod to Hoven. Fig. 42.

Ground level: about + 38 m.

Borehole log:

0.0– 1.2 m. Sand
1.2– 6.0 – Meltwater clay, oxidized above
6.0– 8.4 – Meltwater sand, grey – brownish-grey
8.4–22.4 – Boulder clay, sandy, stony, grey; with Miocene material (at 21 m.: a defective right valve of *Astarte reimersi*).
22.4–23.7 – Meltwater sand and gravel
23.7–24.5 – Boulder clay, grey, with small bits of chalk and flint
24.5–26.5 – Gram Clay
26.5–27.6 – Glauconite Clay
27.6–28.3 – Hodde Clay, fractured
28.3–29.3 – Meltwater sand, stony and gravelly
29.3–44.2 – Mica Silt
44.2–47.7 – Mica Clay, dark grey – black, with irregular parts of Mica Silt, paler grey
47.7–49.2 – Mica Silt, dark grey above, paler grey below
49.2–49.5 – Mica Clay, dark, with irregular parts of paler Mica Silt
49.5–58.4 – Mica Silt, fine, grey, with fragments of shells, marine; at 54 m. numerous shells of molluscs and fragments of shells
58.4–58.8 – Micaceous siltstone with many shells of molluscs.
The boring continued to the depth of 103.7 m. in fossiliferous marine beds of Mica Clay and Mica Silt.

Remarks: As there is meltwater sand between the Hodde Clay and the Mica Silt at the depth of 29.3 m., it must be assumed that the Younger Miocene series of clay in the boring is found in a secondary position. There is also, however, a possibility that a deep crevice full of sand has penetrated deep into the Miocene strata at some time in the Quaternary period.

The borehole is placed close to the clay pit of the brickworks of Østbæk, where diluvial clay is dug which is glacially disturbed and in places occur in connexion with interglacial diatomaceous earth (cf. Sv. Th. Andersen's description of the occurrence in V. Milthers a. o. 1957, p. 260).

Level of the surface of the Miocene: Uncertain, perhaps about + 13 m.

Molluscs are available only in the form of a small number of fragments from glauconitic Gram Clay taken at the depth of 25.0 m. The boulder clay from the interval 8.4–22.4 m., as mentioned above, contains fossils derived from the Gram Clay. Faunal analysis, see Table 4, p. 208 and Table 41, p. 250.

Description of the fossiliferous sample:

25.0 m. Weight of sample before washing: 100.5 g; after washing: 16.98 g. The sample apparently consists of typical Gram Clay, but the wash residue, which is dark brown, mainly consists of dark brown, irregularly shaped grains with a smooth, pitted surface. Besides, some grains of quartz and some pyrite are seen. Few foraminifera and fragments of shells. A single small fragment of a *Cupuladria.*

There seems to be both Gram Clay and Glauconite Clay in the sample. The samples from 26.0 m., 27.0 m. and 28.0 m. contain no fauna.

Hesselho

At Hesselho there is a brickworks where Younger Miocene clay, e.g. Gram Clay, was previously dug. In 1957 the D.G.U. made a boring to the depth of 80.3 m. close to this clay pit. About 1960–61 the brickworks abandoned digging at Hesselho and now gets its clay from a new pit at Hauge, about 1.5 km. farther south. This new locality will be mentioned separately, while the old pit and the borehole will be described below.

1. The clay pit at the brickworks.

Situation: 1 km. SE of the railway station of Gårde, 400 m. east of Hesselhogård and 800 m. east of the Esbjerg–Struer railway line. The clay pit is situated immediately north of the brickworks, but is now water-logged. Fig. 43.

Ground level: about + 39 m.

Sequence of strata: At a short visit on 8/8 1947 to the clay pit, then about 15 m. deep, only Gram Clay and greenish Glauconite Clay without fossils were observed, but no actual examination was made.

Reference is therefore made to the following description made by AXEL JESSEN (1922, p. 17).

"Stratification is not seen in the clay, which is very homogeneous; on the other hand a bed of concretions in the west wall shows an east–west strike and a dip of 15°–20° towards the north. The concretions are partly clay ironstone, partly calcareous concretions. Sometimes a concretion consists of alternating pale and dark strata, in which the binding material is calcium carbonate and ferric hydroxide. Immediately below the bed of concretions there is a bed up to three metres thick consisting of greenish, very sticky Mica Clay, which contains gritty, loose zones. This clay cannot be used for brick-making, as it gives blistered, shapeless bricks. The Mica Clay, is covered by 2–3½ m. Quaternary, towards the east stratified diluvial (meltwater) sand, towards the west diluvial (meltwater) clay without stones or a glacial floe of the Mica Clay poor in stones. At the bottom of the clay pit, which is 7–8 m. deep, a 56 m. deeper boring was made half a century ago in order, if possible, to find coal seams. The clay, however, was completely homogeneous throughout this depth. Animal remains are not known from the clay, but in a few of the concretions there are imprints and casts of shells of molluscs."

It is probable that the 3 m. thick layer of greenish clay corresponds to the basal layer of the Gram Clay. On the other hand, it is uncertain whether Hodde Clay was ever visible in the pit of the brickworks.

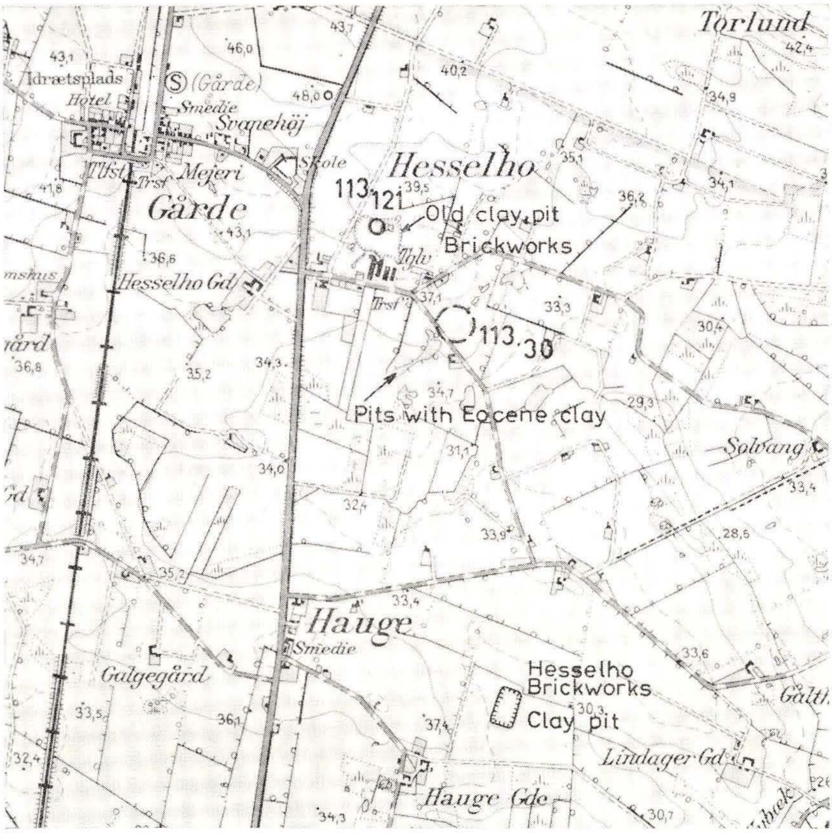

Fig. 43. Situation of the old clay pit of the brickworks of Hesselho and the new one at Hauge. Furthermore the situation of the boreholes D.G.U. File Nos. 113.121 at the brickworks and 113.30 at old clay pits in Eocene clay.
(Segment of map sheet 1113 I NV on the scale of 1:25,000).

Position of strata: To judge from A. JESSEN's description, the Tertiary layers here have been disturbed, presumably by Quaternary ice.

Level of the surface of the Miocene: about + 37 m.

Molluscs are only available as moulds and casts in concretions. List of fossils published in JESSEN 1922, p. 17.

2. The borehole at the brickworks.

D.G.U. File No. 113.121. Made by the D.G.U. in 1957.

Ground level: about + 39 m.

Borehole log:

0.0– 0.3 m. Mould
0.3– 1.1 – Clay, reddish yellow, sandy
1.1– 4.8 – Sand, greyish yellow, somewhat argillaceous

4.8– 5.1 m.	Mica Clay, greyish yellow
5.1–11.3 –	Mica Sand, grey, darker below, fine- to medium-grained
11.3–11.9 –	Mica Clay, grey, sandy
11.9–13.7 –	Mica Clay, dark grey, a little sandy, very hard
13.7–15.2 –	Mica Clay, dark greyish brown, rather sticky
15.2–19.8 –	Mica Clay, dark, greyish brown, very hard
19.8–20.5 –	Mica Clay, in part greenish
20.5–26.1 –	Mica Clay, dark greyish brown, hard
26.1–27.4 –	Clay, greenish, with concretion
27.4–?35.5 –	Mica Clay, dark greyish brown, with greenish zones, fossiliferous
?35.5–38.2 –	Clay, darker
38.2–40.1 –	Clay, green, hard, with a yellowish concretion bed and fossils
40.1–41.3 –	Clay, dark green
41.3–43.5 –	Mica Clay, greyish brown, with greenish zones and fossils
43.5–44.7 –	Clay, greenish, with yellowish brown concretion beds
44.7–60.8 –	Mica Clay, brownish, very hard, fossiliferous
60.8–63.6 –	Mica Clay, somewhat darker, with yellowish brown concretion beds, fossiliferous
63.6–67.6 –	Clay, dark green, down to a depth of about 65 m. with fossils
67.6–72.6 –	Clay, dark green, less sticky
72.6–80.3 –	Mica Clay, blackish brown, hard

Level of the surface of the Miocene: about + 34 m.

Molluscs are available from the intervals 44.0–50.0 m., 50.0–56.0 m., and 56.0–65.0 m. Faunal analysis, see Table 43, p. 251.

Description of the fossiliferous samples: The samples from the intervals mentioned above were washed with a screen having a width of meshes of 0.5 mm. The wash residues therefore mainly consist of needles and lumps of pyrite, to which should be added some fragments of molluscs, good-sized foraminifera, etc.

Remarks: The sequence of strata in this borehole, thus the fact that greenish Glauconite Clay occurs above as well as below the Gram Clay, shows that the Miocene beds have been dislocated, at any rate down to a depth of 44.7 m.

500 m. south of the pit of the brickworks there was formerly a marl pit in Søvind Marl (presumably Upper Eocene). A boring (D.G.U. File No. 113.30) made by the Raw Material Department of the D.G.U. in 1951 showed that there is boulder clay at a depth of 35 m. below the Søvind Marl. Farther down there were alternating beds of Miocene Mica Clay and Quaternary meltwater sand. In these layers the boring was stopped at a depth of 77 m. without the Quaternary layers being penetrated (cf. RASMUSSEN 1961, p. 13).

Thus it is evident from these borings that the Upper Miocene in the region east of Gårde has been exposed to glacial action to a comparatively great depth.

Hauge

Situation: Pit of a brickworks immediately east of the built-up area Hauge, 2.4 km. SE of the railway station of Gårde and 1.5 km. SSE of the brickworks of Hesselho. Fig. 43.

Ground level: about + 31 m.

Sequence of strata: About 1960 the brickworks of Hesselho began digging clay in a field immediately east of Hauge.

When I visited the locality on 7/5 1962 and 12/6 1963 the clay pit was of an almost rectangular shape and its dimensions were about 100 × 50 m. The depth is varying, in places down to about 10 m. Admission to the pit was along a ramp at the northern end.

Immediately south of the ramp there was a deep excavation in dark greenish sandy clay with scattered molluscs. Above this excavation, towards the middle of the clay pit, there was a small bank of dark greenish clay with some shells of *Dentalium badense.* Dark clay without fossils was observed nearly in the middle of the pit, and in the southern part, towards the east wall, dark green clay was again seen. (Fig. 44). At the south end of the pit there was fossiliferous Gram Clay, and a large heap of this clay was placed on the surface of the field immediately west of the clay pit. This heap was rich in shells of molluscs. The greater part of the loosely collected material originates from the heap.

Because of the very irregular digging no smooth sections were seen, for which reason it was impossible to obtain a clear impression of the sequence of strata. However, it seems certain that Gram Clay and Glauconite Clay are deposited there. There may also be Hodde Clay, as much dark clay seems to have been dug in the northwest corner of the pit.

Position of strata: The Miocene beds were evidently glacially dislocated. A

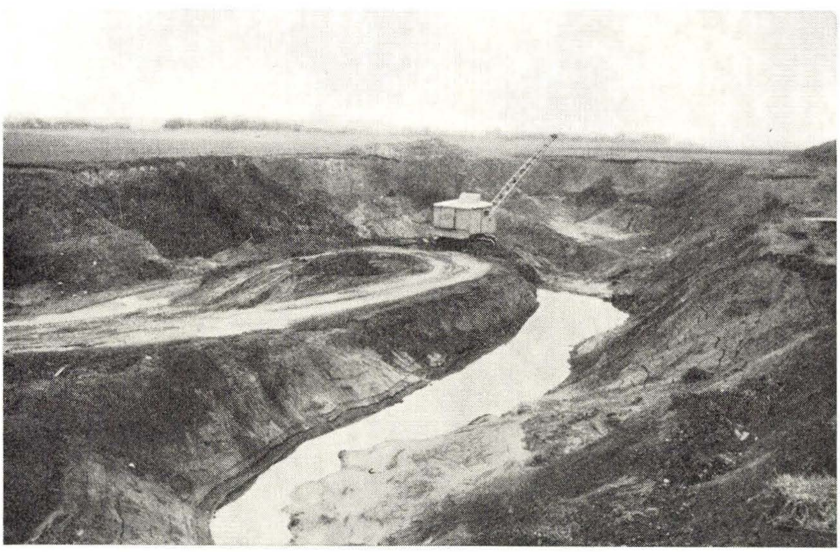

Fig. 44. The new clay pit of the brickworks of Hesselho at Hauge, as seen from the north towards the south. On the left Glauconite Clay. In the background Gram Clay.
Phot. Chr. Westergaard 1962

glimpse of the position of the layers is given by the appearance of the various types of clay. At the southern end there only seems to be Gram Clay, and Glauconite Clay has only been found in the eastern and southeastern part. Perhaps there has been an upthrust of the series, so that the latest layers are now found in the southwest and the earliest in the north. Just as the sequence itself, the position of the beds, however, are very uncertain.

Level of the surface of the Miocene: about + 29 m.

Molluscs were collected on 7/5 1962 and 12/6 1963 in the above-mentioned heap of Gram Clay and in situ in greenish, sandy clay in the northeastern corner of the clay pit, and in dark greenish clay in the northern part of the pit.

Furthermore, numerous shells of molluscs have been found in samples of clay (Gram Clay) taken at the southern end of the clay pit, about 5–6 m. below ground level.

Of the dark clay in the middle part of the pit two samples were taken which, as regards fossils, proved to contain only some almost dissolved foraminifera and a single small fragment of a lunulitiform bryozoa, but no remnants of molluscs. Faunal analysis, see Table 44, p. 252.

Tønding

Situation: Clay pit 2.2 km. east of the church of Tistrup, immediately east of the built-up area Tønding and closely west of the Kybæk (branch of the Grindsted river.) Fig. 45.

Ground level: about + 25 m.

Description: The brickworks of Østbæk near Ølgod about 1960 began digging clay at Tønding, immediately west of the Kybæk. I visited the clay pit on 22/6 1962 and 12/6 1963.

Fig. 45. Situation of the new clay pit of the brickworks of Østbæk east of Tønding. (Segment of map sheet 1113 I NV on the scale of 1:25,000).

At that time the greater part of the clay pit was water-logged. Only a small, about 10 m. deep portion in the southwest corner of the pit was dry and accessible.

In this part only Gram Clay was dug, which in places was overlain by a layer of sand up to 2 m. thick. In a few places the Gram Clay seems to occur immediately below the top soil. In the uppermost parts, down to about 3–4 m. below the surface of the ground, the clay was yellow-coloured because of oxidation. Otherwise the clay was homogeneous and a little fractured. Furthermore it was fairly rich in fossils. Finally the occurrence of a septarium-like concretion may be mentioned.

Position of strata: Because of the irregular slopes and the limited accessibility to the locality it was not possible to have the position of layers elucidated.

Level of the surface of the Miocene: about + 24 m.

Molluscs were collected detached from the slopes and floor of the clay pit. Furthermore two samples of clay were brought home, where they were washed and examined for molluscs. Faunal analysis, see Table 45, p. 254.

Hodde

About the years 1941–43 a new, 10 km. long canal was dug for the regulation of the water level of Karlsgårde Lake, which is used to work the high tension power station at Karlsgårde, about 6 km. NE of Varde. The canal is generally called "Karlsgårdekanalen".

It starts 200 m. SW of the place where the Grindsted river and the Ansager river unite and become the Varde river. From there it follows the Varde river towards the SW to about 1.2 km SE of Hessel. There the canal turns towards the SE up through a dry side valley branching off from the Varde river valley. Already 700 m. SE of this place the canal again changes its course and for 3 km. goes straight towards the SW, after which it takes a more southerly course towards Karlsgårde Lake.

During the digging Miocene layers were found in several places. The northeasternmost of these occurrences is at the bridge by which the road from Hodde to Ansager crosses the canal. The others are found on a stretch, about 1.6 km. long, from the bridge by which the road from Hodde to Nordenskov crosses the canal, towards the NE to a point about 500 m. ESE of the Røgelhøj farm. All the occurrences are in the parish of Hodde.

Unfortunately these interesting sections were only noticed after the canal had long been dug and submerged. The first information about the deposits was due to the farmer JOHS. MADSEN, Hoddemark, who in 1947 approached the Mineralogical Museum in Copenhagen concerning rich findings of fossils which he had made during the digging of the canal. E. M. NØRREGAARD, M. Sc., from the Museum then went to Hodde and learnt that a number of marine

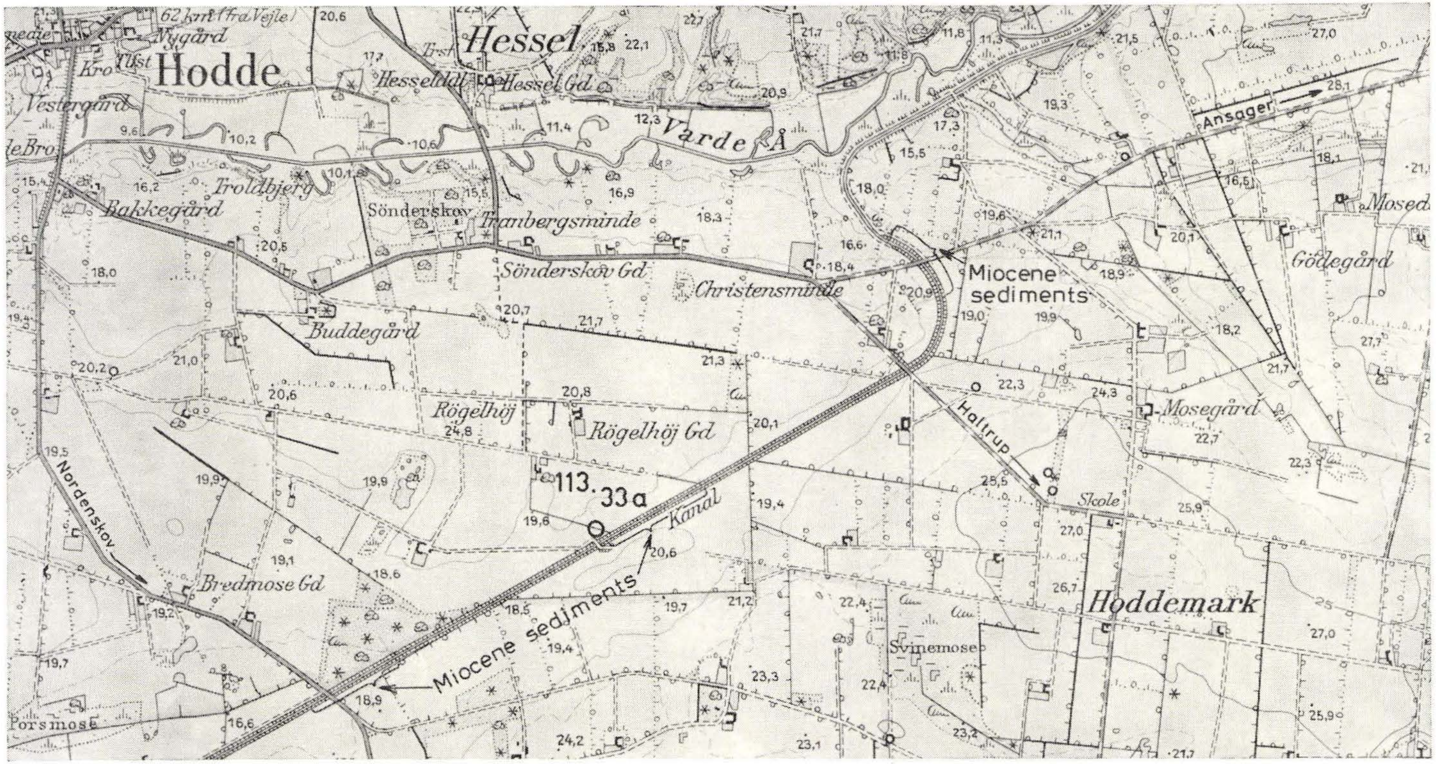

Fig. 46. The situation of deposits beside the Karlsgårde Canal SE of Hodde. The occurrence "Grøde" is east of the farm Christensminde. The sections at Hoddemark are SE of the Røgelhøj farm, where the borehole D.G.U. File No. 113.33a is seen, too. Another occurrence was found SE of the Bredmose farm. The areas with Miocene layers are bracketed. (Segment of map sheet 1113 I SV on the scale of 1:25,000).

Miocene deposits had been found, some of them containing a rich molluscan fauna. NØRREGAARD, amongst other things, established the occurrence of *Spirulirostra* and gave a lecture on this in the Palaeontological Club on the 15th of December 1947. He did not, however, succeed in working up the large material of other molluscs before his death in 1959. This material almost exclusively originates from the large heap of dug-out material coming from the digging of the canal. The heap of sediments is found immediately NE of the bridge by which the road from Hodde to Nordenskov crosses the canal.

On behalf of the D.G.U. I recognized the slopes of the canal in May 1949 and collected a large material in situ. Furthermore the D.G.U. in 1952 made a total of five borings close to the canal in order to obtain further stratigraphical information and a new material of fossils originating from sure levels.

Apart from a small note by NØRREGAARD (1947, p. 240) the localities at Hodde have only been published in brief outline (RASMUSSEN in V. MILTHERS and others, 1957, p. 259, and RASMUSSEN 1961, pp. 14 and 33).

In what follows only the two occurrences by the canal are described where digging had been made through Hodde Clay, dark green Glauconite Clay, and Gram Clay, viz. at Grøde and Hoddemark, and one of the boreholes of the D.G.U., "Hodde I" (D.G.U. File No. 113.33 a), where these beds of clay were found.

1. Grøde.

Situation: The slopes on both sides of the bridge by which the road from Hodde to Ansager crosses the Karlsgårde Canal, 700–800 m. NW of the built-up area Grøde. Fig. 45.

Ground level: about + 17 m. –+ 18 m.

Sequence of strata: Farthest south of the bridge (about 50 m.) brownish quartz sand was seen, which obviously contained quartz gravel in the upper part, to judge from numerous pebbles of quartz, as big as peas, which were scattered over the surface. Immediately north of the quartz sand there was dark Mica Clay alternating in thin strata with grey Mica Silt. The latter layers were only found on a stretch, 6–7 m. long, on the eastern side of the canal. On the western side, on the other hand, only down-slides were seen until immediately south of the bridge, where a rust-coloured, limonitized, loosely connected layer with numerous moulds and casts of molluscs were seen. This layer in the north bordered on Hodde Clay, which also cropped out on the eastern side of the canal for a prolonged stretch. Here it was not, however, possible to establish the occurrence of the rust-coloured layer with the impressions of fossils.

The Hodde Clay could be followed on both sides of the canal to the bridge, where green, gritty Glauconite Clay appeared. Immediately north of the bridge Gram Clay was seen on both sides of the canal on an about 100 m. long stretch.

Because of down-slides, growth of plants, and other changes of the original sections, it was not possible to obtain a completely accurate impression of conditions, but it could be established with great probability that the following sequence was present:

6. Gram Clay
5. Dark green Glauconite Clay
4. Hodde Clay, fractured
3. Layer with dissolved shells
2. Alternating layers of Mica Clay and Mica Silt
1. Quartz gravel.

The oldest layers were found in the south, the youngest in the north.

Position of strata: The rust-coloured layer with the impression of fossils seemed to dip a few degrees towards the north. The boundaries between the three uppermost layers in the series, on the other hand were almost vertical or dipped steeply towards the north or NE. Thus there was a rather considerable dislocation of the original sequence, presumably as a consequence of ice-thrusts from the north or the northeast.

Level of the surface of the Miocene: about + 12 m. –+ 13 m.

Molluscs were collected detached in the Hodde Clay on the east side of the canal and in the Gram Clay on both sides of the canal. Fossil analysis, see Table 7, p. 210 and Table 46, p. 255.

2. Hoddemark.

Situation: The slopes on both sides of a 450 m. long stretch of the canal from the bridge 400 m. south of the Røgelhøj farm towards the NE to a point about 550 m. SE of the same farm. Fig. 45.

Ground level: about + 20 m.

Sequence of strata: On the stretch mentioned there is farthest west Gram Clay and then dark green, gritty Glauconite Clay, which gradually becomes more sticky. These species of clay occur on a stretch about 300 m. long on both sides of the canal. Then there is Hodde Clay. On the south side the basis of this clay leaves the water level 22 m. farther east and rises towards the surface of the ground. On the north side this does not happen until 8 m. farther east. Cf. figs. 46 and 47.

Immediately below the basis of the Hodde Clay there is on both sides of the canal an about 30 cm. thick bed which mainly consists of shells of molluscs. Most gastropods on the whole are well-preserved, whereas the larger pelecypods generally have been crushed, but with the fragments lying in situ. Besides shells there are also some pieces of wood and some quartz gravel. The sediment occurring as a matrix between the shells, is partly black Mica Clay (Hodde Clay), partly paler grey Mica Silt.

Under the shelly beds there is a series of layers in which thin beds of black

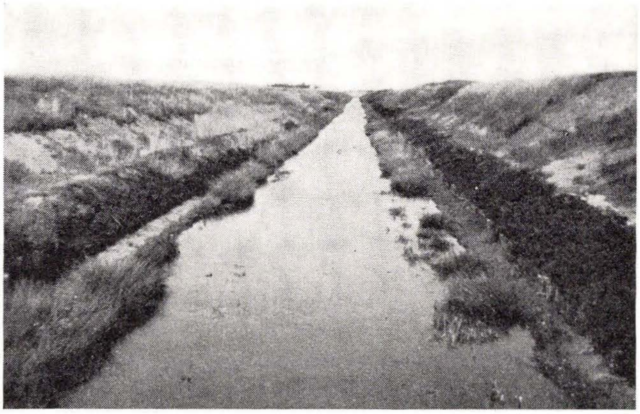

Fig. 47. The Karlsgårde Canal as seen towards the NE from the bridge across the canal south of the Røgelhøj farm. Below in the slopes on both sides in the foreground there is Gram Clay.
Phot. L.B.R. 1949

Mica Clay and pale grey Mica Silt frequently alternate. Thus the series seems regularly "varvic". In many places small faults have been observed.

Under the "varvic"-looking series there were on the north side of the canal a layer of quartz gravel with pebbles of the size of a pea.

The same layer could be traced in the southern slope, where, for that matter, it was possible farther east to see a number of different Miocene beds, of which it was difficult or even impossible to unravel the order, as the soil in many places had slid down the slopes, while in other places the vegetation covered

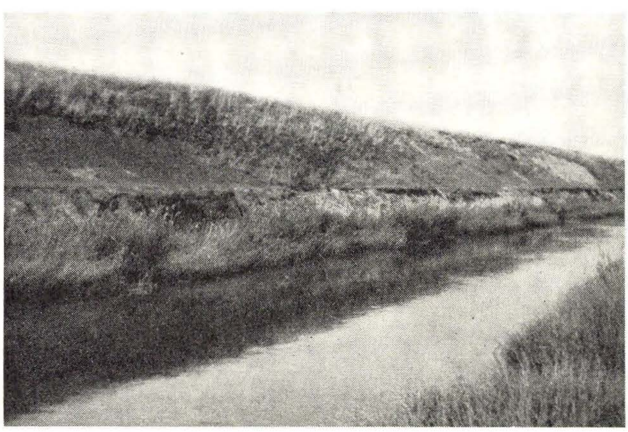

Fig. 48. The northern slope of the canal south of the Røgelhøj farm. On the left there is Hodde Clay. Between this and the pale layer containing quartz sand farther to the right in the picture, Shell Bed I curves up on a level with the ledge.
Phot. L.B.R. 1949

the layers. Furthermore, the layers in some places have been highly glacially dislocated.

The most characteristic strata on the northeasternmost part of the stretch discussed here, are beds of concretions in connexion with which there is a great concentration of shells of molluscs. Such strata could be shown to occur in three different places. Mica Sand and Clay were seen on the stretch between them.

Because of the poor conditions of observation it was difficult to make a complete survey of the sequence of strata. The five boreholes made beside the canal by the D.G.U., however, offer a possibility to place the strata lithostratographically, as the strata have all been found in the boreholes.

Their order is like this:

At the top:

11. Gram Clay
10. Dark green Glauconite Clay
9. Hodde Clay
8. Shell bed (I) with concretions
7. Hodde Clay alternating in thin layers with grey Mica Silt
6. Quartz gravel
5. Dark Mica Clay alternating with pale Mica Sand
4. Shell bed (II) with concretions
3. Dark Mica Clay alternating with pale Mica Sand
2. Shell bed (III and IV?) with concretions

At the bottom:

1. Dark Mica Clay alternating with pale Mica Sand.

Position of strata: The layers as now situated have all of them been dislocated from their original position which first of all appears from the fact that the whole series is found at the same level if we go from the SW towards the NE along the line of the canal.

In certain places the disturbances become more evident, thus e.g. the shell bed (I) under the Hodde Clay is seen to emerge above the surface of the water 8 m. farther east on the north side of the canal than on the south side. From this fact it appears that this shell bed here strikes N 26° E. Its dip is more difficult to determine. Indeed, the layer is visible as a curve in the north slope, but the southwestern part of the curve is concealed below downslide and vegetation in the south slope.

The dislocations also appear from the fact that brownish coloured meltwater sand, which can be seen in several places on the stretch of the canal on which the Tertiary strata occur, contain many rolled lumps of dark Mica Clay, and a shell bed (III), which is not identical with any of the other two shell beds, is found in a dislocated position, perhaps even without any proper connextion with the other Miocene strata.

The latter disturbances may be due to the action of the meltwater in the late-Glacial Period or perhaps rather at some time further back in the Quarternary Period. The actual deformations of the sequence are undoubtedly due to glacial action.

Molluscs were found in the Gram Clay and in large quantities in the three or four shelly beds. Shells were not collected in the Hodde Clay on the stretch of the canal mentioned here, even though shells undoubtedly occur there. Faunal analysis, see Table 46, p. 255.

Remarks: A smallish area in which Miocene layers crop out in the slopes of the canal, occurs by the bridge by which the road from Hodde to Nordenskov crosses the canal. In this place Hodde Clay has been observed, a rust-coloured layer with numerous moulds and casts of molluscs, as well as Hodde Clay alternating with thin layers of grey Mica Silt. This series of strata undoubtedly corresponds to layers 7–9 at Hoddemark south of the Røgelhøj farm.

No determinable fossils are available from this area.

3. Borehole at Hoddemark ("Hodde I").

D.G.U. File No. 113.33 a. Made by the D.G.U. in 1951.

Situation: 400 m. SE of the Røgelhøj farm, immediately north of the Karlsgårde Canal, above the place where Gram Clay crops out in the banks. Fig. 46.

Ground level: about + 19 m.

Borehole log:

0.0– 0.9 m.	Meltwater sand
0.9– 5.6 –	Quartz sand, pale grey, medium-grained
5.6– 6.1 –	Quartz sand, dirty grey, medium-grained
6.1– 6.3 –	Mica Clay, dark grey (probably Gram Clay)
6.3– 7.9 –	Mica Clay, silty, in brownish and reddish brown layers
7.9–10.0 –	Gram Clay, dark grey, in upper part with a slightly yellowish tint
10.0–13.8 –	Clay, dark greenish grey, glauconitic, in upper part weathered, yellowish grey
13.8–14.2 –	Hodde Clay, black, in small lumps
14.2–18.5 –	Hodde Clay, dark brownish grey, in lower part almost black, with grains of quartz
18.5–18.9 –	Hodde Clay with thin layers of grey Mica Silt
18.9–19.5 –	Hodde Clay with thin layers of Mica Silt and with numerous shells of molluscs
19.5–21.3 –	Mica Silt, pale grey, alternating with numerous thin layers of dark Mica Clay
21.3–23.4 –	Mica Silt with quartz gravel
23.4–27.3 –	Mica Clay, brownish grey, with thin layers of slightly paler Mica Silt
27.3–29.3 –	Mica Silt, greenish brown, with numerous molluscs and concretions
29.3–31.2 –	Mica Silt, brownish and grey, alternating with layers of Mica Clay, dark, in lower part with numerous shells of molluscs and concretions
31.2–36.1 –	Mica Silt, pale greyish brown, in lower part with numerous shells of molluscs and concretions
36.1–41.6 –	Mica Silt, pale grey, alternating with layers of Mica Clay, brownish, in lower part with numerous shells of molluscs and concretions

41.6–44.1 m. Mica Silt, pale grey, with numerous shells of molluscs and concretions
44.1–45.7 – Mica Clay, pale brownish grey, silty, with many shells
45.7–47.1 – Mica Silt, pale brownish grey, with shells and concretions
47.1–49.9 – Mica Clay, pale brownish grey, with many shells
49.9–67.3 – Mica Silt, pale grey, with shells. Concentration of shells at 58.0 m., 65.8 m., and 67.2 m.
67.3–73.2 – Mica Clay, dark brown, with layers of silt, pale grey; in lower part with concretions
73.2–74.3 – Mica Silt, dark brownish, with a few shells
74.3–75.2 – Mica Silt, dark grey, with a few shells.

Level of the surface of the Miocene: about + 13 m.

Molluscs are available from 9.0–10.0 m., and 18.5–18.9 m. Faunal analysis, see Table 7, p. 210, and Table 46, p. 255.

Stenderup

Borehole at JOHAN HANSEN's farm (Damgård). Made in 1952.
D.G.U. File No. 113.36.

Situation: 1.4 km. NW of the church of Stenderup, 4.4. km. ESE of the church of Ansager and well over 100 m. north of the road from Ansager to Stenderup. Fig. 49.

Ground level: about + 32 m.

Borehole log:

0.0– 5.0 m. Old well
5.0–10.0 – Clay, dark grey, sandy, stony
10.0–13.0 – Sand, grey, medium-grained
13.0–27.1 – Gram Clay, with concretions below
27.1–31.5 – Mica Silt, dark grey.

Level of the surface of the Miocene: about + 19 m.

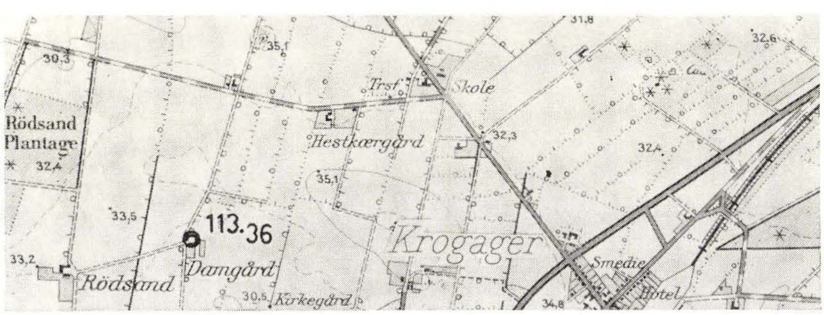

Fig. 49. Situation of borehole D.G.U. File No. 113.36 at Stenderup.
(Segment of map sheet 1113 I NØ on the scale 1:25,000).

Molluscs are available from 18.0–23.1 m. and from 23.1–27.1 m. Faunal analysis, see Table 41, p. 250.

Description of the fossiliferous samples:

18.0–23.1 m. Weight of sample before washing: 47.42 g; after washing: 5.52 g. Typical Gram Clay; the wash residue mainly consists of ellipsoidal small bodies and some pyrite, many foraminifera and a few fragments of molluscs. Some grains of quartz perhaps are mainly contaminations, just as an about 2 cm. long piece of flint.

23.1–27.1 m. Weight of sample before washing: 19.66 g; after washing: 10.42 g. Gram Clay with bits of concretion, which to some degree dominate the wash residue. Besides, there are the usual components of Gram Clay, including foraminifera, ostracods, and fragments of molluscs.

Region IV
The Esbjerg Region

In the region of Esbjerg Miocene deposits have only been found in and near the town itself and at Måde, one or two kilometres east of the town. At the base of the Quaternary beds there is mainly Gram Clay. This is in the area overlain by very sandy, in part hard, dark grey boulder clay with abundant Miocene material in a secondary position (upthrust Gram Clay, Middle Miocene Mica Sand, concretions and loose shells of molluscs), above which there is grey marine clay and silt of interglacial age (so-called "Esbjerg Yoldia Clay"). Above this there is meltwater sand, moraine sand, or boulder clay, according to the situation in the area. In all outcrops there are great glacial disturbances of the Miocene as well as of the earlier glacial and the marine, interglacial layers.

In the present region it would be natural also to include the cliffs at Ho bay on the stretch north of *Hjerting*, 8–10 km. NW of Esbjerg. There we see Mica Clay and Sand and Limonite Sandstone, some of the Mica Clay by K. Dreyer Jørgensen (1940a, b) being termed Astarte Clay (= Gram Clay). It is stated that "in this, in different places in the cliffs, about 10 sure Upper Miocene fossils have been found." I have not myself, in spite of repeated examinations of these cliffs been able to demonstrate the presence of fossils anywhere in the clay seen in various places, for which reason I must leave this occurrence out of consideration in the present paper.

Esbjerg

In the town itself fossiliferous Miocene strata besides in three boreholes have been found in a now disused pit of a brickworks and on the beach off the gasworks in the southeastern part of the town. The situation of the occurrences appears from the map figs. 50 (p. 104), 51, and 52 (p. 107).

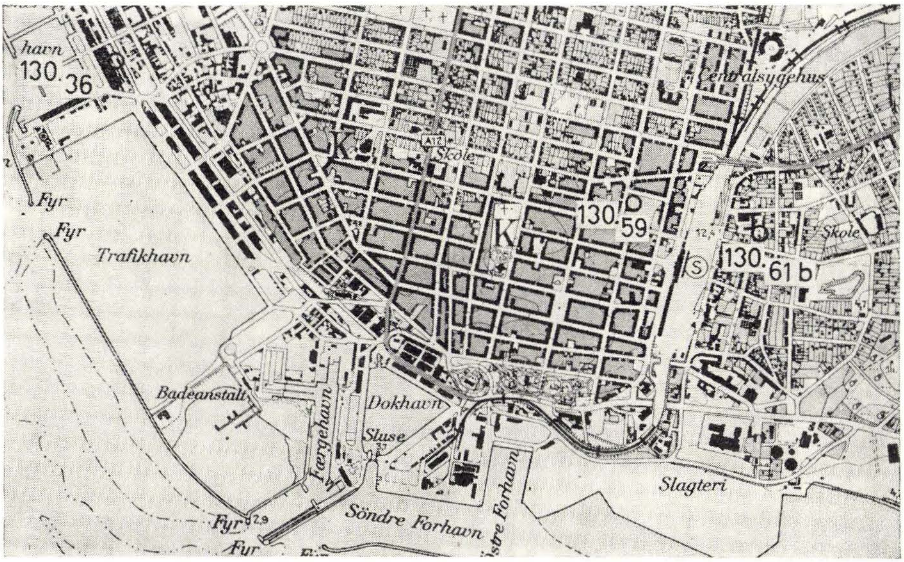

Fig. 50. Situation of the boreholes D.G.U. File Nos. 130.36, 130.59, and 130.61 b in the town of Esbjerg.
(Segment of map sheet 1113 III SØ on the scale of 1:25,000).

1. Borehole at the Ice Factory in the new fishing harbour.

D.G.U. File No. 130.36. Made in 1923.

Ground level: about + 2 m.

Abridged section (in part according to the judgment of AXEL JESSEN, State Geologist, in the Well Record Department of the D.G.U.):

0.0– 3.0 m.	Filling
3.0– 4.5 –	Marine mud
4.5– 8.7 –	Sand of unknown character
8.7– 61.0 –	Mainly marine sand and clay (presumably interglacial)
61.0 –	Gravel (Quaternary) with numerous Miocene shells
61.0– 62.5 –	Clay and sand (Quaternary)
62.5– 63.0 –	Gravel (Quaternary) with Miocene shells; furthermore argillaceous sand
63.0–108.5 –	Gram Clay (and perhaps other Miocene clay beds) with shells of *Astarte reimersi*
108.5–113.0 –	Grey, argillaceous sand with numerous shells of *Vaginella depressa*.

Level of the surface of the Miocene: about — 61 m.

Molluscs are available from the following depths: 61.0 m., 62.5–63.0 m., 84 m., 94 m., 109.0 m., and 113.0 m., but have a very rolled looking. They, therefore, have not been listed in this paper.

2. Borehole near the Cooperative Bacon Factory in the street of Nørregade.

D.G.U. File No. 130.59. Made in 1927.

Ground level: about + 16 m. Abridged log:

0.0– 9.0 m.	Well
9.0– 20.0 –	Meltwater sand
20.0– 67.0 –	Marine sand and clay (interglacial)
67.0– 78.1 –	Gravel and sand, clayey (Quaternary; presumably moraine sand or washed boulder clay) with Miocene shells and concretions
78.1– 80.0 –	Gram Clay.

Level of the surface of the Miocene: about — 62 m.

Molluscs are available from the following depths: 71.25 m., 72 m., 72.5 m., 73–74.5 m., 75 m., 76.5–77.5 m., 78 m., and 78.5 m. Faunal analysis, see Table 47, p. 256.

Description of the samples with molluscs:

71.25 m. Gravel, fine, with bits of weathered pyrite and lignite; fragments of shells.

72 m. Gravel, coarse, with stems and bits of pyrite, pieces of concretions, and molluscs.

72.5 m. Sand, coarse, and boulder clay, dark grey, hard, with pebbles (granite), stems of pyrite, pieces of concretions, and molluscs.

73–74.5 m. Gravel, fine, mainly quartz, but also granite, quartzite, etc. Numerous stems of pyrite and pieces of concretions of two types: (1) clay-ironstone and (2) calcareous concretions (containing claw of crab). Numerous Miocene molluscs.

75 m. Sand, coarse, grey – dark grey. Few bits of brown concretions. A few molluscs.

76.5–77.5 m. Pieces of clay-ironstone concretions. Numerous stems of pyrite. Fragments of molluscs.

78 m. Gravel, fine and coarse. Pieces of clay-ironstone concretions and stems of pyrite. Molluscs.

78.5 m. Gram Clay with concretions of clay-ironstone as well as calcareous clay. Stems of pyrite. A few molluscs and fragments of *Cupuladria.*

3. Borehole at the Bacon Factory in the street of Exnersgade.

D.G.U. File No. 130.61 b. Made in 1928.

Ground level: about + 10 m. Abridged section:

0.0–18.0 m.	Sand, fine
18.0–46.5 –	Marine sand and clay (interglacial)
46.5–49.0 –	Meltwater sand, grey, with numerous stems of pyrite originating from Gram Clay
49.0–60.0 –	Boulder clay?
60.0–72.0 –	Gram Clay, fossiliferous.

Level of the surface of the Miocene: about — 50 m.

Molluscs are available from the following depths: 60.0 m., and 72.0 m., but no analysis has been carried out.

Description of the samples with molluscs:

60.0 m. Gram Clay, grey – dark olive, with pieces of yellowish brown concretions, stems of pyrite, fragments of molluscs and pieces of *Cupuladria*. The sample contaminated with glacially transported material (flint, granite, etc.).

72.0 m. Gram Clay, dark grey with a greenish grey tint, with pieces of yellowish brown concretions, stems of pyrite and fragments of molluscs and *Cupuladria*.

4. Pits of brickworks in the southeastern part of the town.

Situation: There seems to have been at least two clay pits in Gram Clay, one belonging to A/S Esbjerg Teglværk, the other to LAUERSEN, owner of a brickworks (cf. C. GOTTSCHE 1898, p. 14). The latter brickworks is perhaps identical with that which on the oldest map of the Esbjerg region (1870) (Fig. 51) and on an edition drawn later (1896) (Fig. 52) is seen situated close to the beach, exactly 1000 m. ESE of Bavnehøj (with the water tower). It was abandoned shortly before the turn of the century.

A/S Esbjerg Teglværk still exists. It is situated 100 m. NE of the site of LAUERSEN's brickworks and since about 1890 has utilized the marine interglacial clay ("Esbjerg Yoldia Clay"). Formerly Gram Clay, too, was dug in a clay pit immediately west of the large pit still operated. This older clay pit (according to the map corrected in 1896) was situated south of the brickworks, immediately within the beach.

Ground level: about + 3 m.

Sequence of strata: The locality was mentioned by C. GOTTSCHE (1898, p. 14), J. P. J. RAVN (1907, p. 232), and A. JESSEN (1922, p. 16) without detailed description of conditions. GOTTSCHE in 1898 (loc. cit.) found dark sandy clay on the stretch between the Gram Clay and the interglacial clay. In 1893 VICTOR MADSEN (1895, p. 100) demonstrated the occurrence of boulder clay in the same place in the sequence.

As regards Miocene layers the above-mentioned authors only mention grey Mica Clay (= Gram Clay). On the other hand the locality is lauded by GOTTSCHE (loc. cit.) for the occurrence of "crab balls", just as the same author elsewhere (1891, p. 150) mentions that there were thick beds of clay ironstone.

Position of strata: The position of layers in the old clay pits in Gram Clay is unknown. The above-mentioned occurrences of clay as compared with the logs from the three boreholes in the town of Esbjerg, where the Gram Clay was only reached at — 50 m. to — 62 m., clearly shows that it was thrust up by a glacier in a limited area.

Level of the surface of the Miocene: about 0 m.

Fauna: Molluscs from the Gram Clay at Esbjerg were first mentioned by O. MØRCH (1873), who records 14 species under the locality designation "East of the harbour of Esbjerg". Among other fossils he mentions: bones of whales,

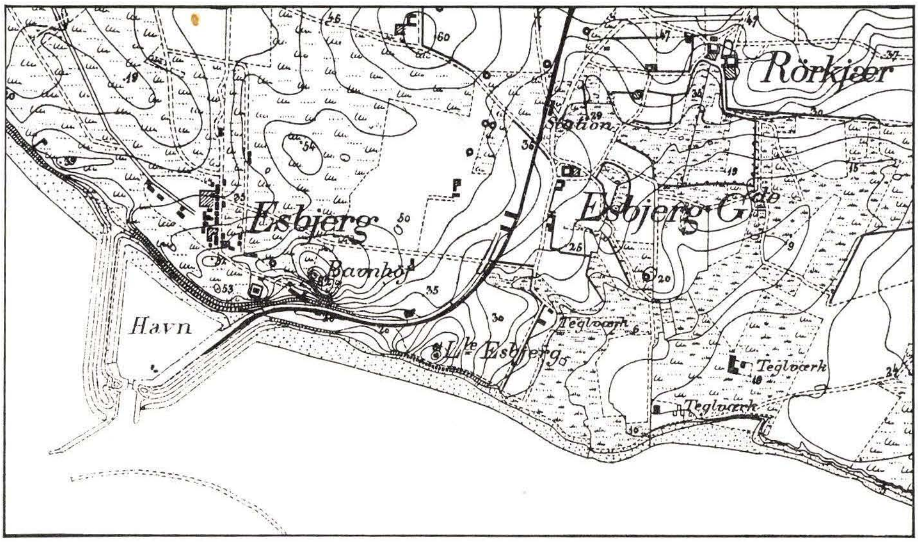

Fig. 51. Situation of the earliest brickworks at Esbjerg. (Segment of the oldest map on the scale of 1:20,000, Sheet Z4 Jærne, according to survey of 1870).

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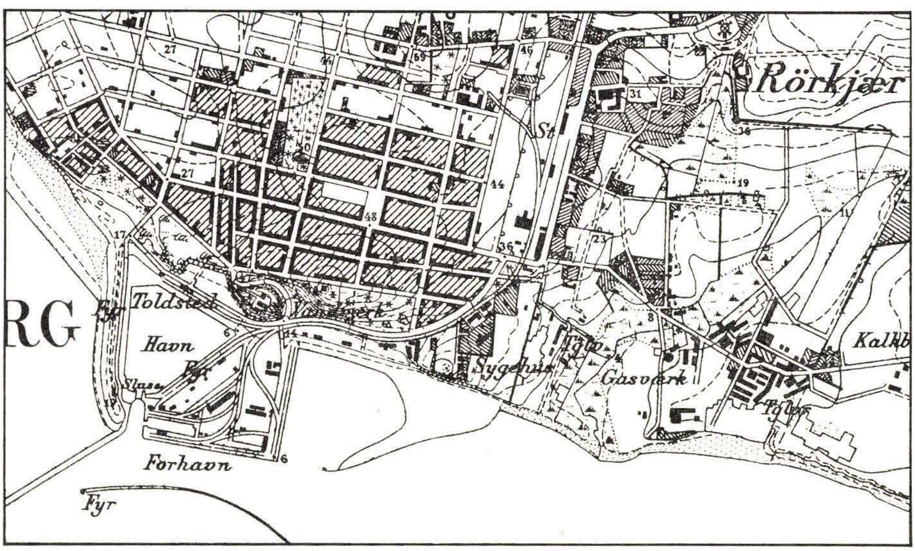

Fig. 52. Situation of the same brickworks in 1896 according to the edition of that year of map sheet Z4 Jærne on the scale of 1:20,000. The deposit on the beach SE of the town is found outside the coast line south of the southeasternmost brickworks.

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crabs, and bryozoa ("*Lunulites rhomboidalis*"). The material is stated to have been collected by Professor JOHNSTRUP and his assistants at the time: LØFFLER and HOWITZ.

According to RAVN (1907, p. 232) fossils were collected for the Mineralogical Museum in Copenhagen for a number of years and in a large number of individuals. Nevertheless, only 28 species of molluscs are known from there. They are listed by RAVN (loc. cit.) and A. JESSEN (1922, p. 17).

The material from these early collections, which are exclusively due to piecemeal picking up in the clay pits, has been examined in connexion with the present work. It has not been possible to provide samples of clay for a quantitative analysis. Faunal analysis, see Table 48, p. 257.

5. The beach off the Gasworks.

Situation: On the beach off the old pits of brickworks now filled in, west of the large pit in the interglacial clay belonging to A/S Esbjerg Teglværk (mentioned under Loc. 4 above) Gram Clay crops out, only covered by a layer of ooze and sand deposited by the tide and the current at high water. All over the area there are furthermore numerous boulders from the washed-away glacial beds. The occurrence must be supposed to be a direct continuation of the Gram Clay in the old pits of brickworks. (Cf. figs. 50, 51, and 52).

Ground level: about 0 m.

Sequence of strata: Only Gram Clay has been observed. Pieces of concretions of clay-ironstone as well as whole "crab balls" are scattered over the area. In the east the Gram Clay is overlain by a layer of boulder clay at least 3 m. thick, and this again by the marine interglacial clay. These two species of clay crop up in a low cliff which starts immediately east of the place where the Gram Clay is seen on the beach (see A. JESSEN 1922, p. 38).

Position of strata: As a consequence of the special character of the occurrence, the position of layers are uncertain. However, they probably correspond closely to conditions in the clay pits inland. No doubt there has been a glacial upthrust of Gram Clay.

Level of the surface of the Miocene: about 0 m.

Fauna: During visits to the place on 10/7 and 25/7 1940, 25/6 and 30/7 1941 and 9/8 1947 the species and individuals of molluscs were collected which are mentioned in Table 48, p. 257 and which were found washed-off on the surface of the Gram Clay.

Måde

Miocene strata have been found by digging of brick clay in several places in the area south of Måde, 2–3 km. east of Esbjerg. Geological conditions there, however, are highly complicated, since, as at Esbjerg, there are both Miocene and Quaternary strata under very irregular conditions. The sequence of strata established so far is this:

6. Boulder clay or meltwater sand (Riss Glacial)
5. Marine interglacial clay ("Esbjerg Yoldia Clay") (Mindel/Riss)
4. Sandy boulder clay ("Moraine A") (Mindel Glacial)
3. Gram Clay with beds of concretions (Gram Formation)
2. Green Glauconite Clay (basal layer of Gram Clay) (Gram Formation)
1. Hodde Clay (Hodde Formation).

Older Miocene layers (the Arnum Formation) obviously were influenced by the Quaternary in the area itself or its proximity, as Layer 4, the dark, sandy boulder clay, besides molluscs from the Gram Clay and the Hodde Clay, contains numerous loose molluscs and concretions filled with fossils from the Arnum Formation. It should also be kept in mind that on the beach near the brickworks of Måde numerous boulders of Middle Miocene age have been found, described by E. M. NØRREGAARD (1916a, b). It is possible that these boulders may have been washed off the same horizon of dark sandy boulder clay found in some of the pits of the brickworks and that this early moraine also reaches the surface of the ground near the coast close to the brickworks of Måde.

In the area of Måde there are two brickworks, viz. besides the brickworks of Måde, which is situated about 700 m. SW of the built-up area Måde, another brickworks, that of Strandgård, about 900 m. SE of Måde. Both brickworks have dug clay in several pits. Fig. 53.

1. The northwesternmost clay pit of the brickworks of Måde (being in operation about 1934–1943).

Situation: 200 m. NE of the brickworks, on the north side of the road from the brickworks to Måde. Fig. 54.

Ground level: about + 4 m.

Sequence of strata: Marine, interglacial clay ("Esbjerg Yoldia Clay") is here overlain by meltwater sand and gravel. A floe of Hodde Clay was found on a visit on 2/8 1942 in the northwest corner on the floor of the clay pit, which, for that matter, was partly water-logged.

Position of strata: The position of the marine clay was uncertain because of its homogeneous appearance. On the other hand, in the west and north wall of the clay pit it was overlain by folded and irregular layers of meltwater sand and gravel (observation by SIGURD HANSEN, Ph. D., on 22/9 1938). The small occurrence of Hodde Clay suggests irregular position of the layers.

Level of the surface of the Miocene: about + 3 m.

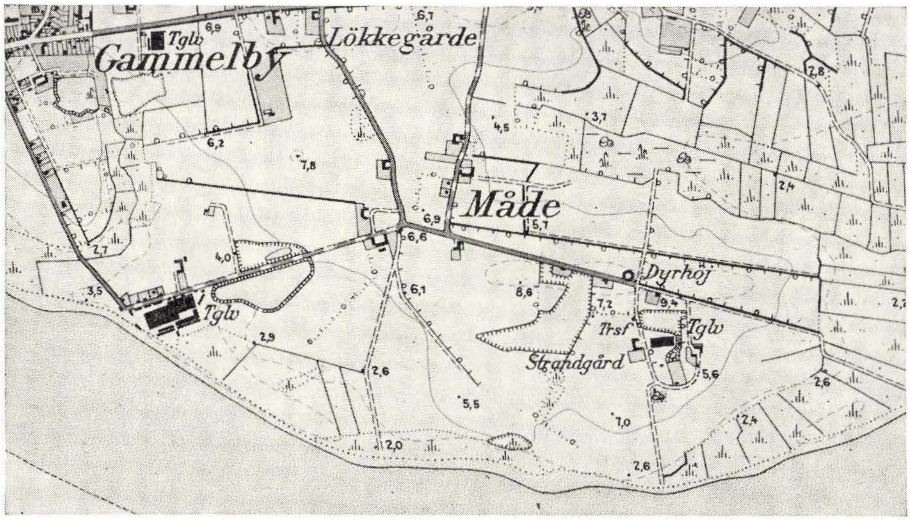

Fig. 53. Map of the area at Måde east of Esbjerg. (Segment of map sheet 1113 III SØ on the scale of 1:25,000).

Fauna: During visits on 17/8 1941 and 2/8 1942 a small number of molluscs were collected in the Hodde Clay. Faunal analysis, see Table 8, p. 211.

2. The southwestern pit of the brickworks of Måde (being in operation since about 1958).

Situation: 200 m. SE of the buildings of the brickworks, 200 m. north of the coast. Fig. 54.

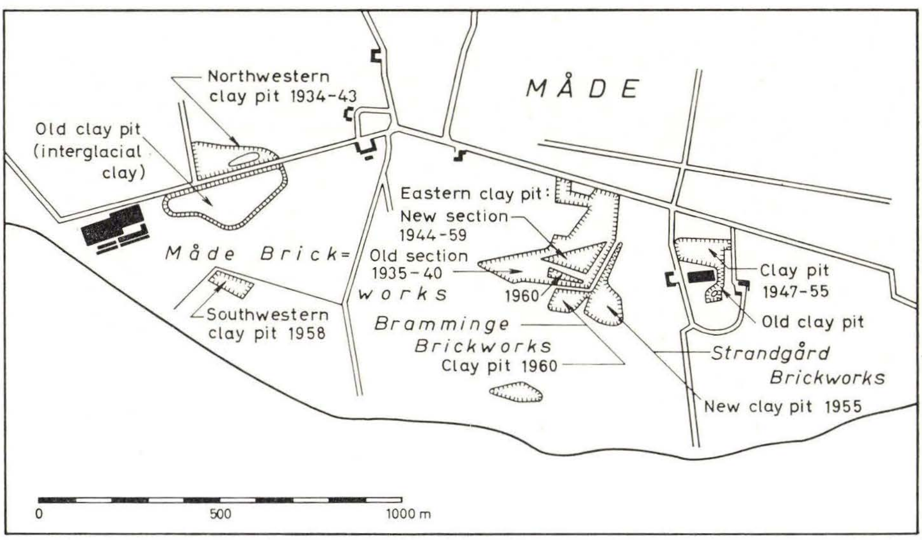

Fig. 54. Situation of clay pits at Måde.

Ground level: about + 3 m.

Sequence of strata: Not examined in detail. The occurrence was only inspected on a short visit on 8/5 1962, on which the presence of green Glauconite Clay (presumably the basal layer of the Gram Clay) and Hodde Clay was observed.

Position of strata: The two types of clay observed were placed irregularly in relation to each other, presumably as a consequence of glacial action.

Level of the surface of the Miocene: about + 1 m.

Fauna: On the short visit on the date mentioned, a single shell of a gastropod was picked up from the Hodde Clay. See Table 8, p. 211.

3. *The eastern pit of the brickworks of Måde, early part* (being in operation about 1935–40).

Situation: 1000 m. ESE of the buildings of the brickworks, 300 m. SW of Dyrhøj. Fig. 54 (cf. fig. 53).

Ground level: about + 7 m.

Sequence of strata: At the top a layer of 1–2 m. boulder clay (with some fairly large stones) was found, and Miocene Clay below that. Gram Clay with beds of concretions as well as Hodde Clay was dug. No details concerning the sequence are available, apart from diary notes by SIGURD HANSEN, Ph. D., State Geologist (diary for "Kortbladet Ribe" ('The Map Sheet of Ribe'), 22/9 1939). From this it appears that in the north wall there was "black, probably very coaly fractured Mica Clay" (= Hodde Clay) in a layer of at least 4 m. thickness. In the east wall SIGURD HANSEN observed a curved bed of concretions in the Gram Clay.

Position of strata: Details concerning the position of the layers are not available, apart from the above-mentioned observation of the east wall. There a bed of concretions was seen to form a double sine curve at a height of 2 m. above the floor of the pit, stretching over about 15 m. of the wall. The Miocene strata obviously had been glacially disturbed.

Level of the surface of the Miocene: about + 5 m.

Fauna: Molluscs from Gram Clay as well as Hodde Clay were collected by Dr. KNUD DREYER JØRGENSEN, now Professor, then an undergraduate, who has kindly placed his material at my disposal. It includes the fossils which were submitted to the Palaeontological Club on 16/12 1940.

The material includes the following species and specimens:

1. *Nucula* (probably *georgiana* SEMPER)	7 fragm.
2. *Limopsis aurita* (BROCCHI)	11 valves
3. *Chlamys clavata* (POLI)	1 valve
4. *Astarte vetula* PHILIPPI	19 valves and 11 fragm.

5.	*Astarte reimersi* SEMPER	2 valves
6.	*Astarte radiata* NYST & WESTENDORP	6 valves
7.	*Cardita chamaeformis* (SOWERBY)	27 valves
8.	*Cardita orbicularis* (SOWERBY)	15 valves
9.	*Isocardia cf. forchhammeri* BECK	9 fragm. valves and 10 fragm.
10.	*Dentalium dollfusi* v. KOENEN	24 fragm.
11.	*Dentalium badense* PARTSCH	15 shells and 7 fragm.
12.	*Archimediella subangulata* (BROCCHI)	1 shell
13.	*Turritella tricarinata* (BROCCHI)	24 shells
14.	*Leiostraca cf. glabra* (DA COSTA)	1 fragm.
15.	*Policines catena* (DA COSTA)	5 shells
16.	*Typhis fistulosus* (BROCCHI)	1 shell
17.	*Semicassis miolaevigata* (SACCO)	1 shell
18.	*Galeodea echinophora* (L.)	5 fragm.
19.	*Sipho distinctus* (BEYRICH)	6 fragm.
20.	*Nassa? bocholtensis* (BEYRICH)	1 fragm.
21.	*Nassa fuchsi* v. KOENEN	10 shells
22.	*Nassa sp.*	1 shell
23.	*Lathyrus rothi* (BEYRICH)	1 shell
24.	*Aquilofusus luneburgensis* (BEYRICH)	1 shell
25.	*Aquilofusus semiglaber* (BEYRICH)	1 shell
26.	*Uromitra wirtzi* HINSCH	1 shell
27.	*Scaphella bolli* (KOCH)	12 fragm.
28.	*Narona rothi* (SEMPER)	1 shell
29.	*Conus antediluvianus* BRUGUIÈRE	1 shell and 14 fragm.
30.	*Gemmula badensis* (R. HOERNES)	20 shells
31.	*Gemmula zimmermanni* (PHILIPPI)	4 shells
32.	*Fusiturris duchastelii* (NYST)	8 shells
33.	*Bathytoma cataphracta* (BROCCHI)	4 shells
34.	*Bathytoma mioturbida* KAUTSKY	1 shell
35.	*Turricula steinworthi* (v. KOENEN)	1 shell
36.	*Tahusyrinx corneti* (v. KOENEN)	1 shell
37.	*Spirotropis modiola* (JAN)	1 fragm.
38.	*Borsonia uniplicata* (NYST)	1 shell
39.	*Splendrillia selenkae* (v. KOENEN)	1 shell
40.	*Turridae indet.*	1 shell
41.	*Ringicula buccinea* (BROCCHI)	2 shells
42.	*Acera bellardii* (v. KOENEN)	1 shell

The fossils were denoted as "Upper Miocene", but after it has been possible to make collections by horizons at Måde, it has proved that shells from the Gram Clay and the Hodde Clay are mixed up in this collection.

On my own visits to the clay pit on 1/7 and 2/7 1940, the deeper parts were found to be water-logged. Gram Clay at that time was only dug down to about 1.5 m. below its surface in a flat part of the clay pit. The fossils found there were more or less dissolved. Analysis, see Table 49, p. 258.

4. The eastern clay pit of the brickworks of Måde, late part (being in operation about 1944–59; new portion taken into use in 1960).

Situation: Large triangular clay pit 1200 m. east of the brickworks, 200 m.

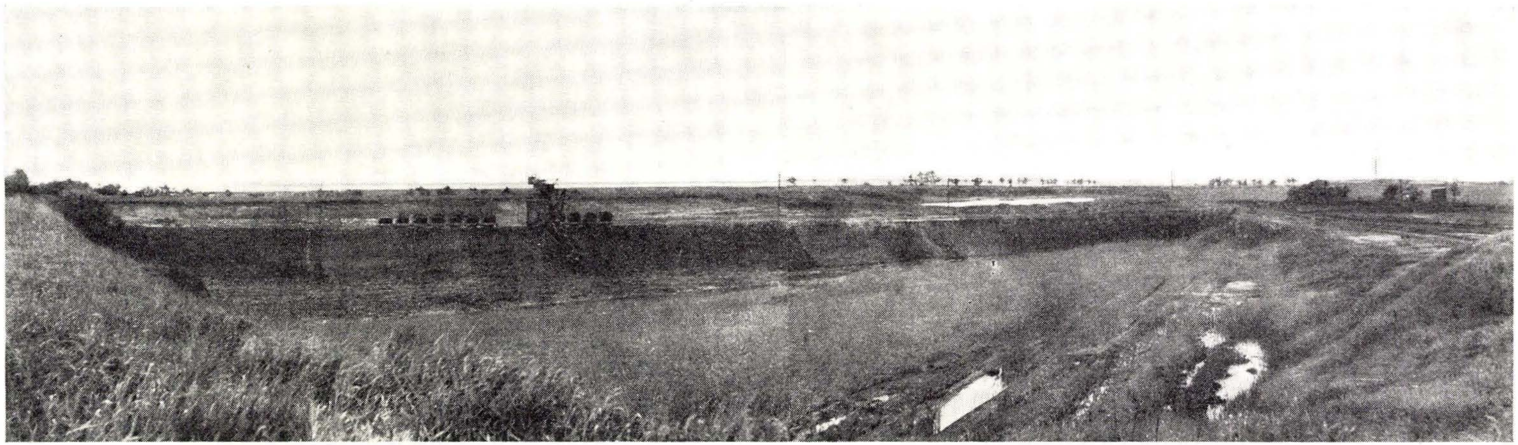

Fig. 55. The south wall of the easternmost pit of the brickworks of Måde, as seen from the NE. The bared section is identical with the uppermost one in fig. 57.

Phot. L.B.R. June 1955

SW of Dyrhøj. A new pit is now found immediately south of the old one, which is water-logged. Fig. 54.

Ground level: about + 7 m.

Sequence of strata: In the old triangular clay pit:

Under about 1.5 m. boulder clay there was Miocene clay: Hodde Clay, Glauconite Clay, and Gram Clay, with beds of concretions. Mainly Gram Clay was dug. They started in the place which later became the north wall of the large, triangular clay pit, and worked themselves in a southerly direction, the pointed western corner of the pit practically being retained.

This pit was visited by me several times in the course of the years (17/8 1945, 2/7 and 15/7 1946, 30/6, 8/7, 9/8, and 21/8 1947, 6/7 1948, 7/7 1949, 2/8 1950, 16/8 and 20/8 1951, 19/8 1954, 21/6, 22/6, 24/6, and 25/6 1955, 3/8 1956, 5/8 1957, 23/8, 25/8, and 1/11 1958, and 24/4 1959). Unfortunately no details about the clay beds were noted on these visits, but it appears from the collections of fossils that it must exclusively have been Gram Clay that was accessible in the fresh south wall. Possible small occurrences of other kinds of clay (without a macrofauna) have not been observed. At an investigation of the south wall in June 1955 Glauconite Clay was found in a single place.

From 1956–1959 the digging of clay was removed to the north wall, where, besides Gram Clay, Glauconite Clay as well as Hodde Clay was found, especially in the northeastern part of the section.

The sections have previously been described by HINSCH (1958) and RASMUSSEN (1957, 1959, 1961 b).

In the south wall at least two beds of concretions were shown to occur, and at especially favourable conditions of observation (as in June 1955) a bedding could be observed in the Gram Clay, as certain beds of this clay stood out with faint, paler tints (cf. the section fig. 57). A large number of concretions were found scattered over the floor of the clay pit, especially in the eastern part, where the latest part of the series was found (cf. fig. 56).

Fig. 56. The east wall of the easternmost pit of the brickworks of Måde with the late layers of Gram Clay bared under stony clay resembling boulder clay. In the wall a few and on the floor of the pit numerous concretions of clay ironstone.

Phot. L.B.R. 1955

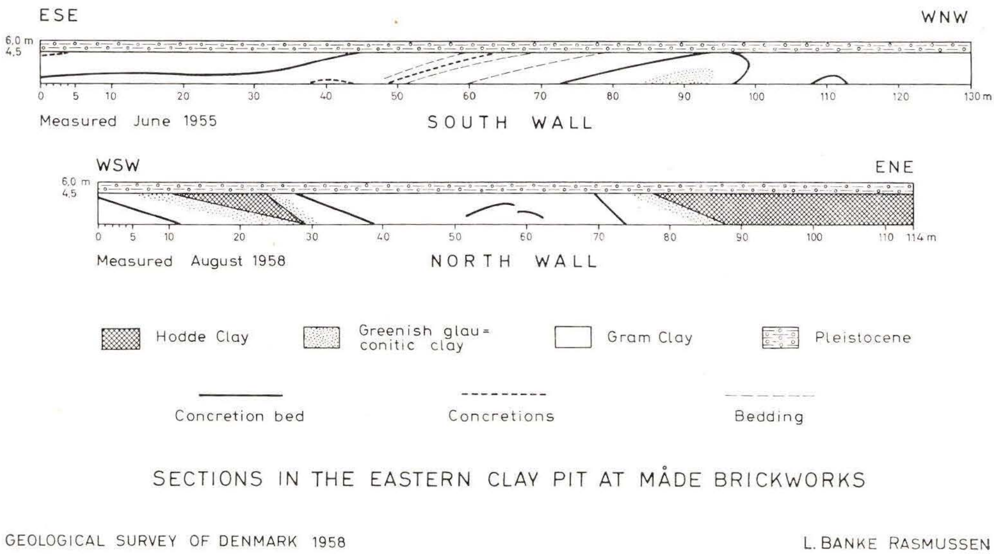

Fig. 57.

An estimated valuation of the thicknesses of the strata on the basis of surveying of the south wall in June 1955 (cf. the mention below) suggests that an about 22–23 m. thick series of Gram Clay had been bared in the clay pit. Of this series the layers above the topmost bed of concretions constituted 7–8 m., while the layers between the horizons of concretions together amounted to about 10 m. in thickness. Under the lowermost bed of concretions there were about 4–5 m. Gram Clay. The thickness of the Glauconite Clay hardly surpassed 2 m., so that the bared part of the Gram Formation must be supposed to have had a total thickness of some 25 m. The thickness of the Hodde Clay is unknown in this locality. For that matter this clay could be found at a long distance in a northerly direction on the area north of the north wall, where overburden was removed.

In the new digging portion:

Since 1960 the brickworks of Måde has been digging in a new excavation south of the large, triangular, now water-logged clay pit in the same area with removed overburden. The digging wall strikes in the direction NW–SE. Here, besides Gram Clay with at least one bed of concretions, some dark, very sandy boulder clay was found which had a high content of Miocene sediments (Mica Clay, Mica Sand, quartz sand, concretions, shells of molluscs, etc.).

Position of strata: In the old triangular clay pit:

The south wall was measured in June 1955 (fig. 57, p. 115). It had an ESE–WNW strike and at the time of the measurement was 130 m. long. What was informative for the estimate of the position of the beds was especially the two above-mentioned beds of concretions, the westernmost (and lowermost) of of which clearly had been deformed by ice-thrust from the east. The easternmost of the beds of concretions seemed to be almost parallel with the surface of the ground for a stretch of 30 m. in length before it curved upwards, parallel to the other concretion bed.

The layers were oblique and seemed to be parallel for a stretch about 60 m. long in the middle of the wall, and in the western part of the wall the disturbances appeared more radical in the form of steeply placed folds of the lowermost beds of concretions.

In the north wall, which was surveyed in August 1958 (fig. 57, p. 115), conditions also showed a folding of the strata due to ice-thrust from the east. In the 114 m. long wall, a fine wedge of Hodde Clay, flanked by a layer of green Glauconite Clay on each side was seen in the western half. A larger occurrence of Hodde Clay dominated the 35 m. long easternmost part of the wall. Between this clay and the Gram Clay, which occupied the 50 m. long central part, there was a layer of Glauconite Clay. A bed of concretions which originally was 4–5 m. above the Glauconite Clay, appeared in three places in the section. All these strata showed a steep dipping towards the east (to judge from the oblique position perhaps rather towards the SE), so that the folds can be supposed to have arisen by ice-thrust from the southeasterly direction.

Conditions in the Gram Clay in the middle part of the wall were uncertain at the time of the surveying, but there were traces of a dislocated bed of concretions.

In 1955 three beds of concretions with a fairly steep dip towards the south were seen in the east wall immediately north of the eastern end of the south wall. The two lowest horizons were close to each other, while the uppermost one was at some distance from the two others. Unfortunately it was not possible to find the contact to the concretion bed of the south wall, but that of the east wall undoubtedly belongs in the upper parts of the Gram Clay in this locality. The northern part, for that matter, had been greatly covered by downslide.

In the new digging area:

A guiding examination of the digging wall (fig. 58, p. 117), made on 9/5 1962, showed that in the western half of the about 110 m. long wall there was Gram Clay with concretions (presumably as beds) to about 22 m. from the westernmost point. After that, dark, sandy boulder clay was found for a stretch 37 m. long. For the first 20 m. the boulder clay was found only in the upper half of the wall, whereas there was Gram Clay in the lower part, but about 42 m. from the westernmost point there was a completely vertical boundary between the two kinds of clay. Another boundary between boulder clay and Gram Clay took an oblique direction with a dip towards the east from the upper edge of the wall about 55 m. from the westernmost point of the wall, and reached the floor of the pit about 59 m. from the west end. In the rest of the wall eastwards only Gram Clay was seen. On both sides of the oblique boundary between the boulder clay and the Gram Clay there was at the top of the wall a few rather narrow crevices filled with yellow-coloured sandy boulder clay from the superjacent

Fig. 58. The eastern clay pit of the brickworks of Måde. The north wall of the new zone, where digging was started about 1960. In the dark zone in the wall west of the middle, the sample of clay was taken the analysis of which is found in Table 49. On the right of this zone the somewhat paler moraine sand is seen. In the background the water-logged clay pit shown in fig. 55.

Phot. Chr. Westergaard

yellowish boulder clay. These crevices were completely parallel to the oblique boundary mentioned.

Level of the surface of the Miocene: about + 5 m.

Fauna: With the exception of the green Glauconite Clay all the layers occurring in the locality under the area where overburden was removed, contain marine molluscs. The collections were made by me during the visits mentioned on p. 114, but unfortunately I did not arrive at an understanding of the occurrence until 1955, for which reason all collections before that year are mixed-up material originating from several different horizons of Gram Clay. Faunal analysis, see Table 8, p. 211, and Table 49, p. 258.

5. The new clay pits of the brickworks of Strandgård and Bramminge (being in operation since about 1955).

Situation: The brickworks of Strandgård, which is situated 600 m. SE of the built-up area Måde, in 1955 began digging clay in a new pit 200 m. west of the buildings. This clay pit is close to the easternmost pit of the brickworks of Måde (Locality 4), only separated from it by a windbreak belt of spruces and a narrow strip of land. At the beginning they dug parallelly to the windbreak, but after one or two years they made the digging wall curve towards SE (cf.

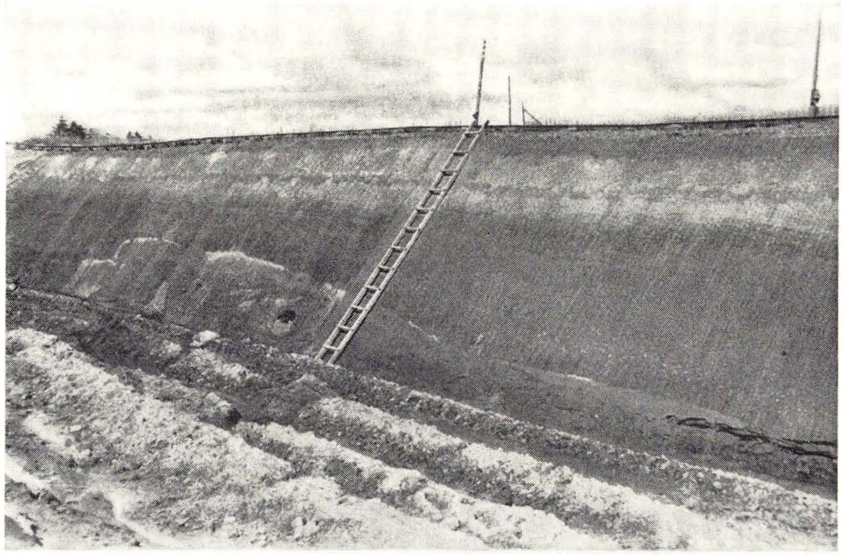

Fig. 59. Section in the clay pit of the brickworks of Strandgård immediately east of the east side of the easternmost clay pit of the brickworks of Måde, only about 25–50 m. behind the wall shown in fig. 56. The section faces west and shows interglacial marine clay, superposed on an irregular fold of dark, very sandy boulder clay, with high contents of Tertiary material.

Phot. L.B.R. 1956

RASMUSSEN 1959, the map on p. 116) and gradually expanded the clay pit in that direction, so that now there is a large pit SE of Locality 4. Fig. 54.

The brickworks of Bramminge fetches clay in a new pit which has been dug from the SW end of the clay pit of the brickworks of Strandgård in the direction towards the west, immediately south of the new digging zone of the easternmost clay pit of the brickworks of Måde (Locality 4). The clay pit of the two brickworks thus together form one large pit, which encircles Locality 4 towards the east and the south. Fig. 54.

Ground level: about + 7 m.

Sequence of strata: Of Miocene layers in the two clay pits only a smallish zone of Gram Clay has been found in the northernmost end of the clay pit of the brickworks of Strandgård. Here it crops out from the floor of the pit, overlain by dark grey, sandy boulder clay or moraine sand. Farther south there is marine interglacial clay ("Esbjerg Yoldia Clay") (Cf. fig. 59).

Both clay pits contain boulder clay or moraine sand towards the NW and marine, interglacial clay towards the SE and S.

Position of strata: The fact that there is Gram Clay only in the northernmost corner in spite of the clay pit of the brickworks of Strandgård for a long stretch being parallel to the east wall of Locality 4, where Gram Clay is seen all the way, clearly shows that the Gram Clay dips steeply towards the east, or rather SE, on the boundary between the two clay pits. The occurrence of the Quaternary strata in the pits indicates the same deposition.

Fossils: On a visit on 19/8 1954 some few molluscs were collected in the Gram Clay (see Table 50) and some few isolated Miocene shells in the moraine sand in the narrow clay pit immediately east of Locality 4. On 8/5 1962 supplementary collections of Miocene molluscs were made in the moraine sand in the large clay pits S and SE of Locality 4. It was noted that these molluscs were found only in the northern and western walls of the clay pits.

6. The old clay pits of the brickworks of Strandgård.

Situation: Formerly there was a brickworks about 200 m. south of the present brickworks of Strandgård. AXEL JESSEN (in his diary for "Kortbladet Ribe" ('The Map Sheet of Ribe'), September 1906) terms it "The new brickworks of Maade", "MATHIESEN's Brickworks" or "ABRAHAM's Brickworks". The clay pit was situated immediately south of the buildings. It was probably disused about 1920.

The brickworks of Strandgård was built in 1947 and dug clay from the old pit, which was expanded towards the north and afterwards to the west, north of the buildings. The digging there was abandoned about 1955. Figs. 54 and 60.

Ground level: about + 7 m.

Sequence of strata: In the old as well as the new clay pit Gram Clay was seen to be overlain by stony meltwater sand. Concretions were seen here and there in the clay.

Position of strata: No disturbances were observed in the Miocene layers in the small sections which I have had an opportunity of seeing, but the occurrence must nevertheless be assumed to have been glacially influenced, as exclusively Quaternary layers are found in clay pits only 200 m. farther west (see Locality 5).

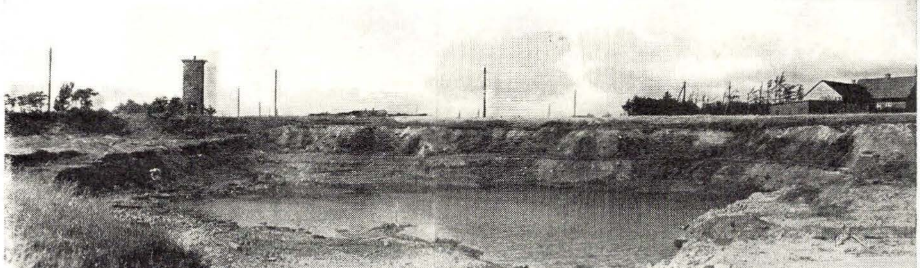

Fig. 60. Clay pit immediately north of the brickworks of Strandgård, dug in fossiliferous Gram Clay, as seen towards the north.

Phot. L.B.R. 1956.

Level of the surface of the Miocene: about + 5 m.

Fauna: Collections of molluscs from the Gram Clay in the oldest part of the clay pit were made by AXEL JESSEN and V. NORDMANN. Furthermore, I have myself collected some shells in the youngest portion of the pit, immediately north of the buildings of the brickworks. Faunal analysis, see Table 50, p. 260.

Region V

Western North Slesvig

Younger Miocene formations are distributed over the whole of the western half of North Slesvig, but Gram Clay only approaches the surface of the ground in the northern part of the province, where the occurrences are especially grouped within the area Brørup – Jels – Arnum – Spandet – Tobøl – Brørup.

No actual connexion with the Younger Miocene of the Esbjerg region has been established as localities are missing from the area between Måde and Tobøl – Holleskov. The northern demarcation of the region is on the whole uncertain. The northernmost locality is a pit of a brickworks, now disused, at *Gørding*, from where Upper Miocene molluscs are available, but where conditions of finding are unknown. Presumably there was a glacial floe of Gram Clay. Upper Miocene molluscs have furthermore been found in boulder clay at *Bramminge* (*Astarte reimersi* SEMPER in the collection of the D.G.U.) and at *Præstkær* north of Brørup (*Nucula georgiana*, SEMPER, *Dentalium badense* PARTSCH, *Xenophora testigera* BRONN, *Turritella tricarinata* (BROCCHI), *Natica catena* DA COSTA, *Cassidaria echinophora* L., and *Sipho distinctus* (BEYRICH); see V. MILTHERS 1925, p. 17–18). Some remnants of molluscs were also collected by SIGURD HANSEN, Ph. D., in a small clay pit at *Goldbæk* about 4 km N of Hellevad (situation, see fig. 9, p. 24). They were, however, too badly preserved for a determination, but they are surely derived from a Younger Miocene deposit (probably Gram Clay).

Apart from these localities with finds of Upper Miocene fossils in secondary position, *Sønderskovgård* south of Brørup is the northernmost known locality in the region in which Gram Clay must be supposed to be in primary position.

However, it seems probable to me that the Gram Formation can be found in situ even close to the Bramminge–Gørding–Brørup area.

The eastern limit of the distribution of Gram Clay in North Slesvig is also uncertain. The easternmost occurrences are in the Jels-Øster Lindet tract in the north and at Heds NW of Tinglev in the south. For that matter, the distribution of the Upper Miocene in Slesvig-Holstein (see JOHANSEN and PRANGE 1961, p. 70) shows that the eastern limit is considerably farther east south of the Danish frontier than north of it.

The area in which we may expect to find the Younger Miocene deposits to have been preserved within the North Slesvig region is considerably reduced because the base of the Quaternary does not seem to appear until below the level of — 100 m. west of a line nearly from Darum by way of Hjortlund, Seem, Roager, Brede to Ballum (see fig. 61). The large number of borings known from this area, which do not reach Miocene beds below the level of — 100 m., have all passed a marine series deposited in the same interglacial period as the "Esbjerg Yoldia Clay". The uppermost Miocene deposits found at this comparatively great depth seem to belong to the Arnum Formation or the Ribe Formation.

For that matter, the boreholes examined show that the clay series Gram Clay-Glauconite Clay-Hodde Clay also occurs in North Slesvig. Unfortunately the well-borers have often sent only a single sample from the total interval of clay. If the sample has been taken in the upper part of the interval, it will mostly be Gram Clay, and if has been taken deep in the interval, it often proves to be Hodde Clay. Samples of Glauconite Clay (the basal layer of the Gram Clay) are rarely available, but in a sufficient number of cases to establish with certainty that this clay is found in the whole of the North Slesvig region.

Besides the five outcrops described by me in 1956, there exists a total of 34 boreholes in which fossiliferous Gram Clay has been shown to occur, apart from the doubtful occurrence at Gørding. Hodde Clay has been found in 18 and the Glauconite Clay has been found in 6 boreholes.

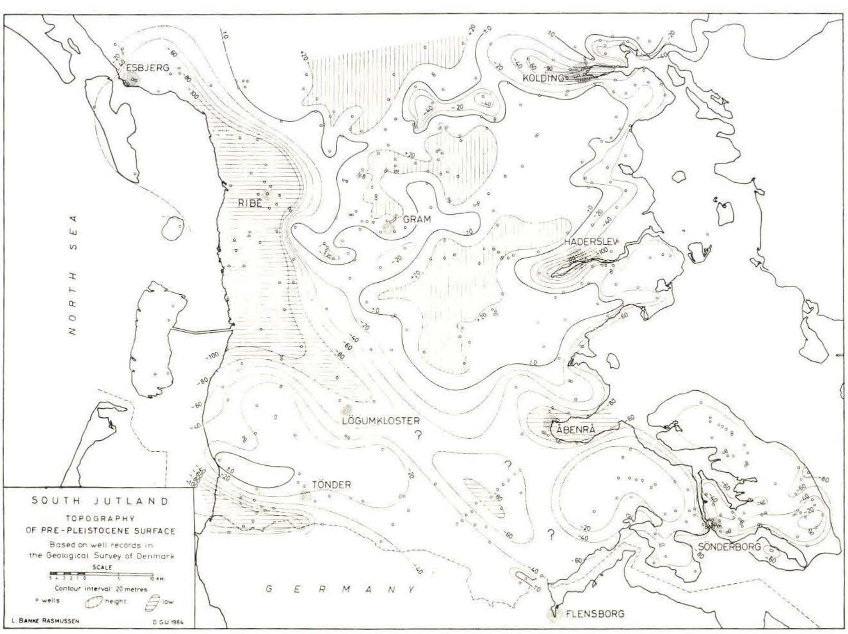

Fig. 61. Relief of the Pre-Quaternary surface in North Slesvig. Equidistance of the contours: 20 m. The vertically hatched areas: Pre-Quaternary above level + 20 m. The horizontally hatched areas: Pre-Quaternary below level — 80 m.

Gørding

Gram Clay seems to have been accessible in a pit of a brickworks now disused, N. HARTZ about the turn of the century acquiring a small collection of Upper Miocene molluscs which were stated to have been found at the brickworks of Gørding (see Table 51, p. 261).

We have no information about the geological conditions in the place (cf. RAVN 1907, p. 29, and A. JESSEN 1922, p. 18). Presumably the reference was to a glacial floe, the boreholes at Gørding showing that the Quaternary has not yet been penetrated at the level − 8 m. On the other hand, there is boulder clay which, if anything, must be characterized as a glacial floe of Mica Clay, often with lumps of Miocene clay, fairly close to the surface of the ground (cf. D.G.U. File No. 131.150).

The borehole closest to Gørding at which fossiliferous stationary Miocene is found, is at *Klostergården*, 2.8 km. SE of the station of Gørding and 4 km. SE of the church of Gørding. (Fig. 62). The boring, D.G.U. File No. 131.137, was made in 1953 and passed the following sequence of strata:

Ground level: about + 29 m.

Borehole log:

0.0–11.5 m.	?
11.5–16.0 –	Boulder clay
16.0–19.5 –	Sand, brownish grey, mixed with clay
19.5–19.8 –	Mica Clay, dark grey-greenish grey, contaminated with Quaternary transported material (stones, quartz, etc.), marine, with a few fragments of molluscs and *Cupuladria*. Perhaps a glacial floe of Mica Clay (Gram Clay?).
19.8–25.0 –	Mica Clay, dark brown, with layers of Mica Silt, pale grey, marine, fossiliferous, with bits of micaceous siltstone
25.0–27.1 –	Mica Silt, pale grey, marine, fossiliferous
27.1–30.5 –	Mica Clay, dark brown, marine, fossiliferous
30.5–75.0 –	Mica Silt, pale grey, marine, fossiliferous. (Final depth).

Fig. 62. Situation of borehole D.G.U. File No. 131.137 at Klostergård SE of Gørding. (Segment of M 3405 on the scale of 1:20,000).

From the depth of 19.5–19.8 m. only a few indeterminable fragments of molluscs are available. It seems that a single rolled fragment can be referred to an *Astarte sp.*

The layer from 19.8 to 25.0 m. contains typical Middle Miocene molluscs such as *Nassa schlotheimi*, *Terebra hoernesi*, *Vaginella depressa*, *Neoguraleus tenella*, *Aporrhais alata*, *Bittium tenuispina*, and *Chrysallida nodifera*. This assemblage is typical of the Arnum Formation.

The sample from the interval 25.0–27.1 m. contains numerous molluscs, among which *Nassa schlotheimi* and *Spisula subtruncata* are dominant. These fossils show a definite biostratigraphical correlation with the Arnum Formation.

This formation thus has been reached already at a level of about + 9 m. at Klostergården, which is situated only a few metres higher than Gørding and its nearest environs, where it can therefore be expected that Younger Miocene formations do not occur in situ.

Sønderskovgård

Borehole in the farmyard. Made in 1946.
D.G.U. File No. 132.34.

Situation: 3 km. NE of Foldingbro and 1.8 km. ESE of the church of Folding. Fig. 63.

Ground level: about + 39 m.

Borehole log:

0.0– 4.6 m. Boulder clay, weathered, sandy
4.6–10.5 – Mica Silt, dark grey, slightly argillaceous (glacial floe)
10.5–13.0 – Meltwater sand
13.0–27.0 – Gram Clay.
(Final depth).

Level of the surface of the Miocene: about + 26 m.

Fig. 63. Situation of borehole D.G.U. File No. 132.34 at the Sønderskovgård farm. (Segment of M 3507 on the scale of 1:20,000).

Molluscs: A sample from the interval 13.0–27.0 m. contained a few isolated fragments of shells (see Table 51, p. 261).

Description of the fossiliferous sample: Weight of sample: 96.16 g; weight of wash residue: 1.31 g. Typical Gram Clay, the wash residue of which contains the usual components, including many fragments of *Cupuladria* and foraminifera.

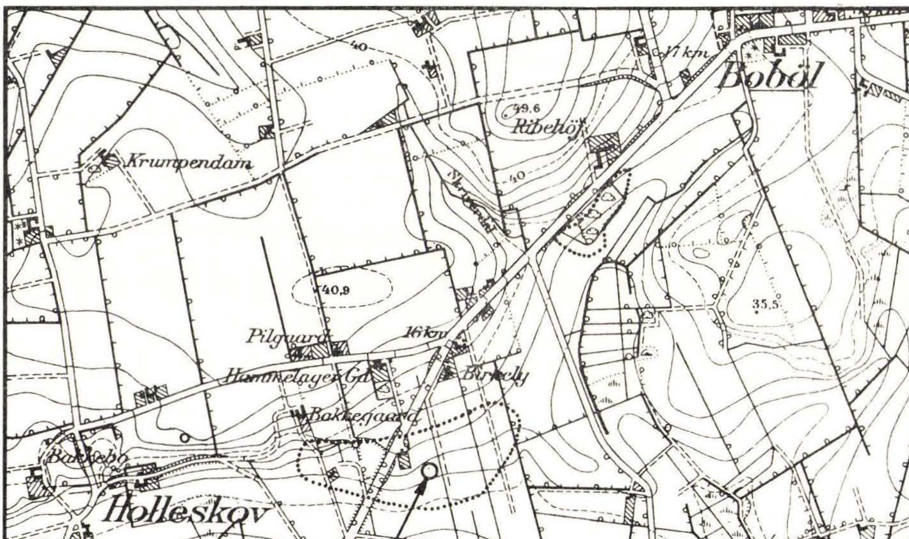

Fig. 64. Situation of the boreholes D.G.U. File Nos. 132.27 (Tobøl) and 132.46 b (Holleskov). – Miocene Clay has been shown to occur in the depth of 1.5 m. within the two areas framed with dots.

(Segment of M 3506 on the scale of 1:20,000).

Holleskov

This locality has previously been mentioned by me (RASMUSSEN 1954). As I have nothing to add, I shall content myself with referring to my article. (Cf. fig. 64). Faunal analysis, see Table 52, p. 262.

Tobøl

This locality has been mentioned in RASMUSSEN 1954, p. 537 (and in the English summary on p. 538). There is no new information to throw light on the borehole log, which is very summary and incompletely known. Situation, see fig. 64.

Ravning

Only a little additional information about this locality has been obtained, for which reason reference is made to my previous mention (RASMUSSEN 1956, p. 22). Situation, cf. fig. 65.

A sample of typical brownish grey Gram Clay taken by V. NORDMANN and AXEL JESSEN on the 18th of September 1906 in "the upper part of the clay" and kept in the collections of the D.G.U. has been examined in detail and washed with a view to a quantitative faunal analysis.

Weight of sample: 422 g. Weight of wash residue: 12.64 g.

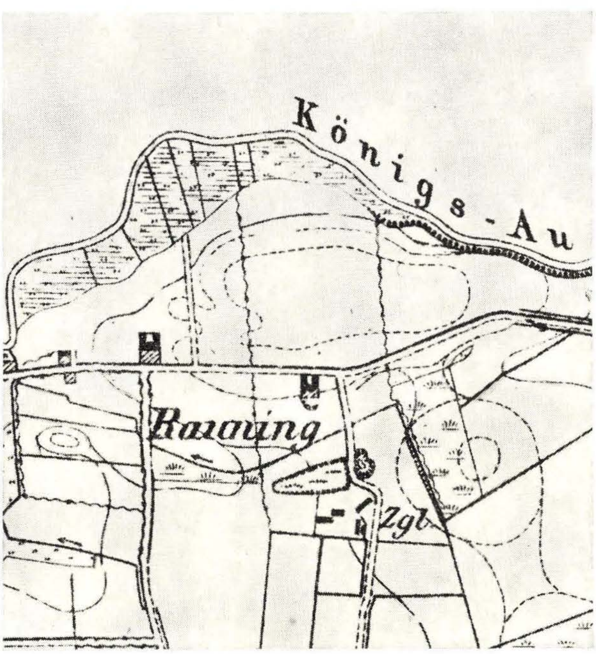

Fig. 65. Situation of the brickworks of Ravning and its clay pits (Zgl. = brickworks).
(Segment of early German map sheet on the scale of 1:25,000 from map after 1900).

The wash residue is dominated by micro-ellipsoids, but also contains numerous pale mica flakes. Furthermore numerous foraminifera and fragments of molluscs are seen. Many fragments of *Cupuladria haidingeri* and a few of *C. canariensis*. Some small grains of quartz and many small bits of pyrite, but few of these are needle-shaped. Some remnants of spatangids. A few ostracods and otolites. The sample is slightly contaminated by i.a. a few isolated grains of felspar and a small piece of quartzite. Faunal analysis, see Table 53, p. 263.

Hjortvad

Borehole at TERKEL TEILMANN's farm. Made in 1955.
D.G.U. File No. 141.178.

Situation: 2 km. ESE of the church of Kalvslund, immediately east of the road Hygum–Hjortvad and 400 m. NNW of the bridge of Hjortvad. The farm is called "Overgård". Fig. 66.

Ground level: about + 19 m.

Borehole log:

0.0– 7.6 m.	Well
7.6–10.2	– Clay, pale grey, sandy, micaceous, with small stones and fragments of Miocene shells (boulder clay)
10.2–23.1	– Gram Clay, in the lower part with brown concretions
23.1–28.1	– Clay, dark greenish grey, glauconitic (contaminated by Gram Clay)
28.1–38.1	– Hodde Clay, black (contaminated by Gram Clay and greenish clay). (Final depth).

Level of the surface of the Miocene: about + 9 m.

Molluscs are available from the following intervals from which samples have been taken: 7.6–10.2 m.; 10.2–15.1 m.; 15.1–20.1 m.; 20.1–23.1 m.; 23.1–28.1 m.; 28.1–33.1 m., and 33.1–38.1 m. Faunal analysis, see Table 54, p. 264.

Description of the fossiliferous samples:

7.6–10.2 m. Clay, sandy, the wash residue of which mainly consists of medium-grained sand (mainly quartz) and pebbles (flint, granite, etc.), with stems of pyrite, small greyish

Fig. 66. Situation of the borehole D.G.U. File No. 141.178 at Hjortvad. (Segment of M 3606 on the scale of 1:20,000).

ellipsoidal bodies, fragments of *Cupuladria haidingeri* and *Lunulites* sp., otolites, and fragments of molluscs. Probably reworked Gram Clay.

10.2–15.1 m. Gram Clay, which is a little marked by Quaternary transported material, especially grains of quartz, which, however, do not dominate the wash residue. This contains the usual components of Gram Clay. Among fossils found there were, besides fragments of molluscs, especially foraminifera and fragments of *Cupuladria canariensis* and *C. haidingeri.*

15.1–20.1 m. Typical Gram Clay with some small bits of yellowish brown concretions. The wash residue is typical of Gram Clay. The sample does not seem to have any contaminations.

20.1–23.1 m. Typical Gram Clay, without contaminations. The wash residue contains the usual components. Besides molluscs and foraminifera there were fragments of *Cupuladria* and *Ditrupa* tubes.

23.1–28.1 m. Clay, dark greenish grey, into which were kneaded small lumps of (1) Gram Clay, (2) Hodde Clay, and (3) yellowish brown concretions. The wash residue consists of dark green grains of glauconite and a few grains of quartz. Presumably the boundary between the green clay and Hodde Clay is passed somewhere between the depths of 23 m. and 28 m., as sure lumps of the latter type of clay were found in the sample.

28.1–33.1 m. Hodde Clay with parts of Gram Clay and greenish clay kneaded into it. The wash residue mainly shows glauconite, but with much pyrite in the shape of stems as well as small bits. Among fossils there were, besides foraminifera and fragments of shells, *Cupuladria haidingeri* and *Ditrupa sp.*

33.1–38.1 m. Hodde Clay, with fewer contaminations than the preceding sample, but still with small sharp-edged bits of Gram Clay. The wash residue contains numerous grains of glauconite, but besides, much pyrite with a slag-like look, which is characteristic of Hodde Clay. Fairly many grains of quartz are seen. Some foraminifera and a few fragments of shells and spines of spatangids.

Remarks: The available samples are nearly all of them contaminated. This must either have happened at the drilling or at the sampling at the place of drilling, perhaps after the drilling was finished and before the samples were submitted to the D.G.U. Pieces of Gram Clay were seen to have been kneaded into the other types of clay, and in the Glauconite Clay there are furthermore pieces of the layers from the depths below 28.1 m. As the pieces are sharp-edged, it is hardly a question of glacially effected contaminations.

Glacial deformations of the penetrated Miocene series of strata, however, cannot be precluded, as no certain boulder clay has been found above the Gram Clay in this place, which is remarkable; for very calcareous boulder clay is of general occurrence in the region about Hjortvad, where it has been dug for marling. Until recently it has been dug in large pits at Bavnegård, 1.4 km. NNW of Overgård.

A borehole 1 km. NE of the farm (D.G.U. File No. 141.254) showed a confused sequence of various Quaternary strata, i.a. with upthrust Miocene lignite.

Lintrup

Borehole in THORVALD CHRISTENSEN's field. Made in 1956.
D.G.U. File No. 132.140.

Situation: 400 m. NE of the church of Lintrup, immediately west of the road from Lintrup to Foldingbro. Fig. 67.

Ground level: about + 34 m.

Borehole log:

0.0– 3.3 m.	Boulder clay, pale grey, very calcareous
3.3– 3.8 –	Glacial floe of Gram Clay
3.8– 4.8 –	Mica Clay, silty
4.8– 9.8 –	Mica Silt, paler grey, stratified
9.8–24.8 –	Gram Clay
24.8–28.0 –	Clay, dark green, glauconitic. (Final depth).

Level of the surface of the Miocene: about + 30 m. ?

Molluscs are available from the following intervals: 3.3–3.8 m.; 3.8–4.8 m.; 4.8–9.8 m.; 9.8–14.8 m.; 14.8–19.8 m.; 19.8–24.8 m., and 24.8–28.0 m. Faunal analysis, see Table 55, p. 265.

Description of fossiliferous samples:

3.3–3.8 m. Weight before washing: 97.99 g; after washing: 3.76 g. Gram Clay, contaminated by Quaternary transported material (felspar, flint, quartz, etc.). The wash residue mainly contains grains of quartz and, in smaller quantities, components characteristic of Gram Clay. Besides numerous foraminifera, there are many fragments of shells, some spines of spatangids, a single otolite, and a rolled fragment of a claw of a crab. No remnants of *Cupuladria* and no stems of pyrite.

3.8–4.8 m. Weight before washing: 123.40 g; after washing: 6.07 g. Mica Clay with some quartz sand. The wash residue mainly contains quartz sand and furthermore some small reddish brown pieces of concretions and Quaternary transported material (limestone,

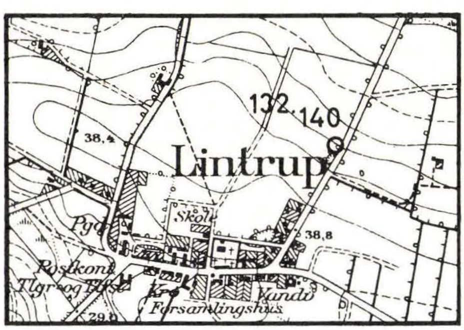

Fig. 67. Situation of the borehole D.G.U. File No. 132.140 at Lintrup. (Segment of M 3506 on the scale of 1:20,000).

flint, felspar, etc.). A few stems of pyrite. No remnants of *Cupuladria*. Few foraminifera and fragments of shells.

4.8–9.8 m. Weight before washing: 123.03 g; after washing: 3.65 g. Mica Silt, the wash residue of which mainly consists of very small grains of quartz, but with very numerous small pale mica flakes. Furthermore a little Quaternary transported material: felspar, Cretaceous bryozoa, flint, etc. A few spines of spatangids. Very few foraminifera and fragments of shells.

9.8–14.8 m. Weight before washing: 125.21 g; after washing: 4.98 g. Gram Clay, the wash residue of which contains much quartz sand and otherwise the components characteristic of Gram Clay. Many small pale mica flakes. Some Quaternary transported material. A few fragments of *Cupuladria*. Numerous foraminifera. Many fragments of shells.

14.8–19.8 m. Weight before washing: 135.23 g; after washing: 38.98 g. Gram Clay, dark grey, which could not be decomposed completely before washing. The wash residue contains a few grains of quartz and very little Quaternary transported material (i.a. flint). A few fragments of *Cupuladria*. No foraminifera and only a few fragments of shells.

19.8–24.8 m. Weight before washing: 152.33 g; after washing: 7.80 g. Typical Gram Clay, the wash residue of which contains the components characteristic of this clay. Fragments of *Cupuladria*. Some foraminifera. Spines of spatangids. Fragments of shells.

24.8–28.0 m. Weight before washing: 137.25 g; after washing: 25.79: g. Clay, dark green, the wash residue of which exclusively consists of grains of glauconite. A few foraminifera and fragments of shells.

Remarks: The samples from 3.3–9.8 m. can hardly be characterized as Gram Clay proper. There are alternating layers of Mica Silt and Mica Clay. All samples down to a depth of 19.8 m. have some contaminations of Quaternary material. This especially applies to the sample from the depth of 3.3–3.8 m., which, if anything, must be considered a glacial floe of Gram Clay.

Hjerting

Borehole at CARL E. HANSEN's farm. Made in 1960.
D.G.U. File No. 141.238.

Situation: 1.6 km. SW of the church of Hjerting, 300 m. SSW of Møllevejgård, which is the name of the farm near which the borehole was made. Fig. 68.

Ground level: about + 38 m.

Borehole log:

0.0– 2.8 m. Meltwater sand, fine, brownish grey
2.8– 6.4 – Clay, reddish brown (presumably weathered Gram Clay)
6.4–30.0 – Gram Clay.
(Final depth).

Level of the surface of the Miocene: about + 35 m.

Molluscs were found in the samples from 20.2 m. and 27.7 m. Faunal analysis, see Table 51, p. 261.

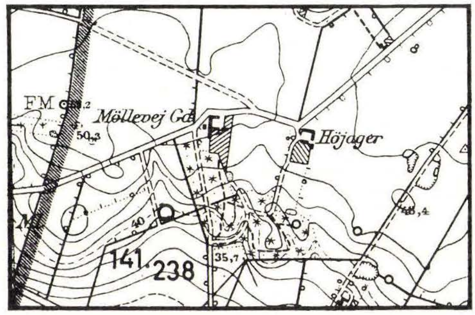

Fig. 68. Situation of borehole D.G.U. File No. 141.238, at Møllevej farm, Hjerting. (Segment of M 3606 on the scale of 1:20,000).

Description of the fossiliferous samples:

20.2 m. Weight before washing: 8.44 g; after washing: 0.36 g. Typical Gram Clay, the wash residue of which contains the usual components. Many foraminifera. A few fragments of *Lunulites sp.* and *Ditrupa* tubes. A few shells and fragments of shells.

27.7 m. Typical Gram Clay like the sample from 20.2 m.

Remarks: The Gram Clay in this place is hardly undisturbed, as another boring about 150 m. NNE of it (D.G.U. File No. 141.239) had not yet penetrated the meltwater sand at the final depth of 29 m. The ground level of this boring is about + 46 m.

Sønder Hygum

In the village of Sønder Hygum and its close environs marine, fossiliferous Miocene layers have been found by at least five borings, which together with other boreholes show that the surface of the Miocene is placed irregularly. While thus the Miocene deposits were not yet found at the level — 1 m. in a boring made for the waterworks of Sønder Hygum (D.G.U. File No. 141.259), the Gram Clay was found already at level + 34 m. only 150 m. farther west (D.G.U. File No. 141.260).

1. Hygum Mark. Borehole at PETER ELBÆK's farm. Made in 1960. D.G.U. File No. 141.215.

Situation: 900 m. NNE of the church of Sønder Hygum and immediately west of the road from Rødding to Tornum. Fig. 69.

Ground level: about + 25 m.

Borehole log:

0.0– 5.1 m. Glacio-fluvial sand and gravel
5.1–11.2 – Boulder clay, sandy, dark grey, with many lumps of chalk

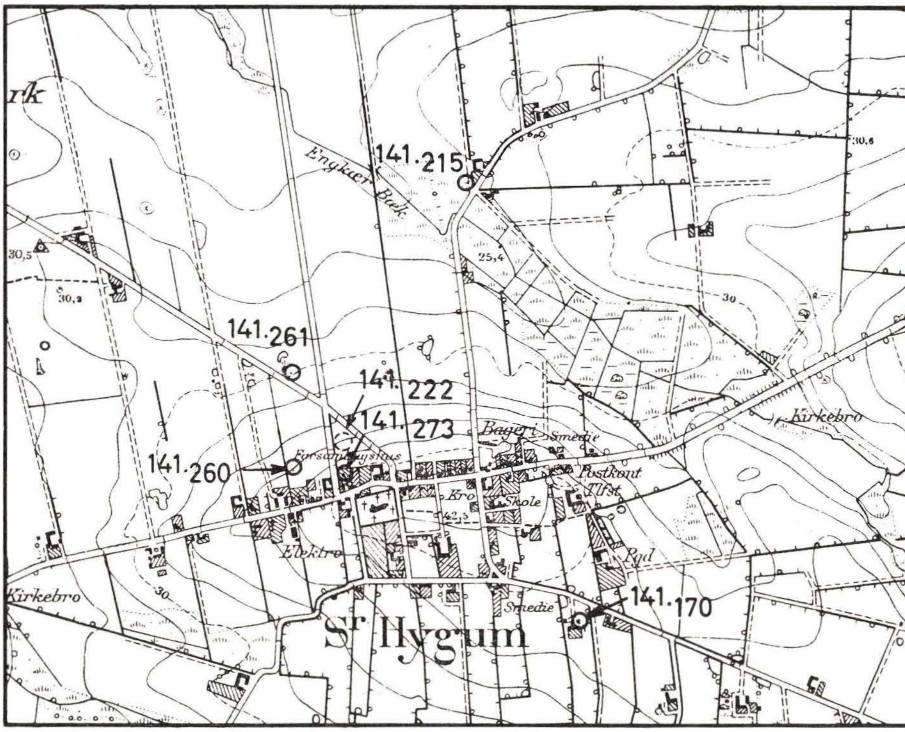

Fig. 69. Situation of boreholes at Sønder Hygum: D.G.U. File Nos. 141.215, 141.261, 141.222, 141.273, 141.260, and 141.170.
(Segment of M 3606 on the scale of 1:20,000).

11.2–18.5 – Gram Clay
18.5–26.2 – Gram Clay and Hodde Clay
26.2–38.2 – Hodde Clay, fractured
38.2–39.2 – Mica Silt, dark grey, alternating with black Mica Clay (Hodde Clay); with a few pea-sized grains of quartz
39.2–39.5 – Gravel of quartz, with rounded pebbles of quartzite up to 1.5 cm. in size
39.5–42.1 – Mica Sand or micaceous quartz sand, grey
42.1–47.0 – Quartz gravel, fine, dark grey.
(Final depth).

Level of the surface of the Miocene: about + 14 m.

Molluscs are available partly from a fairly large sample of the Hodde Clay from the interval 26.2–32.8 m., which was submitted to the D.G.U. during the drilling, partly from a very small sample from the depth of 15.4 m. Fossil analysis, see Table 11, p. 214.

Description of the fossiliferous samples:

15.4 m. Weight before washing: 5.08 g; after washing: 0.18 g. Typical Gram Clay, the wash residue of which contains the usual components of Gram Clay. Besides a few fragments of molluscs some foraminifera and a few ostracods. Fragments of *Ditrupa*.

26.2–32.8 m. Weight before washing: 18.46 g; after washing: 0.36 g. Typical Hodde Clay, the wash residue of which mainly consists of slag-like bits and some stems of pyrite. Besides numerous fragments of molluscs some foraminifera. A smaller sample from the depth of 29.6 m. contained the same components, with the exception of molluscs.

Remarks: The boundary between Gram Clay and Hodde Clay in this borehole is unknown. It is also unknown whether a layer of dark green Glauconite Clay was passed. A sample from the depth of 24.2 m. consists of typical Hodde Clay. The appearance of the wash residue also agrees with the usual appearance of Hodde Clay. Numerous foraminifera are seen, but only a few quite indeterminable fragments of molluscs.

To illustrate conditions of level of the Miocene strata it can be stated that a borehole about 100 m. from that described here ended at the depth of 17 m. (ground level about + 24 m.) without any Miocene strata being reached.

2. Northern part of the village of Sønder Hygum. Three boreholes made for the waterworks in 1962. D.G.U. File Nos. 141.260, 141.261, and 141.273.

Situation: Respectively 200 m. NW, 400 m. NNW, and about 125 m. NNW of the church of Sønder Hygum. Fig. 69.

Ground levels: No. 141.260: about + 36 m., No. 141.261: about + 30 m., and No. 141.273: about + 39 m.

Borehole logs:

No. 141.260	No. 141.261	No. 141.273	Lithology
		0.0– 6.0 m.	Reworked material, rubbish, etc.
	0.0–11.5 m.		Boulder clay, grey, with many lumps of chalk
0.0– 1.8 m.	11.5–12.1 –	6.0–14.8 –	Meltwater sand (below in No. 141.261 with stones and gravel)
	12.1–12.9 –		Stones
		14.8–18.0 –	Mica Silt, greenish grey, heterogeneous
		18.0–24.0 –	Mica Clay, dark grey and black mixed, sandy
1.8–40.0 m. (Final depth)	12.9–20.0 m. (Final depth)	24.0–	Gram Clay (In No. 141.260 weathered and sandy from 1.8–12.0 m.)
		56.0 –	Presumably Hodde Clay
		56.0–65.0 – (Final depth).	Quartz sand, medium-grained, grey, slightly micaceous.

Levels of the surface of the Miocene: No. 141.260: about + 34 m., No. 141.261: about + 17 m., and No. 141.273: about + 24 m.

Molluscs are available from a sample from the depth of 12–40 m. in No. 141.260, and from a sample from the depths of 13–19 m. and 20 m. in No. 141.261.

Furthermore from the depth of 45 m. in No. 141.273. Besides I have collected fossils in a heap of drilled-up clay on a visit to the place on 9/5 1962.

As the sample from the depth of 12–40 m. in No. 141.260 exclusively is clay taken in the outermost part of the heap of drilled-up clay, this material most probably originates from the deeper part of the interval 12–40 m.

Faunal analysis, see Table 56, p. 265.

Description of fossiliferous samples:

No. 141.260. 12–40 m. Weight before washing: 4500 g; after washing: 132 g. Typical Gram Clay. The wash residue contains the usual components. Numerous foraminifera, molluscs, fragments of *Cupuladria canariensis*, *C. haidingeri*, and *Lunulites sp*. Furthermore, ostracods, otolites, and spines of spatangids.

No. 141.261. 13–19 m. Weight before washing: 11318 g; after washing: 275 g.

No. 141.261. 20 m. Weight before washing: 3899 g; after washing: 90 g

No. 141.273. 24–56 m. All the three last samples are completely similar to the first-mentioned one.

Remarks: Besides in these three boreholes the Miocene has been found in one or two other boreholes in the village of Sønder Hygum.

Thus in a borehole made for the waterworks (D.G.U. File No. 141.14d), situated 100 m. NW of the church of Sønder Hygum, were found first 9 m. boulder clay and under that 26 m. Mica Silt and Mica Clay with bits of wood and lignite, which suggests that these deposits are limnic.

Another borehole (D.G.U. File No. 141.222), also made for the waterworks and situated 200 m. NNW of the church of Sønder Hygum, under 14 m. of Quaternary beds presumably reached into Gram Clay and later Hodde Clay. The boundary between these two types of clay was not indicated by the well-borer in question, who only submitted a small sample of Hodde Clay (from the depth of 45 m.) as a representative of the whole interval from 14.0 m. to 55.5 m. Below that depth there was quartz sand.

A third boring (D.G.U. File No. 141.259) made for the waterworks, about 70 m. north of the church of Sønder Hygum, ended at a depth of 40 m. without the Miocene having been reached after a drilling exclusively in glacio-fluvial sand with varying sizes of grains.

These boreholes show in no uncertain manner how great variations there are between the different Quaternary and Miocene strata, at least within the uppermost 40 m., in the area of the village of Sønder Hygum. They indicate that glacial deformations highly manifest themselves in the area.

3. Southern part of the village of Sønder Hygum. Borehole at JENS SCHÖT's farm. Made in 1954. D.G.U. File No. 141.170.

Situation: 600 m. SE of the church of Sdr. Hygum, immediately south of the road from Hygum to Brændstrup. Fig. 69.

Ground level: about + 39 m.

Borehole log:

0.0–12.4 m. Boulder clay, dark (glacial floe of Mica Clay)
12.4–17.1 – Mica Clay, dark grey, silty, fossiliferous
17.1–17.6 – Mica Clay, brownish grey, silty
17.6–18.0 – Mica Clay, sandy, dark grey, glauconitic.
(Final depth).

Level of the surface of the Miocene: about + 27 m.

Molluscs were found in a sample from 17.6–18.0 m.

Brøstrup

At Brøstrupgård 1 km. east of Brøstrup and 1 km. SW of the church of Rødding, fossiliferous Gram Clay and Hodde Clay were found in two boreholes near the farm. Situation, see fig. 70.

1. Borehole 200 m. NE of Brøstrupgård. Made in 1960. Fig. 70. D.G.U. File No. 141.224.

Ground level: about + 29 m.

Borehole log:

0.0– 3.4 m. Glacio-fluvial sand and gravel, grey
3.4–11.0 – Boulder clay, grey
11.0–17.5 – Gram Clay with glacial transported sand and gravel (glacial floe)
17.5–22.0 – Gram Clay
22.0–22.2 – Clay, silty, micaceous, and glacio-fluvial sand and gravel
22.2–25.0 – Hodde Clay, black, with zones of pale grey, fine silt
25.0–28.0 – Quartz sand and gravel, pale grey, micaceous
28.0–30.0 – Mica Silt, coarse, grey.
(Final depth).

Level of the surface of the Miocene: about + 7 m.

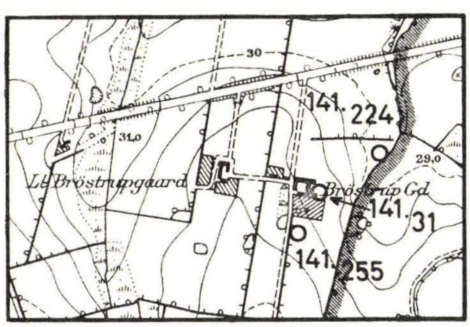

Fig. 70. Situation of the boreholes D.G.U. File Nos. 141.31, 141.224, and 141.255 at Brøstrupgård. (Segment of M 3606 on the scale of 1:20,000).

Molluscs are available from a sample from a depth of 20 m. Faunal analysis, see Table 51, p. 261.

Description of the fossiliferous sample:

20.0 m. Weight before washing: 59.64 g; after washing: 1.47 g. Typical Gram Clay, the wash residue of which contains the usual components. Besides fragments of shells, foraminifera, and a few otolites there were many fragments of and a few whole zoaria of *Cupuladria haidingeri.*

Remarks: The 20 cm. thick layer of glacio-fluvial sand at the depth of 22 m. suggests that the Gram Clay was glacially disturbed, but presumably it has not been moved appreciably from the place where it was originally deposited.

2. Borehole 100 m. south of Brøstrupgård. Made in 1961. Fig. 70. D.G.U. File No. 141.255.

Ground level: about + 37 m.

Borehole log:

0.0– 8.0 m.	Boulder clay, pale grey, with many small lumps of chalk
8.0– 8.4 –	Glacio-fluvial sand, brownish grey, argillaceous, gravelly, with a few stones
8.4–34.5 –	(Gram Clay ? and) Hodde Clay, brownish black
34.5–35.0 –	Quartz gravel, fine, with beds of Mica Clay
35.0–36.1 –	Mica Sand, fine, grey, with a little lignite
36.1–37.0 –	Quartz sand, mainly coarse, grey, gravelly
37.0–37.2 –	Mica Silt, fine, grey, stratified
37.2–40.0 –	Quartz sand, coarse, grey, very gravelly. (Final depth).

Level of the surface of the Miocene: about + 29 m.

Molluscs were found in a sample from 30.3 m. (See Table 9, p. 212).

Description of the fossiliferous sample:

30.3 m. Hodde Clay, brownish black. The wash residue, however, besides the characteristic slag-like bits of pyrite and some grains of quartz, contains numerous dark green grains of glauconite, which suggest that rather close above the depth of 30.3 m. there was Glauconite Clay, from which no samples are available. Numerous foraminifera and a few fragments of shells.

Remarks: It is improbable that the sample of Hodde Clay from the depth of 30.3 m. should represent the whole interval 8.4–34.5 m. The uppermost part is most probably Gram Clay, even though this cannot be proved by the sample.

About 100 m. NE of the borehole just described, another borehole (D.G.U. File No. 141.31) was made in 1940. It seemed to have reached Miocene strata at a depth of 29 m. The ground level in this place is about + 35 m., for which reason the surface of the Miocene presumably was at a level of about + 6 m. This borehole, however, was only 36.5 m. deep and the information available (in the Well File Department of the D.G.U.) insufficient for a judgment of the position of strata.

The situation of the Miocene layers in the three boreholes at Brøstrupgård, however, indicated the presence of glacial disturbances in the Younger Miocene strata.

Rødding

At Rødding Gram Clay reaches a level of + 30 to + 35 m. south of the town and seems to reach the level of + 9 m. north of the town, while boreholes in the area of the town itself show that the Quaternary in this place goes below sea level. As far as is known, the Gram Clay has not been accessible in outcrops, but is known from boreholes only. Its presence has been demonstrated in some seven boreholes, which all have penetrated both the Gram Formation and the Hodde Formation and reached strata of unknown age, but which seem to be limnic and presumably belong to the Odderup Formation.

1. Vestermark. Two boreholes made for the waterworks of Rødding.

Situation: 900 m. NNE of the church of Rødding, immediately west of the highway from Rødding to Foldingbro. The boreholes (D.G.U. File Nos. 141.76 and 141.248) are situated at a distance of some 30 m. from one another on a line striking in the direction WNW–ESE. The former borehole is found farthest WNW. Fig. 71.

Ground level: about + 45 m.

Borehole logs:

No. 141.76 (Made in 1952)	No. 141.248 (Made in 1960)	Lithology
0.0–28.4 m.	0.0–	Silt, brownish grey
		Micaceous boulder clay, grey
28.4–37.2 –	–36.0 m.	Gram Clay (perhaps a glacial floe)
37.2–42.4 –	36.0–	Hodde Clay
42.4–49.6 –		Mica Silt, fine, argillaceous, brownish grey
49.6–50.5 –	50.5 –	Quartz sand, rather coarse, pale grey, micaceous
	(Final depth)	(in No. 141.248 with pieces of lignite)
50.5–52.4 –		Quartz sand and gravel, grey, micaceous
52.4–58.4 –		Mica Silt, rather coarse, brownish grey.
(Final depth).		

Levels of the surface of the Miocene: No. 141.76: about + 17 m. No. 141.248: ?

Molluscs are available from 28.4–37.2 m. in No. 141.76. Faunal analysis, see Table 57, p. 267. The few specimens from the Hodde Clay interval are listed in the same table.

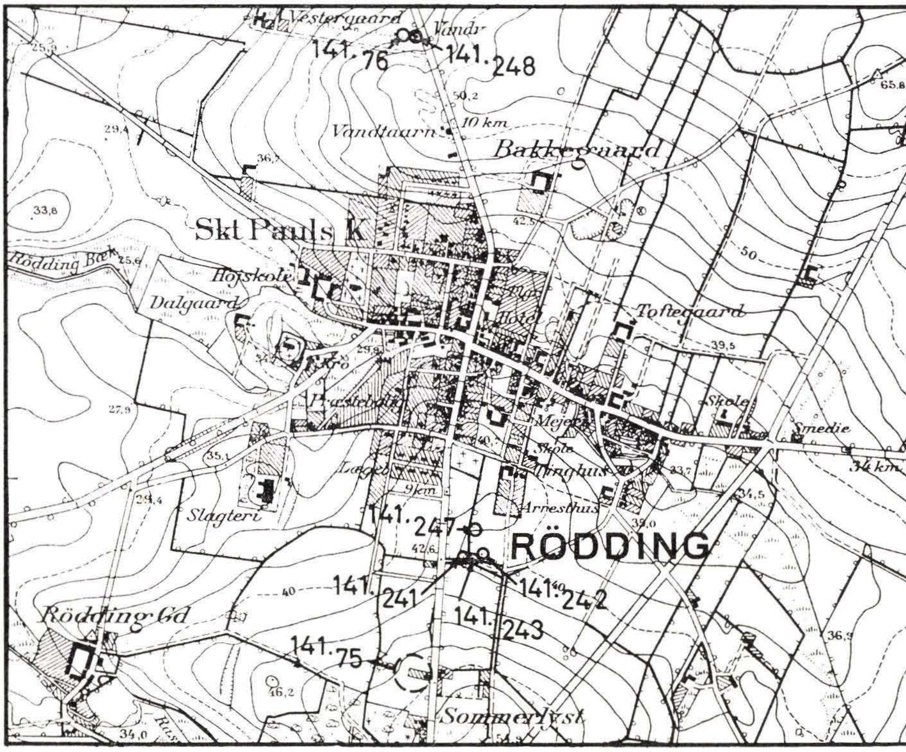

Fig. 71. Situation of boreholes at Rødding: D.G.U. File Nos. 141.76, 141.248, 141.247, 141.241, 141.242, 141.243, and 141.75.
(Segment of M 3607 on the scale of 1:20,000).

Description of the fossiliferous sample:

28.4–37.2 m. Weight of sample: 237.06 g, after washing: 17.34 g. Gram Clay containing large quantities of glacially transported material (small stones of granite, quartzite, etc., and grains of quartz). Furthermore there are in the wash residue the typical components of Gram Clay and some rolled fragments of shells and fragments of *Cupuladria*. Some mica flakes. The sample thus consists either of highly contaminated Gram Clay or of a glacial floe of this species of clay.

2. Southern outskirts of Rødding. Four boreholes made for the waterworks.

Situation: 700 m. SE of the church of Rødding, immediately east of the highway from Rødding to Gram. The boreholes (D.G.U. File Nos. 141.241, 141.242, 141.243, and 141.247) are very near to each other. No. 141.247 is about 100 m. farther north than the other three boreholes, which are situated at intervals of few metres on a line oriented west – east. All the boreholes were made in 1960. Fig. 71.

Ground level: about + 42 to + 43 m.

Borehole logs:

No. 141.247	No. 141.241	No. 141.242	No. 141.243	Lithology
0.0–13.2 m.	0.0– 9.6 m.	0.0– 7.0 m.	0.0– 6.5 m.	Boulder clay, grey (above with 3–4 m. oxidation zone under 20–50 cm. mould)
13.2–29.0 –	9.6–28.0 –	7.0–22.0 –	6.5–27.5 –	Gram Clay
29.0–33.0 –	28.0–33.0 –	22.0–	27.5–33.5 –	Hodde Clay
33.0–36.0 –	33.0–36.0 –	–36.0 –	33.5–35.5 –	Hodde Clay with layer of quartz sand, with quartz gravel below
36.0–42.5 –	36.0–43.0 –	36.0–	35.5–43.6 –	Mica Silt, grey, with bits of lignite
42.5–	43.0–46.5 –		43.6–	Quartz sand, coarse
	46.5–50.0 –	–50.2 –		Mica Silt, grey (in No. 141.241 with bed of brownish grey Mica Clay)
–53.5 –	50.0–50.5 –	50.2–50.5 –	–51.5 –	Quartz sand and gravel
53.5–53.8 –	50.5–51.2 –	50.5–	51.5–52.5 –	Mica Clay, silty, black, slaty
53.8–	51.2–60.0 –	–60.0 –	52.5–60.0 –	Mica Silt, dark grey, with layer of dark Mica Clay.
(Final depth).	(Final depth).	(Final depth).	(Final depth).	

Levels of the surface of the Miocene: about + 29 to + 35 m.

Molluscs are available from the following depths: No. 141.247: 20 m. No. 141.241: 9.6–28.0 m. and 28.0–33.0 m. No. 141.242: 19 m. and 32 m. No. 141.243: 20 m., 30 m., and 34.5 m. Faunal analyses, see Tables 9, p. 212 and 57 p. 267.

Description of the fossiliferous samples:

No. 141.247; 20 m. Weight of sample before washing: 87.96 g; after washing: 3.00 g. Typical Gram Clay. Characteristical wash residue with foraminifera and molluscs.

No. 141.241; 9.6–28.0 m. Weight of sample before washing: 54.02 g; after washing: 0.52 g. Clay, dark grey-brownish grey, silty, resembling Gram Clay; but the wash residue contains an extraordinarily large number of mica flakes and is without the components characterizing Gram Clay. Some contaminations of glacially transported material (small pieces of granite, felspar, flint, etc.). Some foraminifera and a few fragments of shells. Some spines of spatangids.

No. 141.241; 28.0–33.0 m. Weight of sample before washing: 36.32 g; after washing: 0.20 g. Typical Hodde Clay with the wash residue characteristic of this clay. Many foraminifera and fragments of molluscs.

No. 141.242; 19 m. Weight of sample before washing: 101.84 g; after washing: 5.76 g. Gram Clay, which is highly contaminated by glacially transported material (flint, granite, felspar, and grains of quartz sand). Many pale mica flakes. Many bits of pyrite. Foraminifera and fragments of shells.

No. 141.242; 32 m. Weight of sample before washing: 86.72 g; after washing: 0.72 g. Typical Hodde Clay, black, calcareous. The wash residue is characteristic of the Hodde Clay. Mainly pyrite. Some small grains of quartz. Numerous foraminifera. Many fragments of shells. A few spines of spatangids.

No. 141.243; 20 m. Typical Gram Clay.

No. 141.243; 30 m. Weight of sample before washing: 84.54 g; after washing: 1.88 g. Hodde Clay. The wash residue mainly consists of small pitted and cavernous bits of pyrite. Numerous small grains of quartz. A few grains of glauconite. Many foraminifera. Some fragments of molluscs. Spines of spatangids.

No. 141.243; 34.5 m. Weight of sample before washing: 88.42 g; after washing: 1.50 g. Hodde Clay. The wash residue consists of numerous grains of glauconite and quartz. Many mica flakes. Many bits of pyrite. Numerous foraminifera. A few fragments and shells of molluscs. A few otolites.

3. Sommerlyst. Borehole for the waterworks of Rødding.

Situation: 900 m. SSE of the church of Rødding and about 100 m. west of the highway between Rødding and Gram. D.G.U. File No. 141.75. Made in 1952. Fig. 71.

Ground level: about + 48 m.

Borehole log:

0.0– 6.4 m.	Boulder clay.
6.4–10.8 –	Glacio-fluvial sand
10.8–25.6 –	Gram Clay
25.6–33.2 –	Clay, dark green, glauconitic
33.2–35.6 –	Hodde Clay
35.6–43.9 –	Quartz sand and gravel, with strata of micaceous silt containing lignite
43.9–54.1 –	Quartz sand and gravel, with strata of Mica Silt
54.1–56.6 –	Quartz sand and gravel
56.6–57.2 –	Quartz gravel with strata of dark grey, silty Mica Clay
57.2–58.0 –	Quartz sand, very micaceous, with strata or concretions of hard, dark grey-black micaceous claystone.

Level of the surface of the Miocene: about + 37 m.

Molluscs have been found in the samples from the following depths: 10.8–16.8 m., 16.8–25.6 m., and 25.6–33.2 m. Faunal analysis, see Table 57, p. 267.

Description of the fossiliferous samples:

10.8–16.8 m. Weight of sample before washing: 122.78 g; after washing: 7.50 g. Typical Gram Clay, the wash residue of which, besides the usual components, contains numerous brownish grains, which presumably are decomposed glauconite (after treatment of the sample with NaOH). Some grains of quartz. Few impurities (granite, etc.). Many foraminifera and fragments of shells. Fragments of *Cupuladria*. Ostracods. Spines of spatangids.

16.8–25.6 m. Weight of sample before washing: 106.40 g; after washing: 3.04 g. Typical Gram Clay, the wash residue of which contains the same elements as the sample from 10.8–16.8 m., only that there are considerably more of the brownish grains, presumably originally glauconite.

25.6–33.2 m. Weight of the sample before washing: 89.68 g; after washing: 26.56 g. Clay, dark grey, the wash residue of which consists of grains of glauconite and brownish grains which presumably are decomposed glauconite. Apart from a single fragment of a shell no fossils have been found. A small piece of brownish concretion.

Grønnebæk

Borehole at JENS JAKOBSEN's farm. Made in 1958.
D.G.U. File No. 141.205.

Situation: 800 m. north of the Agentoft farm, immediately north of the road from Grønnebæk to Langetved and 4.5 km. east of Rødding. Fig. 72.

Ground level: about + 53 m.

Borehole log:

0.0– 5.0 m.	Well
5.0–11.5 –	Boulder clay, grey, with numerous bits of chalk
11.5–13.0 –	Clay, dark grey, alternating with paler grey sand
13.0–24.0 –	Hodde Clay (perhaps overlain by Gram Clay)
24.0–26.5 –	Quartz sand, medium-grained, greyish brown, alternating with beds of dark Mica Clay
26.5–32.0 –	Quartz sand, pale grey, medium-grained.

Level of the surface of the Miocene: about + 40 m.

Molluscs are available from a sample from the depth of 20.0 m. Faunal analysis, see Table 9, p. 212.

Description of the fossiliferous sample:

20.0 m. Weight of sample before washing: 172.08 g, after washing: 2.90 g. Typical Hodde Clay with the wash residue characteristic of this clay. Numerous grains of quartz. Many foraminifera and a few shell fragments.

Remarks: The interval from 13.0 to 24.0 m. in this borehole can hardly be Hodde Clay all of it. Perhaps the uppermost few metres actually is Gram Clay, of which no sample was taken.

Fig. 72. Situation of borehole D.G.U. File No. 141.205 at Grønnebæk. (Segment of M 3607 on the scale of 1:20,000).

Rojbøl

Borehole at CHR. REFSTRUP's farm (Grøngård). Made in 1956.
D.G.U. File No. 141.194.

Situation: 3 km. NE of the church of Øster Lindet, 2 km. NW of Stursbøl and 3.6 km. SW of the church of Jels. Fig. 73.

Ground level: about + 44 m.

Borehole log:

0.0–13.5 m. Well
13.5–19.0 – Gram Clay
19.0–25.0 – Gram Clay (and perhaps Hodde Clay?)
25.0–35.0 – Quartz sand and gravel, grey, slightly micaceous, with beds of dark Mica Clay.
(Final depth).

Level of the surface of the Miocene: about + 30.5 m.

Molluscs were found in the samples from the depths of 15 and 20 m. Faunal analysis, see Table 51, p. 261.

Description of the fossiliferous samples:

15 m. Weight of sample before washing: 125,14 g; after washing: 3.00 g. The sample looks like typical Gram Clay. The wash residue, however, contains so extraordinarily many grains of quartz that the clay must either have been highly contaminated or reworked. Some foraminifera and a few fragments of shells.

20 m. Weight of sample before washing: 88.86 g; after washing: 11.48 g. The sample is darker than the one from 15 m. The wash residue besides the ellipsoidal grains characteristic of Gram Clay contains some yellowish brown grains, which may originally have been glauconite. Otherwise grains of quartz dominate the sample, which thus must be supposed to be contaminated. Some foraminifera, but few fragments of shells.

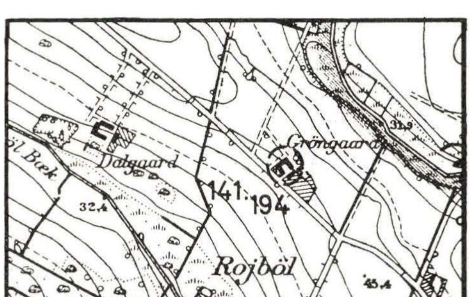

Fig. 73. Situation of borehole D.G.U. File No. 141.194 at Rojbøl. (Segment of M 3707 on the scale of 20,000).

Vester Lindet

Borehole at NIS RAVN's farm. Made in 1960.
D.G.U. File No. 141.246.

Situation: 1.6 km. NE of the farm Billeslund and 3.4 km. NE of Gram Castle, on the eastern outskirts of the village of Vester Lindet. Fig. 74.

Ground level: about + 61 m.

Borehole log:

0.0– 5.3 m.		Well
5.3– 5.7	–	Glacio-fluvial sand, medium-grained, pale greyish brown
5.7–16.4	–	Clay, stone-free, dark grey, with silty parts
16.4–23.7	–	Clay and silt, grey with a greenish tint, micaceous
23.7–24.5	–	Silt, clayey, grey, with a greenish tint, micaceous
24.5–30.6	–	Clay, silty, dark grey, with a little gravel (Quaternary material)
30.6–31.4	–	Mica Silt, coarse, somewhat clayey, grey, with a greenish tint (Gram Silt?).
31.4–45.2	–	Gram Clay. (Final depth).

Level of the surface of the Miocene: about + 30 m.

Molluscs were found in the samples from the depths of 30.9 m., 36.8 m., and 43.2 m. Faunal analysis, see Table 58, p. 268.

Description of the fossiliferous samples:

30.9 m. The wash residue is highly dominated by pale mica flakes. Apart from these there are some ellipsoidal small bodies. Some grains of quartz. Many foraminifera and fragments of shells.

36.8 m. Typical Gram Clay. The wash residue mainly consists of ellipsoidal small bodies. Some stems of pyrite. Few mica flakes. Fragments of *Cupuladria haidingeri.* Many foraminifera, ostracods, spines of spatangids, and molluscs.

43.2 m. Typical Gram Clay. The wash residue is dominated by the ellipsoidal small bodies characteristic of Gram Clay. Numerous stems of pyrite and many fragments of *Cupuladria haidingeri* and many foraminifera and molluscs.

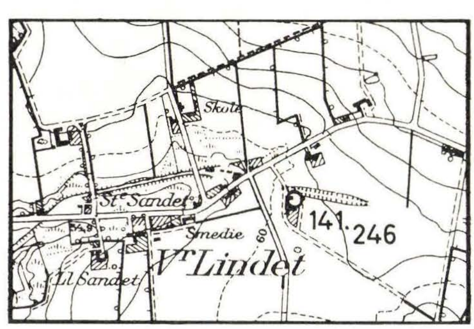

Fig. 74. Situation of borehole D.G.U. File No. 141.246 at Vester Lindet. (Segment of M 3707 on the scale of 1:20,000).

Gram

1. The pit of the brickworks. The occurrence at the brickworks of Gram, which I described in 1956 (p. 10 ff.), has only changed its appearance as regards the situation of the digging section, which now (1963), if anything, strikes NNE–SSW and has been carried some metres west of the old railway embankment. This and the present form of the clay pit are seen in fig. 76.

The Mica Silt which was found in the northeastern part of the section in 1952, is no longer visible.

As a supplement to the information of the locality given previously, I shall quote a letter from Dr. M. Reimers, Gram, to Professor G. Forchhammer of Copenhagen, dated at 4. November 1862. The letter, which is found in the Archives of the Mineralogical Museum of Copenhagen, contains a complete list of the molluscs which Reimers at that time had collected, partly at the brickworks of Gram, partly at the brickworks of Storlund (or Storland).

The brickworks of Gram in 1862 was situated west of the brook. Its site appears from fig. 75, which renders a segment of a German map from about the turn of the century, where the new brickworks, just built at that time, has been

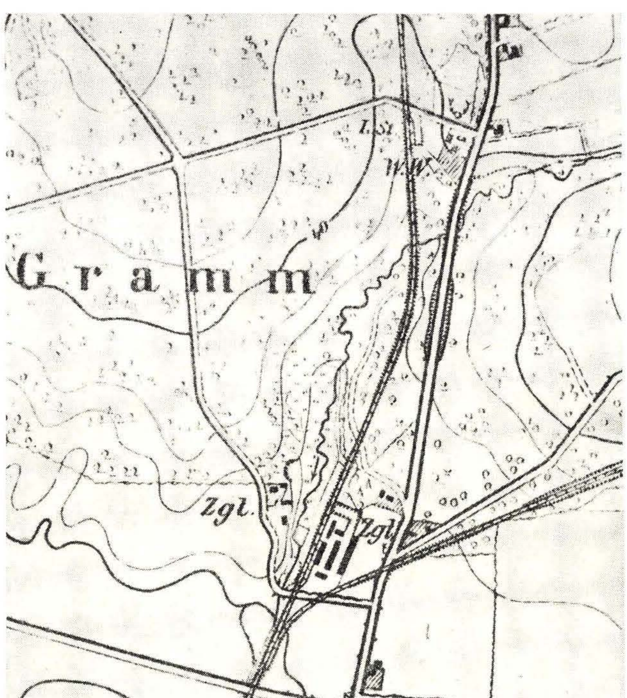

Fig. 75. Situation of the oldest (left) and the later brickworks (right) at Gram soon after 1900. – Segment of an early German map sheet on the scale of 1:25,000.

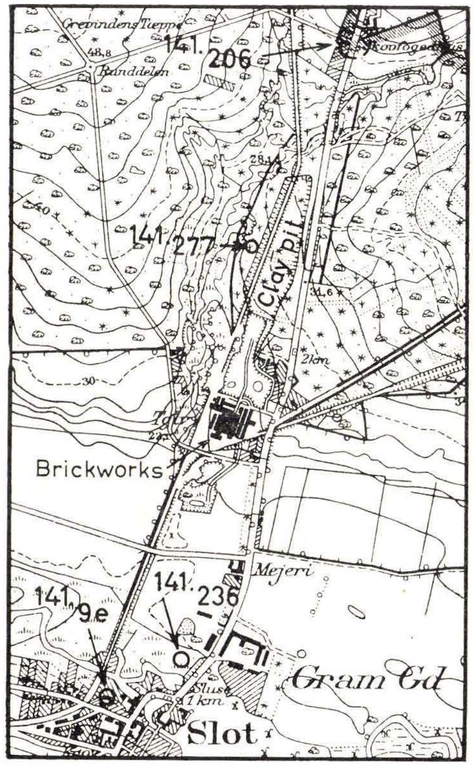

Fig. 76. The clay pit of the brickworks of Gram in 1963 and the situation of the boreholes D.G.U. File Nos. 141.277, 141.206, 141.9 e and 141.236. (Segment of M 3707 on the scale of 1:20,000).

sketched in, while the older, disused brickworks has not yet been removed from previous editions.

It should be emphasized that Reimers had mixed up the collections from the two brickworks. Storlund is situated 6.5 km. west of Gram at Vester Nybøl, but also belonged under the manor of Gram (see further Rasmussen 1956, p. 21, and the present paper, p. 154). The mixing also applies to the material submitted to the Mineralogical Museum of the University of Copenhagen. Nevertheless, Reimers's list of fossils is of importance for the valuation of the biostratigraphical conditions at the old locality at Gram and for the position of the Miocene strata in the region. The letter is quoted in full, only with omission of heading and signature:

"Thanking you most kindly for your letter about my work submitted to the Royal Academy of Sciences and Letters, and the Tertiary shells collected in this region, I have the honour to inform you that I have today posted a small box with 33 species of these shells, in part in several specimens from different periods of development.

These are the following:

Isocardia Forchhammeri	1 spec.
Cassidaria echinophora L.	2 –
Cassis saburon Beyr.	2 –
Fusus distinctus Beyr.	8 –
– *semiglaber* Beyr.	6 –
Conus antediluvianus Brug.	6 –
Pleurotoma rotata Brocch.	12 –
– *obtusangula* Brocch.	2 –
– *catafracta* Brocch.	6 –
– *intorta* Brocch.	1 –
– *semimarginata* Lam.	1 –
– *turricula* Brocch.	3 –
– *modiola* Jan	2 –
– *sp. nova*	1 –
Cancellaria nodulifera Beyr.	3 –
– *minuta* Nyst	1 –
Buccinum Bocholtense Beyr.	2 –
– *descipiens* Semp.	2 –
Turritella tricarinata Brocch.	6 spec.
– *bicarinata* Eichw.	1 –
Tiphys fistulosus Brocch.	1 –
Mitra Borsoni Bellardi	1 –
Natica helicina Brocch.	12 –
– *millepunctata* Lam.	1 –
– *sp. nova*	2 –
Odontostoma plicatum Mont.	6 –
Cardita chamæformis Sowerb.	1 –
Limopsis aurita	1 –
Nucula systensis	3 –
Astarte sp. (*A. Reimersi* Semp.)	12 –
Pecten sp. nova	1 –
Lunulites rhomboidalis Goldf.	2 –
Vaginella depressa	2 –

All these shells have been found here at the manor in the Mica Clay in two different brickworks, one of which is situated near the castle, the other at Storland (Nybøl).

Besides these I am in possession of the following 29 species from the same places, but in few specimens.

Fusus Puggaardi Beyr.
– *eximius* Beyr.
– – *pullus* Beyr.
– *ventrosus* Beyr.
– *sp. nova*
Pleurotoma sp. nova
– *sp. nova*
– *sp. nova*
Turbonilla gracilis Brocch.
– – *var.*
Buccinum prismaticum Brocch.
Murex plicatus Brocch.
Cirsotrema obtusirostrata Wood
Cancellaria nodulifera Beyr. var. *pulla*
Purpura præcedens Semp.
Xenophora testigera
– *crispa* König
Ringicula auriculata Melard
Bulla convoluta Brocch.
Eulimella Scillae
Eurycina sp.
Astarte pygmaea Wood
Limopsis sublevigata Nyst
Venus sp.
Pecten sp. nova
Dentalium entalis? L.
– *sp.*
Vermettus sp.
Leda sp.

The species collected this year have not yet been arranged and determined by me, but at a superficial inspection I have noted that there are several new species. I assume that my collection at present consists of nearly 70 species."

2. Borehole at the pit of the brickworks, made by D.G.U. 31/5–13/6 1963. File No. 141.277.

In 1963 the D.G.U. made a borehole at the pit of the brickworks in order to provide material from the clay series of the Younger Miocene in the whole of its vertical extent. The drilling was stopped at a depth of 50.3 m. in the Mica Silt under the clay series. All the material drilled up was submitted to the institute for closer examination.

Situation: 400 m. north of the buildings of the brickworks, immediately west of the west wall of the pit at the time, between this and a steep bluff in the bed of the brook, at the bottom of which the Gram Clay crops out. (Cf. fig. 76).

Ground level: about + 29 m.

Borehole log:

0.00– 0.30 m.	Mould
0.30– 0.50 –	Sand, clayey, stony, dark grey (presumably boulder clay with upthrust Miocene silt).
0.50– 1.45 –	Boulder clay, sandy, stony, yellow (oxidized)
1.45– 1.70 –	Clay, silty, micaceous, brownish grey, partly rust-coloured (partly oxidized Gram Silt)
1.70– 2.00 –	Clay, silty, very micaceous, pale grey, stratified (Gram Silt)
2.00– 5.30 –	Clay, silty, very micaceous, darker grey (Gram Silt)
5.30–15.10 –	Clay, in a moist state greyish brown, in a dry state darker grey, very micaceous, homogeneous, fossiliferous (Gram Clay) At 14.70 m. a bed of clay ironstone concretion
15.10–16.50 –	Clay, dark grey, micaceous, in a moist state slightly brownish and a little darker than the preceding interval, dense, homogeneous, fossiliferous (Gram Clay).
16.50–18.50 –	Clay, dark grey, micaceous, in a moist state brownish, dense, homogeneous, fossiliferous (Gram Clay)
18.50–22.50 –	Clay, dark, micaceous, in a moist state clearly darker than above, a little brownish, dense, homogeneous, fossiliferous (Gram Clay) At 19.10 m. a bed of clay ironstone concretion.
22.50–25.50 –	Clay, dark, with a greenish tint, a little gritty, glauconitic (Glauconite Clay)
25.50–29.00 –	Clay, grey, micaceous, homogeneous, fossiliferous (according to the drilling log it was "hard" from 25.50 to 27.30 m. and "more sticky", but a little "softer" from 27.30 to 30.60 m.). (Hodde Clay)
29.00–33.80 –	Clay, black, micaceous, dark brown on fractured surfaces, with numerous smooth, glistening, very irregular fractured surfaces, coal-like (Hodde Clay).
33.80–35.80 –	Clay, micaceous, finely silty, homogeneous, fossiliferous (Hodde Clay).
35.80–36.50 –	Clay, dark, micaceous, dark brownish on freshly fractured surfaces, downwards more silty, fossiliferous to 36.10 m.
36.50–36.90 –	Clay, black, micaceous, with contents of grains of quartz, a few of which are gravel (quartz gravel zone)
36.90–37.20 –	Clay, black, micaceous, with contents of quartz gravel and perhaps with beds of paler silt, very micaceous (quartz gravel zone)
37.20–37.40 –	Clay, black, micaceous, thin layers of this clay alternating with clayey quartz sand and containing considerable quantities of quartz gravel, consisting of well rounded pebbles of various sizes, the largest being more than 1 cm. long (quartz gravel zone)

37.40–39.05 m. Quartz sand, fine-grained above, medium-grained below. Some dark grey micaceous clay, especially in the upper part of the zone
39.05–39.15 – Clay, black, micaceous, with beds of pale grey, fine, micaceous silt
39.15–42.00 – Silt, micaceous, coarse and fine silt alternating
42.00–42.30 – Clay, micaceous, dark with a brownish tint, stratified and with thin strata of silt of a paler colour
42.30–42.90 – Clay, micaceous, silty, black, with numerous large mica flakes
42.90–44.00 – Silt, micaceous, fine, clayey, dark grey
44.00–50.30 – Silt, micaceous, coarse, grey, with grains rather homogeneous. (Final depth).

Level of the surface of the Miocene: about + 28 m.

Molluscs were found in all the samples from the intervals 5.30–36.10 m., 68 samples in all. The intervals of the various samples appear from the table below.

Faunal analysis, see Table 10, p. 213, and Table 59, p. 269.

The fossiliferous samples. The samples from 5.30–36.50 m. were washed with a screen having a width of meshes of 0.1 mm. (washing and preparation made by INGRID VILLADSEN). On the table below, the most important data concerning the wash residues are adduced. Their contents of molluscs can be read from the lists of analyses, while the other fossils found have not been examined in detail.

In all the samples there was a higher or lower content of foraminifera, and in most of the samples of Gram Clay there were many fragments of or whole zoaria of the three lunulitiform species of bryozoa: *Cupuladria haidingeri*, *C. canariensis*, and *Lunulites sp.* Furthermore, there were some otolites, numerous spines and plates of spatangids, and ostracods in certain parts of the borehole section, fragments of crab claws, teeth of fish, etc.

Depth interval	Weight of sample in g	Weight of wash residue in g	Percentage of material larger than 0.1 mm.	Dominant components	Special minerals	Remarks
5.30– 5.70 m.	4221	63	1.5	Mica flakes	Bits of pyrite	Some micro-
5.70– 6.10 –	4320	77	1.8	–	–	ellipsoids
6.10– 6.40 –	2769	64	2.3	Bits of pyrite	Micro-ellipsoids. Much pyrite	Much mica
6.40– 6.90 –	4911	280	5.7	Micro-	Some pyrite	Mica flakes
6.90– 7.30 –	3627	124	3.4	ellipsoids	–	
7.30– 7.65 –	4165	207	5.0	–	–	
7.65– 8.05 –	4242	99	2.3	–	–	
8.05– 8.50 –	3685	75	2.0	–	–	
8.50– 9.00 –	4297	176	4.1	–	–	
9.00– 9.50 –	3996	175	4.4	–	–	
9.50– 9.90 –	4848	124	2.6	–	–	
9.90–10.30 –	3853	195	5.1	–	–	
10.30–10.80 –	4368	68		–	–	Some of the
10.80–11.25 –	4337	89		–	–	wash residue lost

Depth interval	Weight of sample in g	Weight of wash residue in g	Percentage of material larger than 0.1 mm.	Dominant components	Special minerals	Remarks
11.25–11.65 m.	4593	229	5.0	Micro-ellipsoids	Some pyrite	
11.65–12.10 –	3208	198	6.2	–	–	
12.10–12.60 –	4629	241	5.2	–	–	
12.60–13.10 –	4170	142	3.4	–	–	
13.10–13.50 –	2695	167	6.2	–	–	
13.50–14.00 –	2633	73	2.8	–	–	
14.00–14.60 –	3399	108	3.2	–	–	
14.60–15.10 –	3967	293		–	–	Fragments of concretions
15.10–15.55 –	4053	119	3.5	–	–	Contamination with Quaternary sand
15.55–16.00 –	3954	118	3.0	–	–	
16.00–16.50 –	4517	132	2.9	–	–	
16.50–17.00 –	4601	152	3.3	–	–	
17.00–17.50 –	4066	138	3.4	–	–	Contamination with Quaternary sand
17.50–18.00 –	4078	211	5.2	–	–	
18.00–18.50 –	4267	337	7.9	–	–	
18.50–19.00 –	4261	432	10.1	Dark brown-	–	
19.00–19.50 –	3527	1265		ish grains	–	Fragments of concretions
19.50–20.00 –	4723	901	19.3	–	–	
20.00–20.50 –	4643	670	14.4	–	–	
20.50–21.00 –	3689	571	15.5	Dark grains of glauconite	–	Single pieces of yellowish brown concretions
21.00–21.50 –	4085	774	18.9	–	–	
21.50–22.00 –	4616	879	19.0	–	–	
22.00–22.50 –	4312	1464	34.0	–	–	
22.50–23.00 –	2089	681	32.6	Darkgreen	Very	
23.00–23.50 –	2334	716	30.7	grains of	little pyrite	
23.50–24.00 –	2035	584	28.7	glauconite	–	
24.00–24.50 –	2610	781	30.0	–	–	
24.50–25.00 –	2673	572	21.4	–	–	
25.00–25.50 –	2691	484	18.0	–	–	
25.50–26.00 –	4376	408	9.3	Dark grains	Some pyrite,	
26.00–26.50 –	3937	189	4.8	of glauconite	partly as	
26.50–27.00 –	3143	187	5.9	(greenish tint)	stems	
27.00–27.50 –	4364	175	4.0	(grey tint)	–	
27.50–28.00 –	4497	127	2.8	–	–	
28.00–28.50 –	4548	129	2.8	–	Much pyrite, both slag-like and as stems	

Depth interval	Weight of sample in g	Weight of wash residue in g	Percentage of material larger than 0.1 mm.	Dominant components	Special minerals	Remarks
28.50–29.00 m.	4213	99	2.3	Pyrite, slag-like and as stems	Dark grains of glauconite	
29.00–29.50 –	4042	56	1.1			
29.50–30.00 –	3827	57	1.5		–	
30.00–30.50 –	3389	49	1.4	–	–	
30.50–30.95 –	3189	70	2.2	–	–	
30.95–31.35 –	3064	55	1.5	–	–	
31.35–31.65 –	2055	23	1.1	Dark grains of glauconite	Much pyrite, both slag-like and as stems	
31.65–31.95 –	1906	18	0.9			
31.95–32.30 –	2255	24	1.1	–		
32.30–32.70 –	3093	23	0.7	–		Considerable content of fragments of molluscs
32.70–33.05 –	1861	19	1.0	–	–	
33.05–33.40 –	2865	41	1.4	–	–	– and few grains of quartz
33.40–33.80 –	3218	42	1.3	Pyrite, slag-like and as stems	Dark grains of glauconite	Fragments of molluscs. Quartz grains
33.80–34.25 –	3121	38	1.2	–	–	–
34.25–34.70 –	3644	56	1.5	–	–	Few grains of quartz
34.70–35.00 –	2920	47	1.6	–	–	Much quartz
35.00–35.30 –	2409	42	1.7	–	–	
35.30–35.70 –	2956	65	2.2	Glauconite, dark green	Grains of quartz	
35.70–36.10 –	3258	40	1.2	Quartz and glauconite	Pyrite and mica flakes	
36.10–36.50 –	2959	225	7.6	Grains of quartz	Some pyrite	No fossils

On the basis of the appearance of the wash residues the section from 5.30 to 36.50 m. may be subdivided into the following eight main sections:

5.30– 6.40 m. The samples are characterized by mica flakes

6.40–18.50 – Micro-ellipsoidal grains of a greenish grey colour, which seem to have been rolled into a regular ellipsoidal shape, are dominant

18.50–20.50 – Dark brown, irregularly shaped grains with a glistening surface are highly dominant

20.50–22.50 – Dark glauconite grains, more or less rounded, are dominant

22.50–25.50 – Green, not particularly rounded glauconite grains are almost completely dominant

25.50–28.00 – Dark, rather well rounded glauconite grains are dominant together with pyrite, which occurs as small bits as well as in the shape of stems

28.00–35.30 – Slag-like small bits of pyrite seem to be dominant

35.30–36.50 – Increasing contents of quartz grains, which at the bottom of the section are quite dominant.

Remarks: It is important that it has not been possible to point out disturbances of a radical kind in the clay series of the borehole. We cannot, however, disregard the possibility that there is a slight dip of the clay series, as observed in the clay pit (cf. RASMUSSEN 1956, p. 13 and fig. 4, p. 12). Because of the absence of distinct layers or other conditions which might constitute the basis of measurements of dip and strike, we are referred to make an estimate. The dips observed in the clay pit of the brickworks on the basis of such an estimate cannot be said to exceed 10°, and the direction of the dip is east or southeast. The series of strata in the borehole, which is situated northwest of the old part of the clay pit, therefore must be assumed to be some metres higher than the corresponding series of layers in the clay pit.

With the borehole as a starting-point it will therefore be possible to estimate which of the layers found in the borehole must have cropped out in the old part of the clay pit, and especially which layers had hardly cropped out.

The early clay pit, now water-logged and being filled-in, was started about the turn of the century and was abandoned about 1932. An impression of its depth below ground level can be obtained from an early photograph rendered in fig. 77 from STRUCK 1909, fig. 9, and dating from one of the first years after the turn of the century. At that time the clay pit was more or less of the same shape as seen on the map segment in fig. 75, where it is seen north of the eastern

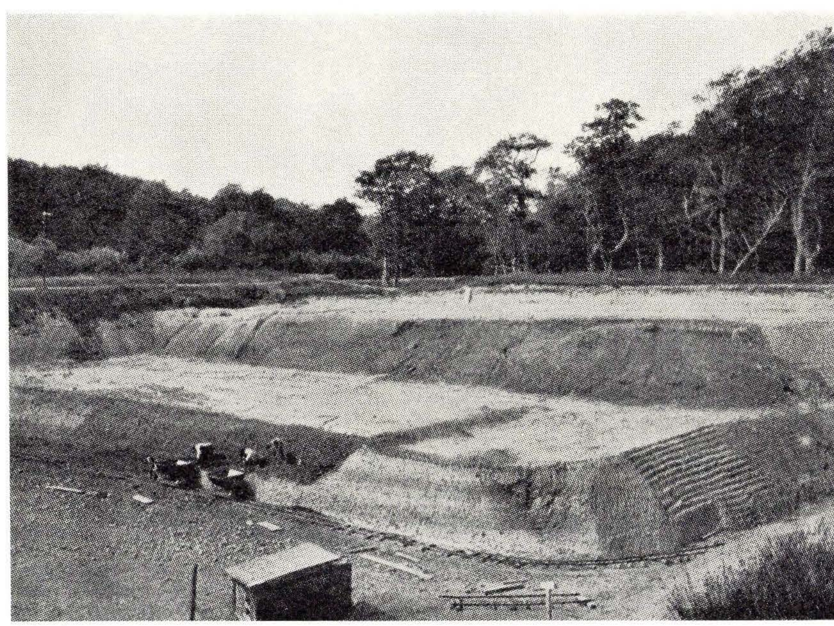

Fig. 77. The clay pit of the brickworks of Gram in the years between 1900 and 1909, as seen towards the NW. On the left, the railway at the time from Gram to Rødding as a pale line (cf. fig. 75).
(From STRUCK 1909, fig. 9).

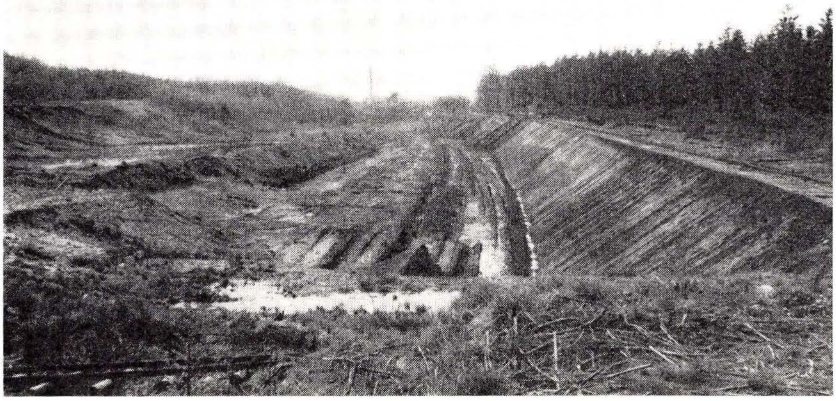

Fig. 78. The brickworks of Gram in 1962 as seen from the north. The brickworks is seen dimly in the background. The wall on the right has reached some metres west of the old railway line which ends in the middle of the foreground and continues on the other side of the clay pit in the small clearing in front of the tall trees on the right.
Phot. Chr. Westergaard

one of the two brickworks mentioned. Judging from the persons and objects visible in the photograph, the depth can be estimated to be about 12–15 m. below ground level, at any rate not more than 20 m. below ground level. Considering the above-mentioned possible dip, there has not, in the clay pit, been any beds represented which in the borehole are below a depth of 18.5 m., and in which there is a typological boundary in the Gram Clay. The layers in the clay pit perhaps even corresponded only to those which in the borehole are immediately above a depth of 15 m. This is of importance for the understanding of certain early finds of fossils which were collected in the clay pit of the brickworks of Gram, but have not been collected in the present pit (see von Koenen 1872, 1882, Ravn 1907, and Rasmussen 1956.

3. Other boreholes in the Gram region. In connexion with the present investigations I have examined samples from other boreholes at Gram in order, if possible, to place the samples lithostratigraphically in the clay series.

D.G.U. File No. 141.9e., made for the waterworks of Gram, published by Rasmussen 1956, p. 15, penetrated "black Mica Clay" from the depth of 8.2–21.6 m. There is only one sample available from a depth of 20 m., consisting of dark grey Mica Clay containing glauconite, the wash residue of which mainly consisted of grains of glauconite and some pyrite. Apart from this there were some quartz, felspar, and other mineral grains originating from the Quaternary strata. If anything, the wash residue indicates that the sample originates from the border area between Glauconite Clay and Hodde Clay. There were no fossils in the sample.

D.G.U. File No. 141.27a., situated near the Gram Carpet Factory, published by RASMUSSEN 1956, p. 15, penetrated Mica Clay at a depth of 4.5–22.5 m. The sample available from this interval consists of dark grey Mica Clay mixed with clay of a more greenish colour. The wash residue mainly consists of grains of glauconite and micro-ellipsoids of the type found in Gram Clay. Apart from a small fragment of an otolite, the only fossils were some half dissolved fragments of shells, only a single one of which could be determined as regards genus (*Cardita sp.*). Presumably the sample originates from a depth interval with Gram Clay as well as Glauconite Clay.

D.G.U. File No. 141.236, drilled for the waterworks of Gram in 1960, situated beside the river, about 150 m. NW of the castle of Gram, at a ground level of about + 19 m. Fig. 76.

Borehole log:

0.0– 1.1 m.	Sand and gravel, reddish brown
1.1– 4.0 –	Sand, medium-grained, with dark grey beds of clay
4.0– 7.5 –	Glacio-fluvial gravel
7.5–11.0 –	Glacio-fluvial sand
11.0–17.0 –	Mica Clay, silty, black, slightly shaly, apparently somewhat coal-like (Hodde Clay with high contents of quartz sand)
17.0–18.9 –	Mica Clay, black, carboniferous, silty (Hodde Clay)
18.9–21.5 –	Quartz sand, medium-grained, dirty grey
21.5–25.0 –	Quartz sand and gravel, in lower part with milky blue pea-sized grains of quartz
25.0–26.3 –	Mica sand, fairly coarse; mainly quartz sand with mica flakes
26.3–?	Mica Clay, silty, dark brownish grey, a little shaly.

Of the beds from 11.0–17.0 m. and 17.0–18.9 m. samples had been sent to the D.G.U. from the depths of 16.5 m., and 18 m. Both showed that in the intervals in question there is a sediment which very much resembles Hodde Clay. Especially the wash residue of the sample from a depth of 18 m. corresponds completely to that of Hodde Clay with its high contents of bits of pyrite and absence of micro-ellipsoids. Unfortunately no fossils were found in the samples.

North of the brickworks of Gram, at the ranger's house at *Låsled*, about 150–200 m. north of the northernmost end of the clay pit of the brickworks, a water well was drilled in 1958 (D.G.U. File No. 141.206). Fig. 76.

During the drilling a sample was submitted to the D.G.U. from a depth of 40 m., consisting of black, fractured Mica Clay. The wash residue was highly dominated by greenish grey micro-ellipsoids and grains of glauconite. Furthermore there were numerous bits of pyrite and a few indeterminable fragments of shells (among them *Yoldia sp.*). This sample thus does not contain typical Hodde Clay, but still, if anything, must be referred to this type of clay.

Unfortunately it has not been possible to obtain information about the borehole log.

Tiset

Borehole at ANDREAS MØLLER's farm (Hovgårdlund). Made in 1960.
D.G.U. File No. 141.244.

Situation: 1.4 km. SW of the church of Gram and about 1 km. NE of the village of Tiset. Fig. 79.

Ground level: about + 40 m.

Borehole log:

0.0–10.5 m. Boulder clay
10.5–15.0 – Meltwater sand
15.0–43.5 – Gram Clay (and probably Hodde Clay at the bottom of the interval)
43.5–47.5 – Quartz sand, fine to medium-grained, dark grey, micaceous. (Final depth).

Level of the surface of the Miocene: about + 25 m.

Molluscs were found in a sample from the interval 15.0–43.5 m. No further indication of depth. Faunal analysis, see Table 51, p. 261.

Description of the fossiliferous sample:

15.0–43.5 m. Typical dark grey Gram Clay with stems of pyrite. As the sample was difficult to decompose, NaOH was used with the result that the wash residue changed character and the pyrite in the cavity of the shells was transformed.

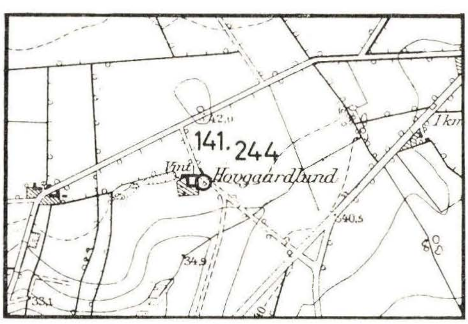

Fig. 79. Situation of borehole D.G.U. File No. 141.244 at Hovgårdlund in Tiset. (Segment of M 3706 on the scale of 1:20,000).
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Storlund

I have still not succeeded in localizing more exactly the old locality at Storlund mentioned in my paper of 1956 (p. 21).

In connexion with the present investigations, on the other hand, the samples from the borehole made by the D.G.U., File 141.84 on the outskirts of the plantation of Brogård have been re-examined (see RASMUSSEN 1956, p. 21).

Situation: 1.2 km. SW of the Vester Nybøl farm and 200–300 m. WNW of Storlund (Exact place unknown). Fig. 80.

Ground level: about + 18 m.–+ 22 m.

Borehole log:

0.0– 6.0 m. Boulder clay
6.0– 8.5 – Gram Clay, in part weathered, with rust-coloured parts
8.5–10.0 – Typical Gram Clay.

Level of the surface of the Miocene: about + 12 m.– about + 16 m.

Remarks: Miocene deposits have furthermore been found near the surface of the ground in several boreholes around Storlund (see RASMUSSEN 1956, p. 21) and south of the Gram river between the Nybøl farm and Gram. (See figs. 81–83). These last boreholes (D.G.U. File No. 141.250, 251, and 252) all seem to have reached Miocene strata already about 3 m. below the ground, which corresponds to levels of the Miocene of + 20, + 18, and + 15 m., respectively. (See fig. 83). The boring first mentioned stopped at a depth of about 21 m. According to the sample submitted to the D.G.U., the layer at that depth consisted of Glauconite Clay with a few partly decomposed and indeterminable shells of molluscs and foraminifera, presumably the basic layer of the Gram Clay. No samples are available from the other boreholes.

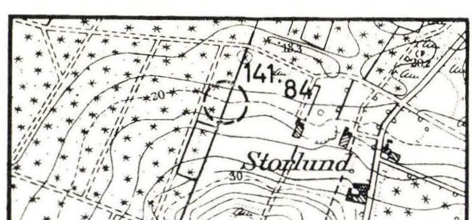


Fig. 80. Situation of borehole D.G.U. File No. 141.84 at Storlund. (Segment of M 3706 on the scale of 1:20,000).

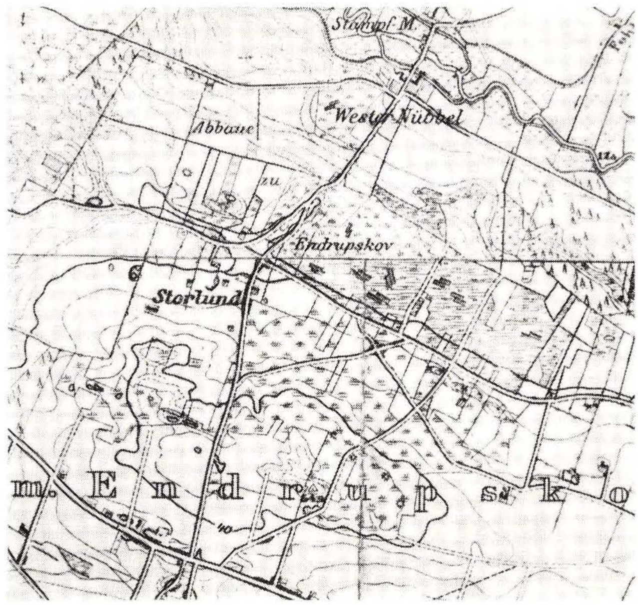


Fig. 81. Map of the region about Storlund and Vester Nybøl about the turn of the century, showing the situation of various clay pits. Segment of early German map sheet on the scale of 1:25,000 reduced to an unknown scale.

Fig. 82. Occurrences of Miocene strata close to the surface of the ground in the Gram-Spandet region. Segment of L. MEYN's geological map of Slesvig-Holstein (on the scale of 1:300,000) from 1881. – The black areas indicate the situation of the occurrences.

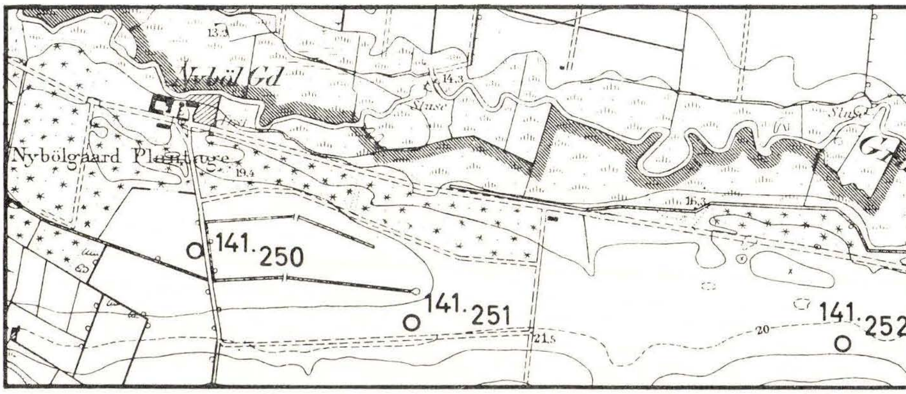


Fig. 83. Situation of the boreholes D.G.U. File No. 141.250, 251, and 252 at the Nybøl farm. (Segment of M 3706 on the scale of 1:20,000).

Enderupskov

Borehole at Anton Jepsen's farm (Damgård). Made in 1956.
D.G.U. File No. 141.196.

Situation: 1.6 km. south of the Nybøl farm, 700 m. east of the church ruin of St. Tøger and immediately north of the highway from Ribe to Gram. Fig. 84.

Ground level: about + 22 m.

Borehole log:

0.0– 5.7 m.	Well
5.7–29.0 –	Boulder clay, sandy, grey
29.0–42.3 –	Mica Clay (which at any rate from 35 m. downwards is Hodde Clay), marine, fossiliferous
42.3–42.8 –	Quartz gravel, homogeneous, size of grains 1–1.5 mm.
42.8–54.0 –	Mica Silt, pale, greyish
54.0–55.0 –	Mica Silt, greenish grey, with a layer of micaceous sandstone and with numerous molluscs, marine. (Final depth).

Level of the surface of the Miocene: about — 7 m.

Molluscs are available from samples from 35 m. and 54 m. Faunal analysis, see Table 2, p. 200, and Table 9, p. 212.

Description of the fossiliferous samples:

35 m. Hodde Clay, black. The wash residue mainly consists of pyrite in the shape of small irregular bits and in part stem-shaped. Furthermore, there are numerous foraminifera and some small bits of shells.

54 m. Mica Silt, greenish grey, with numerous broken or rounded, irregularly shaped bits of fossiliferous, brownish grey micaceous sandstone and with very numerous detached molluscs and foraminifera.

Fig. 84. Situation of borehole D.G.U. File No. 141.196 and an early gravel pit at Enderupskov. (Segment of M 3706 on the scale of 1:20,000).

Remarks: Formerly a gravel-pit was found in the region east of Enderupskov, 900 m. NW of the borehole mentioned and 400 m. north of the ruin of St. Tøger's church. In this gravel-pit, which was dug in Quaternary meltwater sand and gravel, there were many rolled, fossiliferous Miocene boulders, which must originate from the immediate neighbourhood. The boulders were of two different types: (1) a rust-coloured Limonite Sandstone which easily came off and which was quite full of moulds and casts of molluscs, in certain parts even with well-preserved shells, and (2) a hard rock cemented together and quite full of mollusc shells and quartz gravel. In the meltwater sand of the gravel-pits it was often possible to collect hundreds of partly rolled mollusc shells, often with rust-coloured Limonite Sandstone inside the shells. Undoubtedly this was a case of remnants of Middle Miocene deposits which somewhere in the neighbourhood of Enderupskov had been accessible to the meltwater streams during the melting of the Quaternary glaciers. The ground level of the gravel-pit itself is about + 30 m.

Spandetgård

This locality has previously been described (RASMUSSEN 1956, pp. 23–24), but during the years after 1955 when the digging of clay was resumed by Arnum Brickworks, a large clay pit has made its appearance in which there has been and still (1962) is a good opportunity of making observations and acquiring new material of fossils.

The new diggings were introduced immediately west of the old water-logged pit. A 6–7 m. deep excavation appeared in which peculiarly enough molluscs were not especially common, not even at the deep levels.

The digging in this small area was stopped in 1957, after which a digging was started well over 200 m. farther east, immediately north of the road to Mølby.

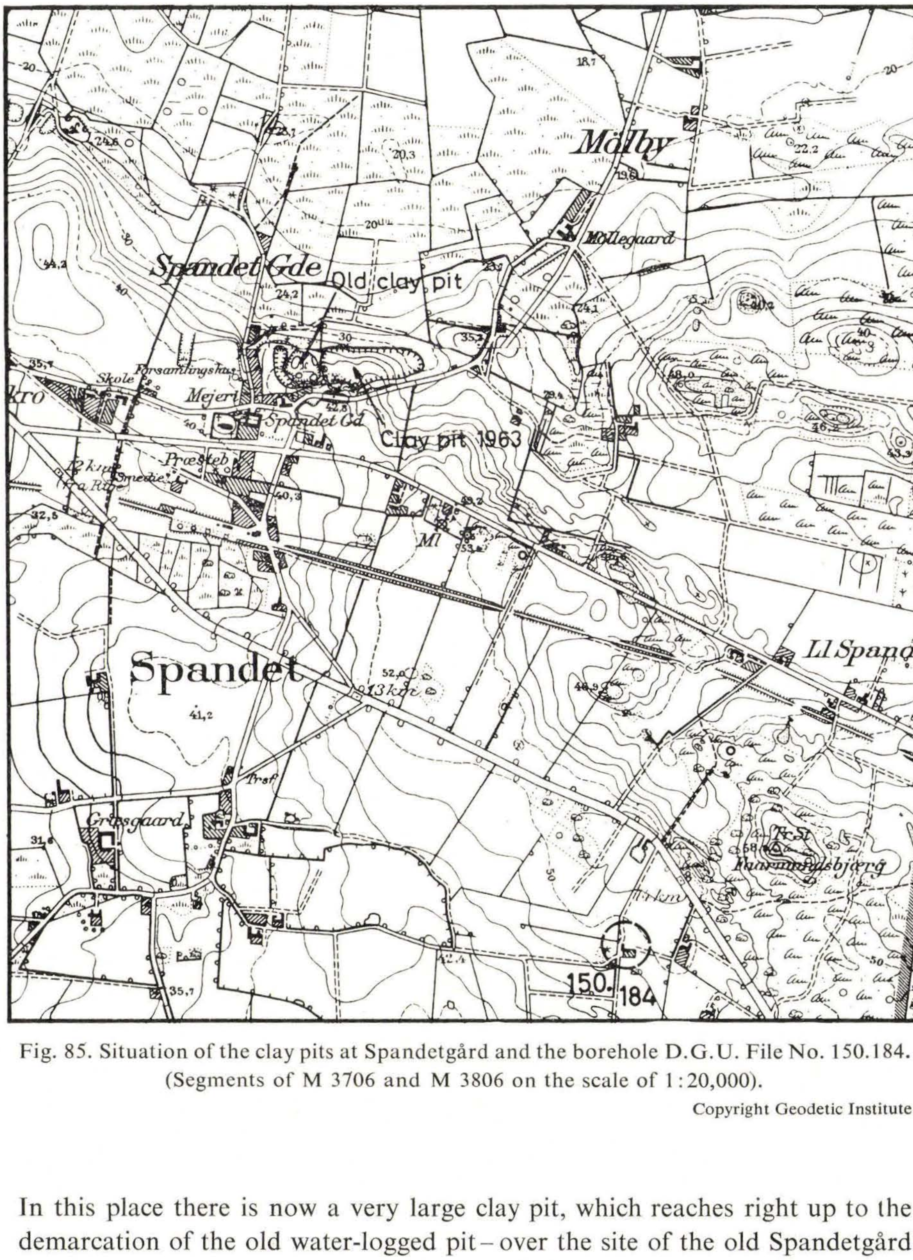


Fig. 85. Situation of the clay pits at Spandetgård and the borehole D.G.U. File No. 150.184. (Segments of M 3706 and M 3806 on the scale of 1:20,000).

In this place there is now a very large clay pit, which reaches right up to the demarcation of the old water-logged pit – over the site of the old Spandetgård Brickworks. At present (1962) this clay pit is approximately rectangular in shape: about 150 m. long and 50–60 m. broad. In the northern half the depth is about 12 m. Fossils are very common, especially in the southern half.

The Gram Clay is covered by beautifully cross-bedded glacio-fluvial sand, which in certain places is rather stony. It is dug in a pit about 5 m. deep, immediately east of the large clay pit. The thickness of the layer of glacio-fluvial sand hardly exceeds 3–4 m. in the sections of the clay pits, for which reason the Gram Clay, which was not reached in the sand-pit, must be found more deeply below ground level farther east.

Because of the method of digging the sections are very uneven. No stratification can be observed in the Gram Clay, which everywhere looks rather homogeneous. Apart from a few "crab balls" no concretions have been observed.

In the north wall the ground level is about + 36 m. and in the south wall about + 38 m., so that the level of the surface of the Miocene is about + 32 m.

The Gram Clay at Spandetgård was presumably glacially disturbed, but unfortunately we have only poor information about the boreholes known from the surroundings of the clay pit.

An old borehole (D.G.U. File No. 150.17a) near the closed-down dairy immediately south of the claypit is stated to have reached "black clay" already at a depth of 4 m. The drilling was continued down to 166 m., but the borehole log is little known and information about it has only been submitted to the D.G.U. by oral communication. The same applies to another borehole (D.G.U. File No. 150.17c) near the old dairy, about which it was told that the Mica Clay was only reached at a depth of 48 m. under "sand with bits of wood" (cf. RASMUSSEN 1956, p. 23).

At a borehole for seismic investigations (D.G.U. File No. 141.107), about 1 km. NW of the clay pit, the Miocene clay seemed to have been reached already at a depth of 1.5 m. below ground level, corresponding to a level of the surface of the Miocene of about + 18 m.

Spandet

Borehole at E. VEJRUP's farm. Made in 1954.
D.G.U. File No. 150.184.

Situation: 1.7 km. SE of the church of Spandet and 500 m. SW of Fårmandsbjerg. Fig. 85.

Ground level: about + 49 m.

Borehole log:

0.0– 3.0 m.	Meltwater sand
3.0–11.5 –	Hodde Clay
11.5–12.5 –	Clay, greenish grey, glauconitic
12.5–16.5 –	Gram Clay
16.5–17.0 –	Boulder clay, dark grey, with stones and fragments of chalk
17.0–21.2 –	Meltwater sand, a little clayey and stony, yellowish grey
21.2–22.8 –	Clay, silty, grey
22.8–37.1 –	Gram Clay. (Final depth).

Level of the surface of the Miocene: about + 26 m.

Molluscs are available from 22.75–27.00 m., 27.00–33.00 m., and 33.00–37.10 m. Faunal analysis, see Table 61, p. 278.

Description of the fossiliferous samples: All the samples consist of Gram Clay, which seems to be a little contaminated.

22.75–27.00 m. Weight of sample: 113.76 g. Weight of wash residue: 6.23 g. The wash residue is dominated by micro-ellipsoids. Many grains of quartz. Much pyrite. Many foraminifera and fragments of *Cupuladria haidingeri*. Some fragments of molluscs. A few fragments of *Cupuladria canariensis*.

27.00–33.00 m. Weight of sample: 140.02 g. Weight of wash residue: 6.14 g. The wash residue is dominated by grains of quartz, but otherwise contains a very large number of micro-ellipsoids. Much pyrite. Many foraminifera. Some fragments of molluscs, *Ditrupa* tubes, and *Cupuladria canariensis*.

33.00–37.10 m. Weight of sample: 113,61 g. Weight of wash residue: 4.12 g. The wash residue contains much pyrite and many micro-ellipsoids and some grains of quartz. Foraminifera. Fragments of molluscs and of *Cupuladria haidingeri* and *Ditrupa*.

Remarks: The whole log of this borehole clearly indicates a glacial disturbance of the Miocene strata. As the Gram Clay from the lowermost part of the borehole contains some quartz sand, there is a possibility that the disturbances go down to or below a depth of 37 m.

Arnum

Borehole for the water-works. Made in 1953.
D.G.U. File No. 150.25 b.

Situation: In the village of Arnum itself, 200 m. SE of the hotel (cf. location map in SORGENFREI 1958, fig. 2, facing p. 28). Fig. 88.

Ground level: about + 28 m.

Borehole log: Reference is made to TH. SORGENFREI's description (1958, p. 27 and fig. 2 facing p. 28). It should only be stated that according to the well log, dark grey, fossiliferous Mica Clay was found from a depth of 24.4–52.5 m., of which, however, only a sample from the depth of 24.5 m. (a ditch sample) is available.

Level of the surface of the Miocene: about + 4 m.

Molluscs were found in the sample from the depth of 24.5 m. See Table 51.

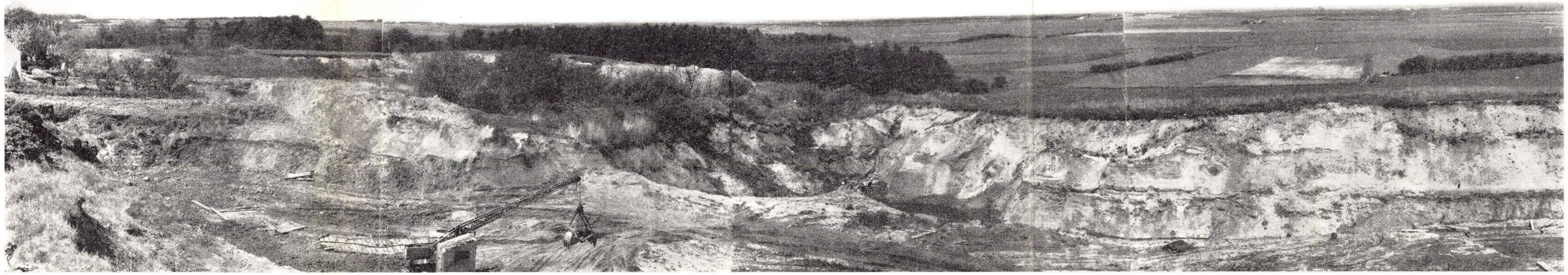


Fig. 86. View of the clay pits at Spandetgård. The photograph was taken towards the NW from the south side of the large pit, in the place in which the arrow from the words "clay pit 1963" in fig. 85 intersects the edge of the pit. The direction of vision is = the direction of the arrow. The old pits from the nineteenth century are concealed under the clump of trees in the middle of the picture, immediately above the arm of the excavator.

Phot. L.B.R. 31.5.1963

Fig. 87. The large clay pit at Spandetgård as seen towards the east from its northwestern corner. Fig. 86 was photographed from the edge in the uppermost right corner.

Phot. Chr. Westergaard, May 1962

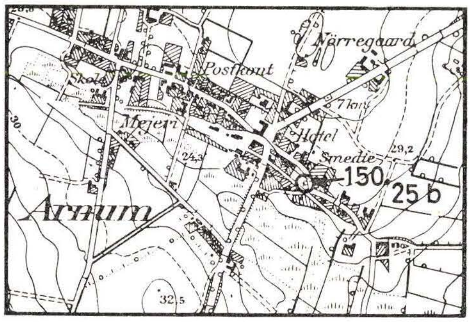


Fig. 88. Situation of borehole D.G.U. File No. 150.25 b at Arnum. (Segment of M 3806 the scale of 1:20,000).

Hønning

Deep borehole made by DAPCo. 1958.
D.G.U. File No. 150.197.

Situation: Immediately north of Hønninggård, 4.5 km. NE of Arrild and 3.5 km. SSE of Gånsager. Fig. 89.

Ground level: about + 28 m.

Borehole log:

0– 19 m.	Glacio-fluvial sand and boulder clay
19– 29 –	Glacio-fluvial sand and gravel
29– 34 –	Boulder clay, with lumps of chalk
34– 54 –	Glacio-fluvial gravel (or glacial gravel?)
54– 59 –	Boulder clay
59– 79 –	Gram Clay
79– 84 –	Hodde Clay
84–136 –	Mica Clay alternating with Mica Sand, in places very fossiliferous. Final depth: 2485.5 m.

Level of the surface of the Miocene: about — 31 m.

Molluscs are available from a ditch sample from the depth of 63–68 m. See Table 51.

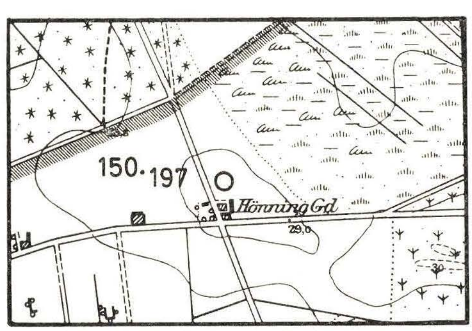


Fig. 89. Situation of borehole D.G.U. File No. 150.197 at Hønning. (Segment of M 3906 on the scale of 1:20,000).

Tornskov

Since my mention in 1956 (pp. 25–26) of the old Miocene locality at Tornskov, demolished long ago, D.G.U. in 1958 made a boring (D.G.U. File No. 159.243) only 100 m. SE of the old pit of the former brickworks. (As to the situation of this pit see RASMUSSEN 1956, p. 25).

Situation: 1 km. NE of Vognshøj, 1.8 km. north of the church of Nørreløgum and immediately south of the mouth of the southern one of the two gorges which off the Tornskov farms stretch into the hilly country towards the west. The situation is indicated in the map segment fig. 1, p. 5, in S. TH. ANDERSEN (1963).

Ground level: about + 22 m.

Borehole log:

0.0– 2.2 m.	Silt, yellowish brown
2.2– 13.7 –	Meltwater sand and gravel
13.7– 22.4 –	Clay, silty, grey, fossiliferous, marine (floc of interglacial clay)
22.4– 24.7 –	Boulder clay
24.7– 27.4 –	Sand and gravel (glacio-fluvial or marine deposits)
27.4– 94.7 –	Clay and silt, grey, slightly micaceous, marine, interglacial (corresponds to "Esbjerg Yoldia Clay")
94.7– 98.5 –	Silt, grey, micaceous, with bits of lignite (interglacial or glacio-fluvial sand)
98.5–107.2 –	Glacio-fluvial sand, grey, with pebbles and numerous rolled Middle Miocene mollusc shells
107.2–107.5 –	Above: Mica Clay, sticky, brownish grey, marine; Below: Mica Clay, blackish brown, slightly silty, with fine quartz gravel and fragments of molluscs, marine
107.5–107.6 –	Mica Clay, blackish brown, slightly silty, with pelagic foraminifera and molluscs (pteropods), marine.

Remarks: The Miocene beds do not seem to have been reached until a depth of 107.2 m.; but as only 0.4 m. more have been drilled, we have no security that they are in situ at the depth mentioned.

The wash residue of the blackish brown Mica Clay from 107.5–107.6 m. contains numerous *Globigerinae* and pteropods, a faunal assemblage which has no equivalent known so far.

A sample from the depth of 107.3 m. besides the blackish brown Mica Clay also contains brownish grey Mica Clay, the wash residue of which contains numerous small sharp-edged grains of quartz, some glauconite, numerous foraminifera, spines and fragments of plates of spatangids, ostracods, and bits of pyrite, and a fragment of *Nuculana sp.* and other indeterminable fragments of molluscs. According to oral information from ARNE BUCH, M. Sc., the foraminiferal fauna is not pelagic as in the blackish brown Mica Clay, but consists of bottom forms.

The age of the fauna is Miocene, but a detailed determination is not yet possible.

The glacio-fluvial sand from 98.5–107.2 m. contains many rolled fragments and shells of molluscs, among which the following species and genera could be determined:

1. *Nuculana emarginata* (LAMARCK)
2. *Arca sp.*
3. *Limopsis aurita* (BROCCHI)
4. *Astarte sp.*
5. *Cardita orbicularis* (SOWERBY)
6. *Isocardia sp.*
7. *Laevicardium sp.*
8. *Chione multilamella* (LAMARCK)
9. *Spisula subtruncata* (DA COSTA)
10. *Varicorbula gibba* (OLIVI)
11. *Cadulus gadus* (MONTAGU)
12. *Dentalium sp.*
13. *Archimediella subangulata* (BROCCHI)
14. *Aporrhais alata* (EICHWALD)
15. *Natica sp.*
16. *Typhis fistulosus* (BROCCHI)
17. *Nassa fuchsi* v. KOENEN
18. *Nassa schlotheimi* (BEYRICH)
19. *Nassa facki* v. KOENEN
20. *Nassa cimbrica* RAVN
21. *Ancilla obsolata* (BROCCHI)
22. *Conus dujardini* DESHAYES
23. *Gemmula stoffelsi* (NYST)
24. *Fusiturris duchasteli* (NYST)
25. *Bathytoma cataphracta* (BROCCHI)
26. *Clavatula boreointerrupta* KAUTSKY
27. *Inquisitor borealis* KAUTSKY
28. *Asthenotoma pannus* (BASTEROT)
29. *Neoguraleus tenella* (MAYER)
30. *Terebra hoernesi* BEYRICH
31. *Acteon tornatilis* (LINNÉ)
32. *Ringicula buccinea* (BROCCHI)

These species, which have all been found in the Arnum Formation, show that strata belonging to this formation have been accessible to meltwater. On the other hand, there are apparently no traces of the fauna of Younger Miocene formations.

The strata from 27.4–94.7 m. contain an interglacial flora and fauna. The sediments and the fauna in this interval are marine, but a contemporary pollen flora has been added and has been examined by S. TH. ANDERSEN (1963) and dated to the time of the Holstein Sea (= the "Stör See" - Period in sensu GRIPP; see GRIPP 1964, p. 204), which is part of the last interglacial period but one of those demonstrated in Denmark. The sediments and their fauna according to A. BUCH (personal information) correspond to conditions in the "Esbjerg Yoldia Clay".

Corresponding deposits underlain by sand with rolled mollusc shells from the strata of the Arnum Formation are known from several places in the region Løgumkloster – Ribe – Esbjerg (= the horizontally hatched area on the map fig. 61, p. 121), thus at Vester Vedsted (south of Ribe), Ribe, and Esbjerg. Cf. the mention of this region on p. 121.

The purpose of the borehole at Tornskov was that of examining whether Miocene formations nearly reach the surface of the ground in this place, as might be supposed from the statements in early German literature (SEMPER, v. KOENEN). The result of the drilling excludes this possibility. The Miocene fossils previously found in the old clay pit of the former brickworks thus are either derivatives in Quaternary sediments or have been gathered in a glacial floe of Gram Clay and/or Hodde Clay.

In the borehole a glacial floe occurs in the interval between the depths of 13.7 and 22.4 m. S. TH. ANDERSEN (loc. cit. p. 6 and Plate I) could show that it is a question of a fragment of the interglacial, marine series farther down in the same borehole.

Tønder

In the region N and NW of Tønder fossiliferous Younger Miocene formations have been shown to occur by two borings. One of these was made isolatedly north of the town, while the other was made NW of the town, close to two other boreholes, which reached down into Early Miocene deposits.

1. Borehole made for structural investigations by the Danish American Prospecting Co. 1948. D.G.U. File No. 166.227.

Situation: 1.7 km. north of the church of Tønder, immediately west of the highway from Ribe to Tønder. (The DAPCo. term for the borehole is "Tønder No. 2"). Fig. 90.

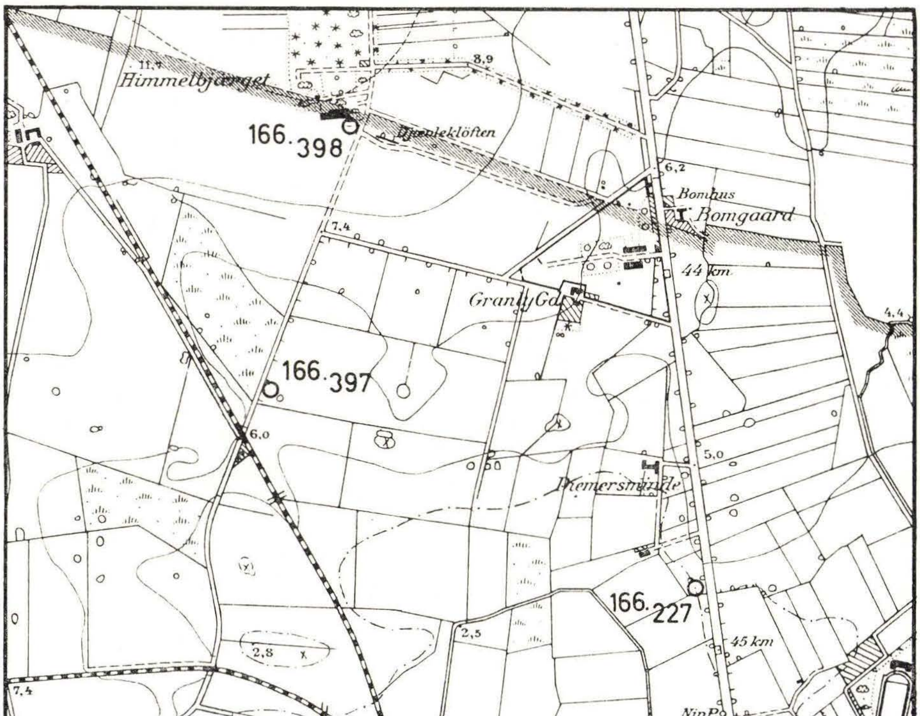


Fig. 90. Situation of the boreholes D.G.U. File Nos. 166.227, 397, and 398 north of Tønder. (Segment of M 4205 on the scale of 1:20,000).

Ground level: about + 2 m.

Borehole log:

0–	36 m.	Quaternary deposits
36– about	61 –	Gram Clay (and Hodde Clay?)
about 61– –	115 –	Mica Clay, Mica Silt, and quartz sand
		Final depth: 412 m. (in Danian bryozoan limestone).

Level of the surface of the Miocene: about − 34 m.

Molluscs occur in the ditch samples from 319′–325′ (= 97–99 m.) and 335′–341′ (= 102–104 m.), but they must undoubtedly originate from higher strata, in all probability from the interval 36–61 m. See Table 51, p. 261.

Remarks: As no core samples were taken in the interval in which the ditch samples showed bits of Gram Clay, the thickness and limits of this interval, especially downwards, are uncertain.

2. *Borehole at Tved.* Made for the waterworks of Tønder in 1963. D.G.U. File No. 166.398.

Situation: 900 m. NW of Bomgård and 1.8 km. NNW of the northern outskirts of the town of Tønder. Fig. 90.

Ground level: about + 10 m.

Borehole log:

0.0–10.5 m.	Boulder clay, silty, slightly gravelly, above: olive grey and greyish brown, downwards: greenish grey
10.5–13.5 –	Mica Clay, rather sticky, brownish black, with many beds of silt only one mm. thick
13.5–16.0 –	"Clay, brownish, with sand admixed" (sample missing)
16.0–18.0 –	Clay, sticky, dark grey, with some silt, micaceous, medium-grained, grey
18.0–19.0 –	Silt, fine, greyish brown, clayey, micaceous
19.0–28.0 –	Clay, grey, sticky, alternating with thin beds of silt, fine, pale grey, micaceous
28.0–43.5 –	Clay, rather sticky, greyish black, dark brown and brownish black, micaceous
43.5–73.0 –	Mica Clay, sticky, black, hard (Gram Clay) At 58.85–59 m. a bed of concretions
73.0–74.0 –	Clay, very sticky, dark olive grey, with beds of Mica Silt, medium-grained, grey
74.0–85.0 –	Mica Clay, sticky, black, firm (Hodde Clay)
85.0–85.5 –	Clay, very sticky, dark olive brown
85.5–90.0 –	Mica Clay, sticky, black, hard (Hodde Clay)
90.0–101.0 –	Mica Clay, brownish black, sticky, hard, with many molluscs
101.0–106.0 –	Mica Clay, dark, with many fossils.

Level of the surface of the Miocene: about − 0.5 m.

Molluscs are available from 24 m., 37 m., 43.5 m., 45 m., 50 m., 58.85–59.00 m., 72 m., 74 m., 76 m., 85 m., 85.5 m., 90 m., 90–101 m., 101–104 m., 105 m., and 106 m. Faunal analysis, see Table 11, p. 214, and Table 62, p. 279.

Description of the fossiliferous samples:

24 m. Weight of sample before washing: 98.18 g., after washing: 2.35 g. Clay, grey, sticky, alternating with silt, fine, light grey, slightly calcareous, with thin beds, which are micaceous and greenish. Strong H_2S smell with HCl. Wash residue: dominance of micro-ellipsoids. Numerous pale mica flakes. No pyrite. A few charred plant residues. Comparatively few foraminifera. Few fragments of molluscs.

37.0 m. Weight of sample before washing: 96.44 g., after washing: 1.02 g. Clay, rather sticky, greyish black, micaceous, slightly calcareous, greenish. H_2S smell with HCl. Wash residue: mica flakes dominant in the sample. Much pyrite. Numerous fragments of molluscs and numerous foraminifera.

43.5 m. Weight of sample before washing: 108.53 g., after washing: 1.57 g. Clay, rather sticky, brownish black, micaceous. Wash residue: micro-ellipsoids dominant. Much pyrite. Numerous foraminifera (*Textularia gramen* very frequent) and fragments of molluscs. A few fragments of *Cupuladria*. Some spines and plates of spatangids.

45 m. Weight of sample before washing: 84.26 g., after washing: 2.77 g. Gram Clay. Wash residue: micro-ellipsoids dominant. Very much pyrite, especially stem-shaped. A few grains of quartz. Many foraminifera and some fragments of molluscs.

50 m. Weight of sample before washing: 115.00 g., after washing: 2.59 g. Gram Clay. Wash residue: micro-ellipsoids and very much pyrite dominant. Many small brownish bits (of concretions?). Numerous foraminifera and small bits of mollusc shells. Many fragments of *Cupuladria haidingeri* and *C. canariensis*. Many remnants of spatangids. A few remnants of crabs.

58.85–59 m. Weight of sample: 2371 g. Gram Clay with fragments of concretions. Wash residue: dominated by large and small brownish bits of concretions. Furthermore, numerous stems of pyrite. Some fragments of molluscs. Fragments of *Ditrupa*.

72 m. Weight of sample before washing: 154.64 g., after washing: 2.84 g. Mica Clay, sticky, black, hard, non-calcareous. Wash residue: dark green micro-ellipsoids and grains of glauconite are dominant. Numerous lumps and stems of pyrite. Several bits of charred plant residues. Some foraminifera.

74 m. Weight of sample before washing: 87.05 g., after washing: 3.53 g. Clay, very sticky' dark olive grey, non-calcareous, with beds of Mica Silt, medium-grained, grey, slightly calcareous. Wash residue: much pyrite and numerous grains of glauconite and greenish micro-ellipsoids. Numerous foraminifera and fragments of molluscs. A few ostracods.

76 m. Weight of sample before washing: 120.68 g., after washing: 1.89 g. Mica Clay, sticky, black, hard, almost non-calcareous. Wash residue: complete dominance of pitted and cavernous small bits of pyrite. Subordinately some foraminifera and a few fragments of mollusc shells are seen.

85 m. Weight of sample before washing: 131.67 g., after washing: 1.22 g. Mica Clay, sticky, deep black, hard, almost non-calcareous. Wash residue: pitted and cavernous small bits of pyrite together with numerous well rounded grains of quartz are dominant. Numerous foraminifera and some fragments of molluscs.

85.5 m. Weight of sample before washing: 114.48 g., after washing: 2.33 g. Clay, very sticky, dark, olive brown, non-calcareous. Wash residue: pitted and cavernous small bits of pyrite dominant. Much quartz, some of it rust-coloured. Many foraminifera and few fragments of molluscs.

90 m. Weight of sample before washing: 118.81 g., after washing: 0.52 g. Mica Clay, sticky, black, hard, almost non-calcareous. Wash residue: highly characterized by numerous foraminifera (especially *Uvigerina hosiusi*) and much pyrite. A few grains of glauconite.

90–101 m. Weight of sample before washing: 136.67 g., after washing: 2.09 g. Mica Clay, brownish black, sticky, hard, calcareous. Wash residue: pitted and cavernous bits of pyrite are dominant. Large quantities of foraminifera. Numerous shells and fragments of molluscs. Some grains of quartz. Fragments of *Cupuladria*, *Ditrupa*, and spatangids. A few isolated grains of glauconite. Otolites.

101–104 m. Weight of sample before washing: 105.95 g., after washing: 1.61 g. Dark clay. Wash residue: dominance of grains of quartz. Many bits of pitted and cavernous pyrite. A few grains of glauconite. Many foraminifera. Comparatively few and small fragments of molluscs.

105 m. Weight of sample before washing: 110.44 g., after washing: 2.44 g. Dark clay. Wash residue: much pyrite. Very numerous fragments of molluscs and numerous foraminifera.

106 m. Weight of sample before washing: 95.01 g., after washing: 0.80 g. Dark clay. Wash residue: characterized by bits of pyrite, grains of quartz, and extremely numerous foraminifera. Isolated grains of glauconite. Numerous fragments and shells of molluscs.

Remarks. It is remarkable that in this borehole there is an at least 95 m. thick unbroken series of Younger Miocene clay, so far the greatest thickness of the series found in Denmark. The succession in the borehole can be summed up as follows:

10.5–43.5 m.	Mica Clay alternating with silt
43.5–about 65 m. (?)	Gram Clay
about 65 m. (?) – about 70 m. (?)	Glauconite Clay?
about 70 m. (?) – 90 m.	Hodde Clay
90 m. – 106 m.	Black Mica Clay with rather high contents of quartz grains and of molluscs.

The zone of Glauconite Clay was not found in the borehole, but as there are no samples available from the whole interval of 59–72 m., it is not excluded that it may occur somewhere in this interval, the more so as there is much glauconite in the samples from 72 m. and 74 m. Such occurrences of glauconite have not been found in the other samples and there are indications that a more glauconitic environment was developing in the strata from the depth of 74 m. and upwards.

If we assume the presence of such a zone of Glauconite Clay from a depth of about 65–70 m., there will be a Younger Miocene clay series of the usual type from the depth of 43.5 to 90 m., which, as regards thickness, corresponds quite well to conditions at e.g. Gram (see above p. 146).

The sandy beds above a depth of 43.5 m. contain no fossils and therefore cannot be paralleled with certainty with other localities, but they remind of conditions in the borehole at the custom-house of Sæd south of Tønder (D.G.U. File No. 167.445; see pp. 173–178), where from 89.50 m. there are Mica Clay and Silt above the Gram Clay. Similar conditions are known from Morsum Kliff on Sylt, where they are referred to the uppermost Upper Miocene or the lowermost Pliocene.

The deepest strata at Tønder, from 90 to 106 m., contain a fauna of molluscs which is not identical with the normal one of the Hodde Clay, but rather seems to resemble that of the Arnum Formation.

The following species were found in the samples:

1. *Nucula sp.*
2. *Nuculana pygmaea* (MÜNSTER)
3. – *westendorpii* (NYST & WESTENDORP)
4. *Arca diluvii* LAMARCK
5. *Limopsis aurita* (BROCCHI)
6. *Limopsis lamellata* LEHMANN
7. *Pecten sp.*
8. *Astarte sp.*
9. *Thyasira sp.*
10. *Laevicardium sp.*
11. *Gouldia minima* (MONTAGU)
12. *Chione multilamella* (LAMARCK)
13. *Spisula subtruncata* (DA COSTA)
14. *Abra sp.*
15. *Saxicava arctica* (LINNÉ)
16. *Varicorbula gibba* (OLIVI)
17. *Cadulus gadus* (MONTAGU)
18. *Dentalium cf. dollfusi* v. KOENEN
19. *Haustator eryna* (D'ORBIGNY)
20. *Bittium tenuispina* SORGENFREI
21. *Naticidae indet.*
22. *Pyrula condita* BRONGNIART
23. *Nassa tenuistriata* (BEYRICH)
24. *Nassa fuchsi* v. KOENEN
25. *Nassa schlotheimi* (BEYRICH)
26. *Nassa cimbrica* RAVN
27. *Gemmula cf. rotata* (BROCCHI)
28. *Gemmula boreoturricula* (KAUTSKY)
29. *Gemmula stoffelsi* (NYST)
30. *Fusiturris duchastelii* (NYST)
31. ?*Splendrillia selenkae* (v. KOENEN)
32. *Asthenotoma gliberti* (HINSCH)
33. *Terebra hoernesi* BEYRICH
34. *Acteon semistriatus* (BASTEROT)
35. *Odostomia conoidea* (BROCCHI)
36. *Eulimella sp.*
37. *Ringicula buccinea* (BROCCHI)
38. *Spiratella atlanta* (MØRCH).

In the sample from the depth of 105 m. *Bittium tenuispina* was dominant, with 16 per cent. of the total number of specimens (100). All the other species are only represented by a single or very few specimens.

As the fauna mentioned seems to derive from black clay of a type similar to the Hodde Clay, into which it gradually merges, the sedimentation of the clay series in this locality was obviously introduced at the time of the Arnum Formation, or we must assume that there was another faunal composition in the early period of the Hodde Clay than usual. The problem can hardly be solved on the basis of the modest material available from the borehole.

The Arnum Formation has, for that matter, been demonstrated in the neighbouring borehole, D.G.U. File No. 166.230 (= the deep boring Tønder No. 1), which is situated well over 200 m. SSW of borehole No. 166.398. There were there Miocene deposits from the depths of 46 to 251 m. (cf. SORGENFREI & BUCH 1964, p. 75 ff.), but because of the drilling method used (flush drilling), the samples included so much contamination of material from different depths that sure determinations of the depths of the various strata are excluded. The shell beds found exclusively contain the fauna of the Arnum Formation, but it is probable that the Hodde and Gram Formations were present, too, just as it must also be taken for granted that the upper edge of the Miocene strata actually is somewhat higher than the 46 m. indicated.

This seems to appear from the borehole described, 166.398, as well as the second borehole of the waterworks of Tønder in the area, D.G.U. File No. 166.397, which was made only 500 m. south of the deep boring and, to judge from the samples submitted to D.G.U., reached the upper edge of the Miocene already at a depth of 11 m. The borehole was made in 1963, immediately before borehole No. 166.398.

Borehole log:

0.00– 0.25 m.	Peat, sandy
0.25– 3.50 –	Meltwater sand, with gravel below
3.50–11.00 –	Boulder clay
11.00–12.00 –	Mica Silt, medium-grained, dark brown, non-calcareous
12.00–16.00 –	Mica Clay, rather sticky, brownish black, non-calcareous
16.00–21.00 –	Mica Silt, fine, dark grey, clayey, non-calcareous
21.00–28.00 –	Mica Silt, medium-coarse, dark grey, non-calcareous
28.00–33.00 –	Mica Silt, fine- to medium-grained, greyish black, clayey, highly glauconitic, non-calcareous
33.00–38.00 –	Mica Clay, rather sticky, black, with many beds of silt, non-calcareous
38.00–40.00 –	Mica Silt, medium-grained, dark grey, non-calcareous
40.00–44.50 –	Mica Silt, as above, greenish. Some comminuted lignite
44.50–46.50 –	Mica Clay, rather sticky, dark grey, with thin beds of silt
46.50–52.00 –	Mica Clay, sticky, greenish black to brownish black, with thin beds of silt
52.00–55.00 –	Mica Clay, sticky, greenish black to brownish black, non-calcareous, with some dark greyish green silty parts rich in glauconite.

No fossils have been found in the samples, but the frequent alternation between clay and silt corresponds to conditions above the depth of 43.5 m. in borehole No. 166.398, in which, however, the series is more than 10 m. thinner. Perhaps the strata in borehole No. 166.397 are steeper and thus have been glacially disturbed.

Both boreholes seem to contain Tertiary strata which are younger than the Gram Clay, as in borehole No. 167.445 at the custom-house of Sæd.

Brodersmark

Borehole made by D.G.U. 1955.
D.G.U. File No. 166.351 b.

Situation: 800 m. NW of the Brodersmark farm and 1.8 km. NNE of the northernmost corner of Rudbøl Lake. Fig. 91.

Ground level: + 0.94 m. (levelled).

Borehole log: Rendered in Rasmussen 1958, p. 22, together with a preliminary faunal list, but published in greatest detail by N. Kingo Jacobsen, 1959, p. 148 (in English ibid. p. 171).

0.0– 1.0 m.	Marsh
1.0– 1.2 –	Peat
1.2– 4.0 –	Blown sand
4.0– 7.3 –	Sand, late-Glacial
7.3–14.5 –	Meltwater sand
14.5–22.4 –	Boulder clay
22.4–33.0 –	Gram Clay. At 31.3 m. and 32.1 m. beds of pale yellowish brown concretions.

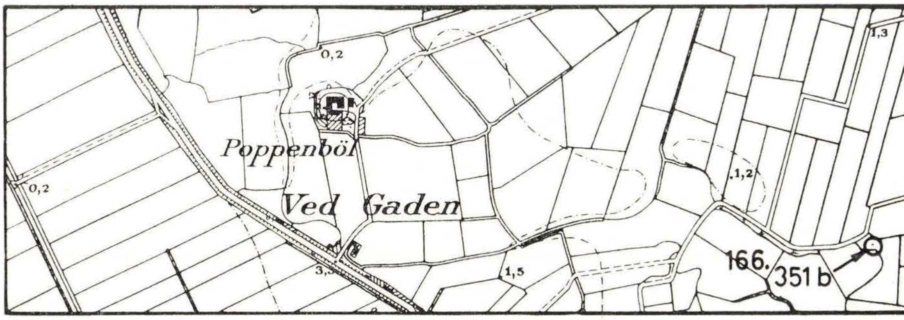


Fig. 91. Situation of borehole D.G.U. File No. 166.351 b at Brodersmark.
(Segment of M 4304 on the scale of 1:20,000).

Level of the surface of the Miocene: — 21.46 m.

Molluscs are available from the following depths: 22.6–24 m., 24–25 m., 25–26 m., 26–27 m., 27–28 m., 28–29 m., 29–30 m., 30–31 m., and 31–32 m. Faunal analysis, see Table 63, p. 280.

Description of the fossiliferous samples: All the samples containing fossils consist of typical Gram Clay, which was washed with a screen having a width of meshes of 0.5 mm. The wash residues therefore are dominated by pyrite stems and shells as well as large specimens of foraminifera. Furthermore, many fragments of *Cupuladria*. All samples contain considerable amounts of Quaternary sand and recent plant residues, which shows that the samples of clay have been placed on the surface of the ground before being wrapped up. The sand and plant material which stuck to the surface of the samples was not removed before they were washed. The sample from the depth of 31–32 m. exclusively consists of crushed concretions.

Heds

Borehole made by DAPCo in 1948.
D.G.U. File No. 167.234 b.

Situation: 2.1 km. SE of Bredevad, 2.9 km. NW of Terkelsbøl railway station and immediately west of the road from Heds to Duborg. (The DAPCo designation of the borehole was "Tinglev No. 1 A"). Fig. 92.

Ground level: about + 20 m.

Borehole log:

0–62 m.	Quaternary deposits
62–about 100 m.	Above: Gram Clay, below: perhaps Hodde Clay, and possibly quartz sand.
	Final depth of the drilling: 172 m. (in Miocene deposits).

Level of the surface of the Miocene: about — 42 m.

Mollusc fragments are available from a ditch sample from 262′–273′ (i.e. 80–83 m.). Only a defective valve of *Astarte reimersi* was collected (see below).

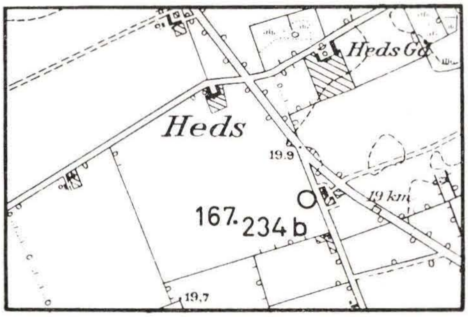


Fig. 92. Situation of borehole D.G.U. File No. 167.234b at Heds.
(Segment of M 4207 on the scale of 1:20,000).

Description of the fossiliferous sample: Lumps of dark Gram Clay and boulder clay, sand and stones, which have derived from the Quaternary strata during the drilling. Besides a single valve of *Astarte reimersi*, TH. SORGENFREI in the same sample found an otolite.

Remarks: The borehole was made as substitute for D.G.U. File No. 167.234a, in which the uppermost 257 m. erroneously were assumed to be Quaternary deposits.

In File No. 167.234b only a single core was taken at a depth of 335′ (= 102 m.), but it was very impure and unrepresentative. Only highly contaminated ditch samples are available from this boring. The thickness and position of the Gram Clay, therefore, are little known.

Hajstrup

Borehole made by DAPCo in 1948.
D.G.U. File No. 167.235.

Situation: 1 km. SW of Hajstrup, 2.2 km. east of the church of Burkal and 2.2 km. south of the church of Bylderup. (Designation of the boring by DAPCo: "Tinglev No. 2"). Fig. 93.

Ground level: about + 12 m.

Borehole log:

	0–	41 m.	Quaternary deposits
	41–	about 44 –	Gram Clay
about	44–	– 51 –	Green, glauconitic clay
–	51–	– 60 –	Hodde Clay
–	60–	– 73 –	Mica Sand with beds of concretions and numerous fossils.

Final depth: 595 m. (in Senonian White Chalk).

Level of the surface of the Miocene: about − 29 m.

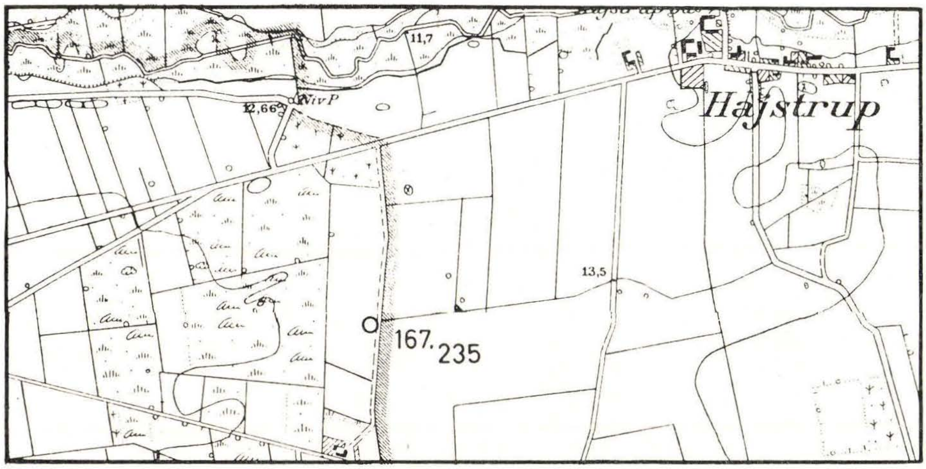


Fig. 93. Situation of borehole D.G.U. File No. 167.235 at Hajstrup.
(Segment of M 4207 and M 4307 on the scale of 1:20,000).

Molluscs are available from the core-intervals: 154′–174′, 174′–194′, 194′–214′, and 214′–234′. Faunal analysis, see Table 12, p. 215.

Description of the samples: Core drilling was made in the following intervals: (1) 134′–154′ (= 40.8–46.9 m.), (2) 154′–174′ (= 46.9–53.0 m.), (3) 174′–194′ (= 53.0–59.1 m.), (4) 194′–214′ (= 59.1–65.2 m.), (5) 214′–234′ (= 65.2–71.3 m.).

Core No. 1 like the four other cores is kept at D.G.U. At an examination of it in 1962, there were still 0.4 m. left. At that time it could be described as follows:
0.00–0.34 m. Mica Clay, dark brownish grey (of the Gram Clay type)
0.34–0.40 – Dark green glauconitic clay.

As the coring interval is 6.1 m., it is difficult to tell the place in this interval from which originates the 0.4 m. of core preserved. No fossils were found.

Core No. 2 in 1962 was 1.2 m. in length. As the core was highly subdivided, the question is whether the pieces at the repeated transport and removal of the coreboxes have not tumbled about each other and been disarranged. As the pieces were arranged in 1962 the succession was as follows:
0.00–0.68 m. Clay, dark green with a distinctly greenish tint
0.68–0.98 – Clay, brownish – dark grey, a little silty
0.98–1.20 – Clay, a little darker than that of the preceding section.

Core No. 3 at the examination in 1962 was 1.30 m. long and contained the following clay:
0.00–0.70 m. Clay, dark brown – blackish brown, sticky homogeneous
0.70–1.30 – Clay, black, coaly, fractured, dense, (presumably Hodde Clay).

Core No. 4 in 1962 contained 0.55 m. in all, consisting of: Clay, brownish grey, rather homogeneous (Mica Clay, but of uncertain type).

Core No. 5 was taken when the hole was reamed and consists mainly of Hodde Clay with numerous pebbles from the Quaternary beds.

Sæd

At the custom-house of Sæd, SE of Tønder, close to the German frontier, two boreholes were formerly (in 1933) made for drinking-water. One of them, D.G.U. File No. 167.4.a, penetrated to a depth of 82.5 m. in marine, Tertiary strata with molluscs. This borehole has previously been described by H. ØDUM (1934) and RASMUSSEN (1958), to whose publications reference is made.

In 1963 D.G.U. made another boring for the purpose of geological investigation at the custom-house in order to obtain a complete sample series down to a depth of 100 m., as the depth of the samplings in 1933 and the succession of the samples were uncertain.

The Tertiary at Sæd is of particularly great interest, because ØDUM there thought it possible to demonstrate the presence of a Pliocene molluscan fauna in the pieces of oolitic siderite sandstone found at the drilling. RASMUSSEN accepted this assumption after a repeated examination of the fossils, but found in clay samples from the same depth, kept in the collection of the D.G.U., a molluscan fauna with a distinct affinity to the fauna of the Gram Clay. The fauna, however, contains certain species which have never been found in the Gram Clay. There were especially numerous shells of a large *Nassa*, probably *N. granulata* (SOWERBY), which occurs in the British Pliocene Crag, and which was also found in many fragments in the siderite sandstone.

Before the borehole was made, a few clay samples were examined which originated from a depth of 70–82.5 m. in the borehole of 1933 (D.G.U. File No. 167.4.a), and which were kept in the collection of the D.G.U. They were washed apart and showed that there were two types of clay of almost the same appearance, but one of them having a wash residue with rather a high content of quartz silt and the other a typical Gram Clay wash residue with microellipsoids and stems of pyrite.

The faunal assemblages in the two samples were also different. In the former type, called "Sæd Clay", there were, i.a., many specimens of the large *Nassa* mentioned, while the other type, which was true Gram Clay, contained the fauna normally found in small samples of Gram Clay (see Table 64, p. 281). Thus it could with certainty be decided that Gram Clay had been found in the borehole of 1933, but the situation of the various strata in relation to one another was still unexplained.

Borehole at the custom-house of Sæd, made by D.G.U. 18. June – about 10. July 1963. D.G.U. File No. 167.445.

Situation: Immediately north of the buildings of the custom-house, about 84.5 m. north of the Sønderå river and 39.3 m. west of the middle of the highway to Tønder. According to oral communication in the place the borehole was made 20 m. north of D.G.U. File No. 167.4.a. This is not, however, in complete agreement with the previous information (cf. RASMUSSEN 1958, p. 3), according

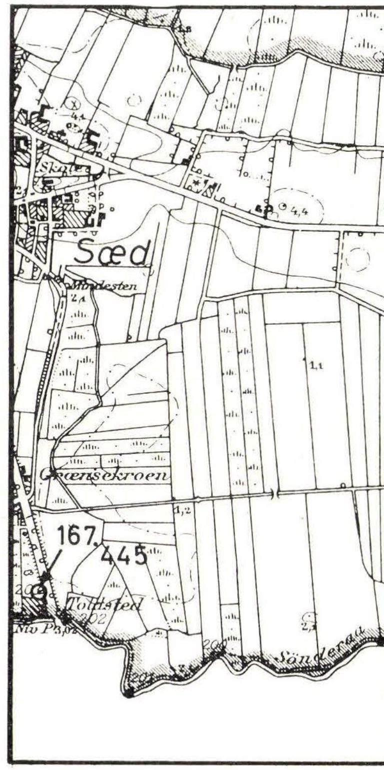


Fig. 94. Situation of borehole D.G.U. File No. 167.445 at Sæd. (Segment of M 4305 and M 4306 on the scale of 1:20,000).

to which the latter borehole should be situated about 30 m. north of the Sønderå river. Fig. 94.

Ground level: about + 2 m.

Borehole log:

0.00–	0.20 m.	Fill
0.20–	2.00 –	Clay, somewhat humic, more or less sandy (marine clay)
2.00–	2.60 –	Peat, somewhat clayey and sandy, with spots of vivianite
2.60–	2.90 –	Sand, black, humic, with plant residues (bits of branches)
2.90–	19.00 –	Sand, more or less coarse, with gravel and many stones of varying sizes, badly sorted. At the depth of 6.3–6.4 m. with dark, almost black, coaly bits of wood. (Presumably late-Glacial outwash-sand)
19.00–	30.30 –	Sand, fine- to medium-grained, with rather homogeneous grains and without stones, well sorted (meltwater sand)
30.30–	33.60 –	Clay, dark grey, sticky, with pebbles and bits of wood (boulder clay)
33.60–	36.00 –	Clay, silty, dark grey, somewhat micaceous, homogeneous

36.00– 37.60 –	Clay, more sticky than the above, dark grey, somewhat micaceous
37.60– 38.50 –	Clay, sandy, dark grey, somewhat micaceous
38.50– 41.70 –	Clay, mainly sticky, in lower part apparently with greater content of sand, dark grey, with a few stones. From 38.7 m. a bit of rhomb-porphyry was found in the wash residue. At 39.7 m. a boulder of kinnediabas of 9 × 8 × 6 cm. (boulder clay, perhaps Riss moraine)
41.70– 47.70 –	Sand and gravel, in places with greenish grey clay. Gravel and pebbles of varying sizes. Bed of gravel at 45.4 m. Pieces of wood here and there. (Glacio-fluvial deposits)
47.70– 58.00 –	Sand, the upper 5–6 m. fine-grained and with contents of bits of lignite and wood. The lower 4–5 m. medium-grained and the lowermost part of the interval with a little gravel. A thin layer of lignite at 53.5 m. (Glacio-fluvial deposits)
58.00– 65.10 –	Mica Silt, grey, in some places with coarser grains, elsewhere with more clayey beds. Bits of lignite here and there (especially at 64.95 m.)
65.10– 66.30 –	Mica Silt, clayey, grey, with a conspicuous greenish tint
66.30– 70.75 –	Mica Silt, grey, with a very slightly greenish tint. At 70.75 m. a thin clayey bed
70.75– 72.00 –	Mica Silt, grey, with an almost imperceptible greenish tint. At 72.0 m. there is some quartz gravel in a thin horizon. The pebbles consist of well rounded flint and quartz 0.5–1.0 cm. in size.
72.00– 82.00 –	Mica Silt, pale yellowish grey. At 80.0 m. small bits of lignite and casts of gastropods
82.00– 83.30 –	Mica Silt, rather fine-grained, grey, with cm.-sized rounded concretions, thus at 82.0 m. and 82.9 m.
83.30– 86.40 –	Mica Silt, slightly clayey, grey, with a slightly brownish and greenish tint
86.40– 87.90 –	Mica Clay, silty, brownish grey, in places with thin layers of pale grey silt
87.90– 89.50 –	Mica Clay, brownish, in frequent alternation with thin beds of paler grey Mica Silt. From 88.95 m. to 89.50 m. the beds of silt seem to be dominant as compared with the beds of clay
89.50– 91.20 –	Mica Clay, silty, brownish grey. Fossiliferous from 90.30 m.
91.20– 92.70 –	Mica Clay, dark brownish grey, fossiliferous. Clay-ironstone concretions at 92.20 m.
92.70–100.10 –	Mica Clay, rather sticky, brownish grey, fossiliferous (typical Gram Clay). Small, more yellowish brown zones at 94.40 m., 96.10–96.50 m. and at 98.55 m.

Level of the surface of the Tertiary: about — 56 m.

Molluscs were found in all the samples from 90.30 to 100.10 m., i.e. 20 samples in all. The intervals in question are indicated in the table below. Faunal analysis, see Table 65, p. 282.

The fossiliferous samples. All the material drilled up from the depth of 90.30 m. was submitted to the D.G.U. and washed with a screen having a width of meshes of 0.1 mm. The most important observations are indicated in the table below, with the exception of information about the fossils.

The molluscs are listed in Table 65, but besides there were in all samples numerous foraminifera as well as many remnants of echinids (spines and plates of spatangids), bryozoa (*Cupuladria haidingeri*), ostracods, and some otolites, a few fish teeth, etc.

Certain strata, viz. from 91 to 94 m., were particularly rich in fragments of molluscs.

Depth interval	Weight of sample in g.	Weight of wash residue in g.	Percentage of material larger than 0.1 mm.	Dominant components	Special minerals	Remarks
90.30–91.00 m.	3017	53.12	1.8	Mica flakes and quartz	A little pyrite	Bits of brownish concretions. Charred plant residues
91.00–91.50 –				Micro-ellipsoids	Quartz and mica. A little pyrite	Charred plant residues
91.50–91.75 –				Micro-ellipsoids and quartz	A little pyrite	Numerous fragments of molluscs
91.75–92.00 –				Micro-ellipsoids	Quartz and mica. A little pyrite	Some brownish pieces of concretions
92.00–92.25 –				–	A little pyrite	
92.25–92.70 –				–	Quartz	Numerous brownish pieces of concretions
92.70–93.00 –				–	Quartz and mica. Much pyrite	Many brownish pieces of concretions
93.00–93.70 –	2139	62.11	2.9	– and quartz	Mica. Much pyrite	
93.70–94.10 –	2651	57.42	2.5	–	Mica	
94.10–94.75 –	3359	75.57	2.3	Quartz and mica		
94.75–95.50 –	2478	24.47	1.0	Mica and quartz	Pyrite	
95.50–95.90 –	1433	12.22	0.8	–	Micro-ellipsoids. Much pyrite	
95.90–96.20 –	1738	34.50	2.0	Micro-ellipsoids	Quartz and mica. Much pyrite	
96.20–96.75 –	2724	102.64	3.8	–	Much pyrite	The micro-ellipsoids are very dark green
96.75–97.40 –	1798	38.74	2.2	–	Quartz. Much pyrite	
97.40–97.90 –	2001	68.54	3.4	–	Mica. Much pyrite	
97.90–98.60 –	3445	64.00	1.9	Quartz	Micro-ellipsoids. Much pyrite	

Depth interval	Weight of sample in g.	Weight of wash residue in g.	Percentage of material larger than 0.1 mm.	Dominant components	Special minerals	Remarks
98.60–99.05 m.	3635	112.76	3.1	Micro-ellipsoids	Much pyrite	The micro-ellipsoids dark green
99.05–99.55 –	3340	148.50	4.5	–	Quartz. Much pyrite	
99.55–100.10 –	3381	120.58	3.6	–	Much pyrite	

Remarks: I estimate the succession penetrated as follows:

0.00– 2.90 m. Postglacial peat and marine clay
2.90– 19.00 – Late-Glacial outwash sand, fluviatile
19.00– 30.30 – Glacio-fluvial sand
30.30– 33.60 – Boulder clay, glacial
33.60– 38.50 – Micaceous silty clay
38.50– 41.70 – Boulder clay, glacial, perhaps Riss
41.70– 58.00 – Glacio-fluvial sand
58.00– 72.00 – Mica Silt with quartz gravel and in places with clayey beds, perhaps limnic-fluviatile. Presumably Pliocene
72.00– 86.40 – Mica Silt with fossiliferous concretions of siderite, perhaps in part marine. Presumably Pliocene
86.40– 89.50 – Mica Clay with many thin beds of Mica Silt, perhaps marine. Presumably Pliocene or latest Upper Miocene
89.50– 92.70 – Gram Clay, fossiliferous, a little silty, with concretions, marine, Upper Miocene
92.70–100.10 – Gram Clay, dark grey, typical, fossiliferous, marine, Upper Miocene.

A corresponding Tertiary series of strata, in which Gram Clay constitutes the lowest and oldest part, has not previously been shown to occur in Danish territory. The beds from 90.30 m. and downwards must for palaeontological reasons be considered Upper Miocene (see p. 318). The age of the overlying beds up to a depth of 58.0 m., on the other hand, is more problematic. The nearest comparable strata are found in Morsum Kliff in Sylt, situated 29 km. west of Sæd, where the lowest and oldest group of the dislocated Tertiary strata are also Upper Miocene, and where the overlying beds are considered to be Pliocene. The sequence in the borehole at Sæd will be discussed in detail in the biostratigraphical part (see p. 318ff).

Considering that thus it must be assumed that the series from 58 m. to 100 m. belongs to the latest Tertiary deposited in Denmark, it is remarkable that the upper edge of these strata is found on the level of — 56 m. It is difficult to understand this fact without presupposing a tectonic cause, as the series of strata does not seem to have been glacially disturbed to a demonstrable degree. The subsidence of the series of strata which thus must have taken place, might perhaps be explained by the situation of the locality on the southeastern flank of a salt anticline under the Tønder area (cf. RASMUSSEN 1958, pp. 23–25 and 27). Rising movements in the strata above this structure, caused by halokinetic movements in the Zechstein salt in the core of the structure, give rise to a relative subsidence of the flanks of the structure, the deeplying rock-salt from there moving towards the middle of the structure. As such movements may very well have taken place in the period between the depositions of the Mica Silt at the depth of 58 m. and the strata of the overlying Quaternary, and perhaps later, too, this explains how these strata are now situated so relatively deeply below sea level.

Rends

Borehole made by DAPCo in 1948.
D.G.U. File No. 167.236.

Situation: 3 km. SW of Rends, 3 km. SE of Lydersholm, and about 800 m. north of the Danish-German frontier, 500 m. NE of the Flydsholm farm. (Designation of the borehole by DAPCo: "Tinglev No. 3"). Fig. 95.

Ground level: about + 8 m.

Borehole log:

0– about 42 m.	Quaternary deposits, mainly meltwater sand
about 42– about 67	–	Gram Clay (and below probably Hodde Clay)
about 67– about 76	–	Mica Sand alternating with Mica Clay
		Final depth of the borehole: 498 m. (in Danian Bryozoan Limestone).

Level of the surface of the Miocene: about — 34 m.

Molluscs are available from the core interval 43–49 m. Faunal analysis, see Table 66, p. 285.

Description of the fossiliferous samples: A core was taken from the depth interval of 140′–160′ (= 42.7–48.8 m.). It consists throughout of typical Gram Clay.

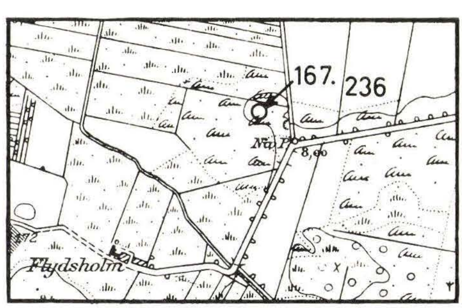


Fig. 95. Situation of borehole D.G.U. File No. 167.236 at Rends.
(Segment of M 4306 on the scale of 1:20,000).

The core length obtained according to the drilling report (kept at D.G.U.) is 12′7″ (= about 3.84 m.). A measurement of the length of the core at D.G.U. on 8. August 1962 showed that it had been reduced to a length of 3.25 m. After the piece from 0.6–0.7 m. below the top of the core was taken as type, the core was subdivided into 0.5 m. long sections, which were washed apart.

Remarks: The driller had been ordered to core as soon as the Miocene Clay had been reached. To judge from the ditch samples, this seems to have been done correctly. As the boundary between the Quaternary and the Miocene must be situated somewhat above the core interval, I suppose that the depth of about 42 m. must be the most correct one.

The downward limit of the Younger Miocene strata is more uncertain, as only flush drilling was made in the interval between 49 m. and 236 m. Probably there are deposits of Hodde Clay under the Gram Clay as in the borehole of Hajstrup.

REMARKS ON MOLLUSCS

The considerable number of species of molluscs found in the Hodde Clay and Gram Clay appears from Table 13, p. 13, and Table 67, p. 287, respectively.

With few exceptions these species are well-known from the Miocene deposits of the North Sea Basin. The determinations have been made by means of the following papers, in which the species have been described and pictured:

ANDERSON 1959a, b, 1960
BEETS 1946
BEYRICH 1853–57
GLIBERT 1945–52, 1954, 1957–59
HINSCH 1952, 1958, 1962
KAUTSKY 1925
KOENEN 1872, 1882
LEHMANN 1892–93
NØRREGAARD 1916a
RASMUSSEN 1956
RAVN 1907
SEIFERT 1959
SORGENFREI 1940, 1958
TEMBROCK 1963
VOORTHUYSEN 1944

The main part of the material from the large number of boreholes investigated consists of fragments. These are often so small that a determination can only be made on the basis of many years' experience in looking at the species in question. During the 27 years in which I have had opportunities regularly to observe each single species during the work in the field and in the laboratory, so intimate a knowledge of the appearance of the species in detail has been acquired that I feel sure regarding the identity of the species adduced in the lists of analysis. In this connexion identity is first of all taken to mean mutual identification of the species from locality to locality.

Regarding the nomenclature and the arrangement of the species I have mainly followed the system in ANDERSON's and SORGENFREI's works, but in certain cases I have preferred generic and specific names used in recent special papers, e.g. in TEMBROCK's paper on the Muricidae.

In the present work only a binominal nomenclature has been used, as the application of subgenus groups in the literature in a number of cases has proved too weakly founded.

An all-embracing monographical treatment of all species of molluscs has been prepared and is available in manuscript. It is intended to publish this monograph as an independent volume.

Description of Certain Important Species

A few species which are new or have previously been described under another name, are so important for the biostratigraphical discussion that it is necessary to mention them in detail in this place.

The species referred to are the following:

(1) *Goodallia esbjergensis nov. sp.*

(2) *Siphonodentalium cf. lobatum* (SOWERBY)

(3) *Nassa slieswicia nov. sp.*

(4) *Neoguraleus sæthensis nov. sp.*

Abbreviations used in the lists of material:

r = right valve	d = double valve
l = left valve	def. = defective
s = single valve	fr(agm). = fragment(s)

PELECYPODA

ORDO: EULAMELLIBRANCHIATA
SUBORDO: HETERODONTA

Familia: *Astartidae* D'ORBIGNY 1845
Genus: *Astarte* I. SOWERBY 1816

Subgenus: *Goodallia* TURTON 1822
Type: *Mactra triangularis* MONTAGU 1803

Goodallia esbjergensis nov. sp.

Fig. 96 a–c

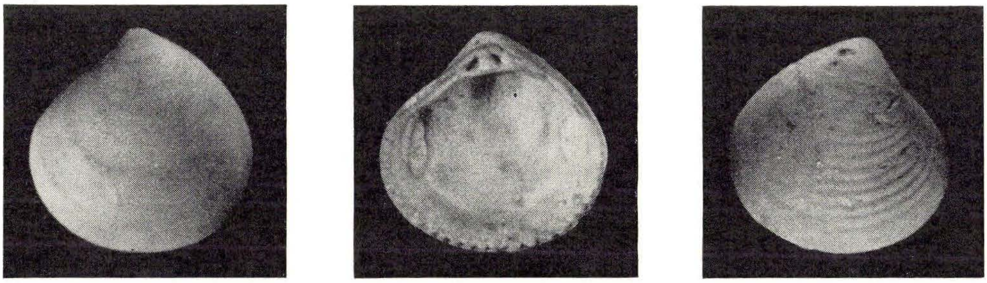
Diagnosis: A *Goodallia* with an oval, almost circular outline. Characters otherwise as in *G. angulata* (LEHMANN 1892, p. 230, pl. IV, fig. 8).

Derivatio nominis: esbjergensis = of Esbjerg. Named after this town, because the species characterizes the faunal assemblage previously found in the clay pits and on the beach on the southeastern outskirts of the town and later found in the upper Gram Clay at Måde Brickworks about 4 km. east of Esbjerg.

Type material. The left valve pictured in fig. 96 a, is the holotype. Locus typicus: Borehole D.G.U. File No. 113.121 at Hesselho. Depth: 56.0–65.0 m. Stratum typicum: Gram Clay. Age: Upper Miocene. Depository: Danmarks Geologiske Undersøgelse, Charlottenlund, Denmark.

Material. Gram Clay.

Skærum Mølle	Clay pit	:	4 complete r, 2 complete l, 1 def. r, 1 def. l.	(5)
Lillelund	73.88	28.5 –49.5 m.:	2 l, 1 d	(2)
–	–	49.5 –62.0 m.:	2 l	(2)



a b c

Fig. 96. *Goodallia esbjergensis nov. sp.* Locality: Hesselho. 113. 121. 56.0–65.0 m. Gram Clay.
a) Left valve. × 15.8. Dimensions. Length: 1.9 mm. Height: 1.9 mm.
b) and c) Right valve. × 13.6. Dimensions. Length: 2.2 mm. Height: 2.1 mm.

Phot. Chr. Westergaard

Aulum	74.321	10.4 –11.4 m.:	1 fragm.	(1)
–	–	11.4 –12.4 m.:	1 def. l	(1)
–	–	13.4 –14.4 m.:	1 def. r, 1 def. l	(1)
Kjærgårde	83.210	3.0 –15.0 m.:	1 def. r	(1)
Spjald	83.127	2.6 –15.0 m.:	1 def. l	(1)
Randbæk	83.591	3.8 –15.0 m.:	1 def. r, 1 def. d	(2)
Brejning Kro	83.197	40.5 m.:	1 def. r, 1 def. l, 1 fragm.	(1)
–	–	42 –45 m.:	1 complete r, 1 complete l	(1)
Muldbjerg	83.1006	6.0 – 7.0 m.:	1 complete r, 3 complete l, 13 def. r, 12 def. l, 1 complete d	(15)
–	–	7.0 – 8.0 m.:	1 complete r, 3 complete l, 6 def. r, 9 def. l, 3 fragm.	(12)
–	–	8.0 – 9.0 m.:	5 def. r, 5 def. l	(5)
–	–	9.0 –10.0 m.:	1 complete r, 1 complete l, 3 def. r, 2 def. l, 1 fragm.	(4)
Kodal-Fjaldene	84.1749	17.55–18.55 m.:	1 complete l, 8 def. r, 6 def. l	(8)
–	–	18.55–19.55 m.:	1 complete r, 1 complete l, 6 def. r, 9 def. l	(10)
–	–	19.55–20.55 m.:	1 complete l, 5 def. r, 2 def. l	(5)
–	–	20.55–21.55 m.:	1 complete d, 1 complete l, 2 def. r	(3)
–	–	21.55–22.55 m.:	2 def. r, 1 def. l	(2)
–	–	22.55–23.55 m.:	1 complete r, 1 complete l, 1 def. r, 2 def. l	(3)
Videbæk	84.1748	22.95–23.95 m.:	1 complete r, 1 def. r, 1 def. l	(2)
–	–	23.95–24.95 m.:	1 complete r, 9 def. r, 13 def. l	(2)
–	84.344	5.6 –15.0 m.:	4 complete r, 3 complete l, 2 def. r, 6 def. l, 1 complete d	(10)
–	84.358	7.2 –15.1 m.:	13 complete r, 8 complete l, 2 complete d, 16 def. r, 34 def. l, 3 fragm.	(44)
–	84.417	2.2 –15.0 m.:	2 complete r, 2 complete l, 1 def. r	(3)
–	84.456	2.2 –15.0 m.:	1 complete r, 2 complete l, 1 def. r, 1 def. l	(3)
–	84.483	2.0– 10.8 m.:	1 complete r, 1 complete l, 4 def. r, 2 def. l	(5)

Videbæk	84.492	5.1 –15.5 m.:	2 complete r, 7 complete l, 3 def. l (10)
–	84.1727	9.4 –10.4 m.:	1 complete l, 3 def. r, 2 def. l (3)
–	–	10.4 –11.4 m.:	3 complete r, 4 complete l, 12 def. r, 27 def. l, 5 fragm. (26)
–	–	11.4 –12.4 m.:	3 complete r, 3 complete l, 22 def. r, 23 def. l, 2 def. s (27)
Møltrup Brickworks		Clay pit	10 complete r, 8 complete l, 34 def. r, 37 def. l, 5 fragm. (49)
Ll. Torup	85.379	16.8 –20.0 m.:	1 complete l (1)
Gjødstrup	85.861	51.0 – m.:	1 complete r, 1 def. r, 1 def. l, 1 def. s (2)
–	–	57.0 m.:	1 def. l (1)
Snejbjerg	85.775	28.25–29.25 m.:	1 complete l (1)
–	–	29.25–30.25 m.:	1 def. l (1)
Bording	86.177	3.2 – 9.8 m.:	1 def. r (1)
Brande Brickworks		Clay pit	1 complete l (1)
Drantum	104.1241	36.0 –40.0 m.:	1 def. l (1)
–	–	46.0 –50.0 m.:	1 r, 1 l (2)
–	–	51.4 –51.8 m.:	1 complete r, 18 def. r, 1 complete l, 18 def. l (19)
Nyholm	104.1166	17.2 –18.2 m.:	1 complete r (1)
Store Langkjær	104.1158	12.1 –13.1 m.:	2 def. r (2)
Hjortsballe	105.320	3.4 – 8.2 m.:	1 def. l (1)
Skjerrisgårde	104.1165	11.5 –12.5 m.:	1 def. r, 1 def. l, 2 fragm. (1)
Leding	93.155	16 –17 m.:	2 def. s (2)
Alkærsig Brickworks		Clay pit	1 complete r, 1 complete l, 1 complete d, 2 def. r, 1 def. l (5)
–	93.101	9.0 m.:	1 def. r, 1 def. l (1)
–	–	10.00 m.:	1 def. l (1)
Lønborg	102.55	6.3– 7.3 m.:	2 def. r (2)
Odderup	103.150	14.5–20.0 m.:	1 complete d, 2 complete l, 8 def. r, 2 def. l (10)
–	–	20.0 –21.0 m.:	1 complete r, 2 complete l, 9 def. r, 23 def. l (25)
Hesselho	113.121	50.0 –56.0 m.:	14 r, 15 l (15)
–	–	56.0 –65.0 m.:	60 r, 55 l, 6 d (66)
Hauge		Clay pit	29 complete r, 100 def. r, 27 complete l, 108 def. l, 3 def. d, 16 def. s (146)
Tønding		Clay pit	8 def. r, 12 def. l (14)
Hodde	113.33a	9.0 –10.0 m.:	6 complete r, 3 complete l, 1 complete d, 6 def. r, 5 def. l (13)
Esbjerg. The beach and the old brickworks pit:			1 complete r, 1 complete l, 1 def. r (3)
Måde Brickworks. Eastern clay pit:			7 complete r, 26 def. r, 9 complete l, 21 def. l, 1 def. d, 1 fragm. (37)
Hjerting	141.238	20.2 m.:	1 complete l, 1 fragm. (1)
Hjortvad	141.178	15.1 –20.1 m.:	2 def. r, 2 def. l (2)
Hygum	141.260	12 –40 m.:	7 complete r, 19 def. r, 12 complete l, 28 def. l (40)
Rødding	141.75	16.75–25.60 m.:	1 complete r, 2 def. l (3)
Gram	141.277	13.10–13.50 m.:	1 def. r, 1 def. l (1)

Gram	141.277	14.00–14.60 m.:	4 complete r, 21 def. r, 1 complete l, 19 def. l, 5 fragm.	(31)
–	–	14.60–15.10 m.:	18 complete r, 35 def. r, 11 complete l, 38 def. l, 1 complete d, 8 fragm.	(54)
–	–	15.10–15.55 m.:	13 complete and 55 def. r, 16 complete and 55 def. l, 11 def. s	(75)
–	–	15.55–16.00 m.:	15 complete r, 23 def. r, 6 complete l, 27 def. l, 2 fragm.	(39)
–	–	16.00–16.50 m.:	6 complete r, 28 def. r, 7 complete l, 25 def. l, 1 complete d, 2 def. s	(35)
–	–	16.50–17.00 m.:	3 complete r, 1 complete l, 3 def. l, 8 def. r, 1 def. s	(11)
–	–	17.00–17.50 m.:	11 complete r, 19 def. r, 12 complete l, 13 def. l, 2 complete d, 1 def. d	(33)
–	–	17.50–18.00 m.:	1 complete r, 1 def. r, 5 complete and 4 def. l	(9)
–	–	18.00–18.50 m.:	1 def. l	(1)
–	–	18.50–19.00 m.:	1 def. r, 1 def. l	(1)
–	–	21.00–21.50 m.:	2 def. d (pyrite casts), 1 def. s	(3)
Spandetgård	Clay pit		1 r, 1 l	(1)
Spandet	150.184	27.0 –33.0 m.:	1 def. r	(1)

Description. Shell small, comparatively solid, with a round, subcircular outline. Length = height, or a trifle greater than the height. In the case of a length of 2 mm., the length may be about 0.05 mm. greater than the height.

The ventral margin almost semicircular and anteriorly as well as posteriorly being merged into the dorsal margin in an even curve. Posteriorly, however, there may sometimes be an almost indistinct angle. The hindmost dorsal margin slightly convex. The foremost dorsal margin almost straight.

Umbo small, clearly prosogyrate.

The shell is relatively little convex.

Lunula and area rather indistinct, oblong lanceolate.

Exterior smooth, with more or less distinct growth lines; sometimes with slightly concentric folds, which, however, are visible only on certain parts of the surface of the shell.

The hinge on the right valve has a somewhat obliquely placed, prominent, cardinal tooth (3b), which as a rule is triangular, often, however, indistinctly, situated immediately under the umbo. In front of and behind the tooth there are deep triangular pits. The front lateral tooth (AI) is long and narrow and sharp-edged, parallel to the dorsal margin and separated from it by a narrow, deep groove. The posterior lateral tooth (P III) is not separated from the dorsal margin, but rises as a sharp, narrow edge.

The hinge of the left valve has a triangular pit under the umbo. The foremost cardinal tooth (2a) is triangular, obliquely placed and projecting, separated from the edge of the lunula by a narrow groove. The hindmost cardinal tooth (2b) of the same size and shape as the foremost cardinal tooth, but retroverse, separated from the edge of the area by a narrow groove. The hindmost lateral tooth narrow, thin, edge-shaped, separated from the dorsal margin by a narrow groove. The foremost lateral tooth is lengthy, sharp-edged, and forms the dorsal margin. On some valves a short groove is seen under it.

The inside is smooth. The adductor impressions are distinct and situated under the hinge-lines anteriorly and posteriorly. They are both, if anything, reniform and almost the same size. The pallial line is parallel to the ventral margin. This is either smooth or crenulated. At a length of shell of 2 mm. about 28 notches on the crenulated valves.

Measurements. Most shells are about 2 mm. long and of the same height. Their thickness is about 0.8 mm. (Measured as the shortest distance between the point of the exterior most distant from the dorso-ventral plane and this plane, immediately ventrally to the hinge).

Excamples of dimensions:

Locality	Valves	Length	Height	Thickness
Gram 141.277				
16.00–16.50 m.	r	2.1 mm.	2.1 mm.	0.8 mm.
–	l	2.1 –	2,1 –	0.9 –
–	l	1.8 –	1.8 –	0.7 –
Hesselho 113.121				
56.0–65.0 m.	l	1.9 –	1.9 –	0.8 –
–	r	2.2 –	2.1 –	0.8 –
Alkærsig				
The clay pit.	d	2.9 –	2.8 –	1.7 –
Videbæk 84.344				
5.6–15.0 m.	r	2.0 –	2.0 –	
–	r	2.1 –	2.2 –	
Videbæk 84.483				
2.0–10.8 m.	l	1.9 –	2.0 –	
Videbæk 84.492				
5.1–15.5 m.	l	2.1 –	2.1 –	

Remarks. G. esbjergensis has a very constant ratio between length and height in all localities and is clearly more circular than *G. triangularis* (LEHMANN), of which, however, it may prove to be a subspecies.

The population in the borehole D.G.U. File No. 167.445 at Sæd from a depth of 90.30 to 94.75 m. seem to be more oval. As this form has not been observed in a single one of the other localities a special subspecific name is used for the shells from Sæd in what follows: *G. esbjergensis pseudo-ovata.* Probably the deviation from *G. esbjergensis* sensu stricto is too small for the setting up of a special subspecies, as it only consists in the inconsiderably, but perceptibly longer and more slightly convex form.

The material comprises:

90.30–91.00 m.:	21 def. r, 30 def. l, 2 fr.	(30)
91.00–91.50 –	: 144 def. l, 112 def. r, 4 complete l, 1 complete r, 16 fr.	(148)
91.50–91.75 –	: 56 def. r, 42 def. l, 2 complete r	(58)
91.75–92.00 –	: 52 def. r, 52 def. l, 3 complete r, 3 complete l, 34 fragm.	(55)
92.00–92.25 –	: 121 def. r, 114 def. l, 4 complete l, 4 complete r, 35 fr., 1 def. d	(126)
92.25–92.70 –	: 117 def. r, 100 def. l, 3 complete r, 2 complete l, 6 fr.	(120)
92.70–93.00 –	: 4 def. r, 10 def. l	(10)
93.00–93.70 –	: 1 def. r, 1 def. l	(1)
93.70–94.10 –	: 2 def. r	(2)
94.10–94.75 –	: 1 def. r	(1)

Measurements.

Depth interval:		Length:	Height:	Thickness:
91.00–91.50 m.	l	2.0 mm.	1.9 mm.	0.4 mm.
–	l	1.2 –	1.1 –	0.3 –
–	l	1.0 –	0.9 –	0.3 –
–	r	1.0 –	0.9 –	0.3 –
–	l	0.9 –	0.8 –	0.2 –
91.50–91.75 –	r	1.0 –	0.9 –	0.3 –
91.75–92.00 –	r	2.0 –	1.9 –	0.6 –
–	r	1.7 –	1.6 –	0.4 –
–	l	1.3 –	1.2 –	0.3 –
–	l	1.1 –	1.0 –	0.3 –
–	r	2.1 –	2.0 –	0.6 –
92.00–92.25 –	l	3.2 –	2.9 –	1.0 –
92.25–92.70 –	r	2.4 –	2.2 –	0.8 –
–	l	2.1 –	2.0 –	0.7 –
–	l	2.2 –	2.0 –	0.7 –

The difference between length and height amounts to 0.1 mm. and sometimes 0.2 mm., in the largest of the shells 0.3 mm. In *G. esbjergensis* sensu stricto this difference is mostly 0 or only 0.1 mm. The shells of the latter form are distinctly more convex.

Distribution. North Sea Basin. Miocene. Denmark: Gram Formation.

SCAPHOPODA

Familia: *Siphonodentaliidae*
Genus: *Siphonodentalium* M. SARS 1859.
Type: *Dentalium vitreum* M. SARS 1851 (non GMELIN 1791 = *D. lobatum* SOWERBY 1860).

Siphonodentalium cf. lobatum (Sowerby 1860).

?1878. *Siphonodentalium vitreum* M. SARS – G. O. SARS, Norges arkt. Fauna, p. 103, Pl. 7, f. 2a–c.
1882. *? Cadulus subfusiformis* SARS – v. KOENEN, Mioc. Nordd. II, p. 327.
1930. *Cadulus (Gadila) gadus* MONT. – STAESCHE, Zur Gliederung, p. 65.

1956. *Cadulus (Gadila) gadus* (MONTAGU) – RASMUSSEN, South Jutland, p. 49, Pl. III, f. 3.
?1959. *Siphonodentalium lobatum* (SOWERBY) – MUUS, Skallus, Søtænder, Blæksprutter, p. 61, f. 35 (p. 60).

Material. Hodde Clay.

Leding.				
93.155.	19 –27	m.:	? 1 fragm.	(1)
– –	27 –28	– :	? 3 –	(2)
– –	31	– :	? 4 –	(3)
Gram.				
– 141.277	26.0 –26.5	– :	? 1 –	(1)
– –	27.0 –27.5	– :	? 6 –	(2)
– –	27.5 –28.0	– :	? 3 –	(1)
Gram.				
– 141.277	28.0 –28.5	m.:	? 2 fragm.	(1)
– –	28.5 –29.0	– :	? 4 –	(1)
– –	29.0 –29.5	– :	? 8 –	(2)
– –	30.0 –30.5	– :	? 1 –	(1)
Hajstrup.				
	194′–214′:		? 1 –	(1)
	214′–234′:		? 2 –	(1)

All the fragments from the Hodde Clay are very small, the determination therefore is uncertain. (Listed in Tables 5, 10, and 12 as *?Cadulus gadus*).

Gram Clay.

Aulum.				
– 74.321	11.4 –12.4	m.:	1 fragm.	(1)
– –	12.4 –13.4	– :	1 –	(1)
Brejning Kro.				
– 83.197	42 –45	– :	1 –	(1)
Muldbjerg.				
– 83.1006.	5.0 – 6.0	– :	5 –	(2)
– –	8.0 – 9.0	– :	1 –	(1)
Kodal-Fjaldene.				
– 84.1749	15.6 –16.6	– :	1 –	(1)
– –	16.6 –17.6	– :	2 –	(1)
Videbæk.				
– 84.1748	14.95–15.95	– :	3 –	(1)
– –	16.95–17.95	– :	2 –	(1)
– –	23.95–24.95	– :	1 –	(1)
– 84.1727	10.4 –11.4	– :	2 –	(1)
Møltrup Brickworks.				
The clay pit:			5 –	(2)
Lille Torup.				
– 85.379	16.8 –20.0	– :	11 –	(3)
Frølund.				
– 85.383	9.2 –17.9	– :	4 –	(1)
Gjødstrup.				
– 85.861	46.0	– :	1 –	(1)
– –	52.0	– :	1 –	(1)
Snejbjerg.				
– 85.775	19.25–20.25	– :	1 –	(1)
– –	22.25–23.25	– :	1 –	(1)
Brande Brickworks. Clay pit:			162 –	(35)
Drantum.				
– 104.1241	36.0 –40.0	m.:	99 –	(35)
– –	40.0– 44.0	– :	17 –	(6)
– –	46.0 –50.0	– :	2 –	(1)
Nyholm.				
– 104.1166	4.2 – 5.2	m.:	2 fragm.	(1)
– –	5.2 – 6.2	– :	4 –	(2)
– –	8.2 – 9.2	– :	4 –	(2)
– –	10.2 –11.2	– :	2 –	(1)
– –	11.2 –12.2	– :	1 –	(1)
– –	12.2 –13.2	– :	2 –	(1)
– –	14.2 –15.2	– :	1 –	(1)
– –	15.2 –16.2	– :	2 –	(1)
– –	18.2 –19.2	– :	1 –	(1)
– –	22.6 –23.5	– :	4 –	(2)
Store Langkjær.				
– 104.1158	10.1 –11.1	– :	1 –	(1)
Skjerrisgårde.				
– 104.1165	8.5 – 9.5	– :	1 –	(1)
Leding.				
– 93.155	16 –17	– :	1 –	(1)
Alkærsig Brickworks.				
Clay pit:			1 –	(1)
Lønborg.				
– 102.55	7.3 – 8.3	– :	1 –	(1)
Odderup.				
– 103.150	14.5 –20.0	– :	13 –	(3)
– –	20.0 –21.0	– :	3 –	(2)
Harkes Brickworks. Clay pit:			7 –	(2)
Stenderup.				
– 113.36	18.0 –23.1	m.:	1 –	(1)
Aalbæk Eng.				
– 102.59	21.8 –22.8	– :	2 –	(2)
– –	22.8 –23.8	– :	2 –	(2)
– –	23.8 –24.8	– :	1 –	(1)
– –	24.8 –25.8	– :	1 –	(1)

Hesselho.					
– 113.121	44.0 –50.0	m.:	8	fragm.	(3)
– –	50.0 –56.0	– :	1	–	(1)
Hauge. Claypit:			11	–	(3)
Tønding. Claypit:			14	–	(3)
Måde Brickworks.					
Eastern claypit: 1 shell,			5	–	(6)
Tiset.					
– 141.244	15.0 –43.5	– :	2	–	(1)
Holleskov.					
– 132.46b	4.9 –11.2	– :	241	–	(34)
Ravning. Clay pit:			11	–	(4)
Hjortvad.					
– 141.178	7.6 –10.2	– :	2	–	(2)
– –	10.2 –15.1	– :	2	–	(2)
– –	20.1 –23.1	– :	2	–	(1)
– –	28.1 –33.1	– :	1	–	(1)
Lintrup.					
– 132.140	3.25– 3.75	– :	1	–	(1)
– –	3.75– 4.8	– :	2	–	(1)
– –	9.8 –14.8	– :	8	–	(3)
– –	14.8 –19.8	– :	1	–	(1)
– –	19.8 –24.8	– :	1	–	(1)
Hygum.					
– 141.170	17.6 –18.0	– :	29	–	(10)
– 141.260	12 –40	– :	20	–	(5)
– 141.261	13 –19	– :	431	–	(90)
– –	20	– :	131	–	(27)
– 141.273	45	– :	1	–	(1)
Rødding.					
– 141.76	28.35–37.15	– :	5	–	(1)
– 141.242	19	– :	10	–	(2)
– 141.243	20	– :	2	–	(1)
Vester Lindet.					
– 141.246	30.9	– :	11	–	(2)
– –	36.8	– :	1	–	(1)
– –	43.2	– :	2	–	(1)
Gram.					
– 141.277	5.30– 5.70	– :	166	–	(35)
– –	5.70– 6.10	– :	196	–	(42)
– –	6.10– 6.40	– :	138	–	(28)
– –	6.40– 6.90	– :	54	–	(11)
– –	6.90– 7.30	– :	89	–	(18)
– –	7.30– 7.65	– :	63	–	(14)
– –	7.65– 8.05	– :	76	–	(16)
– –	8.05– 8.50	– :	48	–	(9)
– –	8.50– 9.00	– :	32	–	(7)
– –	9.00– 9.50	– :	32	–	(7)
– –	9.50– 9.90	– :	57	–	(11)
– –	9.90–10.30	– :	18	–	(6)
– –	10.30–10.80	– :	25	–	(5)
Gram.					
– 141.277	10.80–11.25	m.:	25	fragm.	(5)
– –	11.25–11.65	– :	18	–	(4)
– –	11.65–12.10	– :	17	–	(4)
– –	12.10–12.60	– :	37	–	(8)
– –	12.60–13.10	– :	31	–	(7)
– –	13.10–13.50	– :	19	–	(7)
– –	13.50–14.00	– :	33	–	(7)
– –	14.00–14.60	– :	41	–	(8)
– –	14.60–15.10	– :	27	–	(6)
– –	15.10–15.55	– :	21	–	(5)
– –	15.55–16.00	– :	12	–	(3)
– –	16.00–16.50	– :	7	–	(2)
– –	16.50–17.00	– :	6	–	(2)
– –	17.00–17.50	– :	11	–	(4)
– –	17.50–18.00	– :	7	–	(2)
– –	18.00–18.50	– :	4	–	(2)
– –	18.50–19.00	– :	4	–	(2)
– –	19.00–19.50	– :	6	–	(2)
– –	19.50–20.00	– :	5	–	(1)
– –	20.00–20.50	– :	1	–	(1)
– –	20.50–21.00	– :	1	–	(1)
– –	21.00–21.50	– :	2	–	(1)
– –	21.50–22.00	– :	1	–	(1)
– –	22.00–22.50	– :	3	–	(1)
– –	22.50–23.00	– :	1	–	(1)
– –	24.00–24.50	– :	3	–	(1)
Spandetgård. Clay pit:			400	–	(95)
Tønder.					
– 166.398	24	– :	1	–	(1)
– –	37	– :	2	–	(2)
– –	43.5	– :	3	–	(1)
– –	50	– :	4	–	(1)
– –	58.85–59.00	– :	6	–	(2)
Brodersmark.					
– 166.351b	22.6–24	– :	13	–	(5)
– –	24 –25	– :	3	–	(1)
– –	26 –27	– :	13	–	(5)
– –	27 –28	– :	9	–	(3)
– –	28 –29	– :	2	–	(2)
– –	29 –30	– :	21	–	(7)
– –	30 –31	– :	12	–	(4)
– –	31 –32	– :	8	–	(3)
Sæd Custom House.					
– 167.4	70	– :	50	–	(13)
– 167.445	90.30–91.00	– :	1	–	(1)
– –	91.00–91.50	– :	20	–	(4)
– –	91.50–91.75	– :	39	–	(8)
– –	91.75–92.00	– :	58	–	(12)
– –	92.00–92.25	– :	40	–	(8)
– –	92.25–92.70	– :	28	–	(6)

Sæd Custom House.
– 167.445 92.70–93.00 m.: 26 fragm. (6)
– – 93.00–93.70 – : 52 – (15)
– – 93.70–94.10 – : 61 – (15)
– – 94.10–94.75 – : 64 – (20)
– – 94.75–95.50 – : 42 – (13)
– – 95.50–95.90 – : 22 – (8)
– – 95.90–96.20 – : 16 – (7)
– – 96.20–96.75 – : 17 – (4)
– – 96.75–97.40 – : 49 – (10)

Sæd Custom House.
– 167.445 97.40–97.90 m.: 45 fragm. (9)
– – 94.00–97.70 – : 48 – (9)
– – 97.70–98.60 – : 25 – (6)
– – 98.60–99.05 – : 14 – (4)
– – 99.05–99.55 – : 10 – (3)
– – 99.55–100.10– : 15 – (4)
Rends.
– 167.236 140′–160′ : 316 – (67)

Description. Shell small, arched, more or less highly increasing in diameter from the apical to the apertural end, with a circular or almost circular section.

The curvature of the shell is sometimes rather great. The margin of the apical end is protracted into six lobes, which are rounded off, but mostly broken off. On shells with a more oval section the apertural end seems a very little tumid. The surface is smooth and glistening. The growth lines are very slightly indicated, but sometimes are underlined by coloured zones, which are more or less brownish in contrast to the otherwise white shell. These zones seem to be a little oblique in relation to the axis of the shell.

Remarks. This small scaphopod in the great majority of cases is available as incomplete shells and fragments.

Previously the shells from the Gram Clay were referred to *Cadulus gadus* (MONTAGU 1803), as some of the fragments seemed to have a swelling, although somewhat slighter than in the shells in the Arnum Formation. This fact was pointed out by me in 1956, but still the determination to *C. gadus* by the early authors was retained. However, the shells and the fragments have a distinctly wide apertural end as compared with the apical end, just as any swelling proper is out of the question. Furthermore, many of the shells show a more or less well-preserved apical end with lobes, corresponding to conditions in *Siphonodentalium.*

The number of these lobes is in agreement with the number of lobes in *S. lobatum* (SOWERBY 1860) = *S. vitreum* M. SARS 1851. The shells from the Gram Clay therefore, with reservation, are referred to this recent species.

At the present time *Siphonodentalium* seems to be connected with a clayey or muddy bottom at depths of 100–3000 m.

Distribution. ? North Sea Basin. Miocene. Denmark: ? Hodde Formation, Gram Formation.

Atlantic Basin: The marine Quaternary strata of Norway (W. C. BRØGGER 1900–01). Recent distribution from Novaya Zemlya, the coasts of Northern Norway, Spitsbergen, Western Norway, the Norwegian Sea, the waters around Iceland, the Faroes, the Shetland Islands, the British Isles down to the coasts of Portugal. Furthermore, in the Western Atlantic near East and West Greenland, and near the East coast of North America (MUUS).

GASTROPODA

ORDO: MESOGASTROPODA

Familia: *Nassariidae*

Genus: *Nassa* LAMARCK 1799

Type: *Buccinum reticulatum* LINNÉ 1758.

Nassa slieswicia nov. sp.

1934. *Nassa granulata* SOW. var. *gracilis* HARM. – ØDUM, Mar. Pliocæn, p. 361, f. 1a, b.
1958. *Nassa cfr. granulata* (J. SOWERBY) – RASMUSSEN, Sæd, p. 10, Pl. II, f. 2a, b, 6.

Diagnosis. A comparatively large *Nassa*[1] with rather a large apical angle. The sculpture consists of about 4–6 spiral ribs, which cross 13–20 slightly obliquely placed collabral ribs of nearly the same width. The last whorl comparatively large.

Type material. The shell pictured in RASMUSSEN 1958, Pl. II, f. 2 (a, b) is the holotype. Depository: Danmarks Geologiske Undersøgelse, Charlottenlund, Denmark. Type locality: Sæd Custom-house. Borehole: D.G.U. File No. 167.4a. Depth of finding stated: 70–82.5 m.

Derivatio nominis: Slieswicia = from S., the earliest recorded name of the town of Slesvig, used by ADAM OF BREMEN in his "Gesta Hammaburgensis ecclesiae pontificium" from about 1075. Used here to denote the Danish province of Slesvig.

Material. Gram Clay. Sæd. 167.4a. 70–82.5 m.: 36 shells, numerous fragments. 167.445. 91.75–93.70 m.: Numerous fragments. See Table 65, p. 282.

Siderite oolite. Sæd. 167.4a. 70–82.5 m.: 2 shells, many fragments.

Description. This species has previously (but only in Danish) been described in RASMUSSEN (op cit.). This description will be repeated here in a slightly changed form.

The shell is rather large, ovoid, with rather a pointed apex. The protoconch is conic, multispiral, comprising 2–2½ smooth, highly convex whorls. The teleoconch has up to 5 convex whorls, with a spiral and collabral sculpture of almost the same strength. On several shells, however, the spiral sculpture is the most marked. The spiral ribs are found in a number of 4–6 per whorl, 5, however, apparently being the rule. The ribs are of almost the same breadth as the intervals between them. The spiral rib immediately below the adapical suture is often weaker than the 3–4 equally prominent ribs situated in the middle of the whorl, while the spiral rib immediately above the abapical suture is often the

[1] The genus name *Nassa* is used throughout in this paper in spite of the fact that I soon after finishing the manuscript was convinced that the valid name at present is *Hinia* (LEACH in) GRAY 1847. This genus name has, however, been used in the diagrams figs. 100 and 101 p. 303 and 306.

weakest of all of them. On the last whorl there are 11–20 spiral ribs. A few of these, however, must, if anything, be considered as spiral ribs of the second order. The collabral sculpture consists of ribs, which are narrower than the intervals between them, often nearly half as broad. They are placed a little obliquely and of nearly the same strength during their whole course. On the older whorls about 13–14 ribs and on the younger ones 19–20. On the last whorl there are 20–30 collabral ribs, which as a rule only disappear on the abapical part of the base. Aperture oval. Labrum thickened, on the inside with 8–10 list-shaped teeth. Labium rather narrow, spreading over a small part of the base as a well-defined callus.

Remarks. ØDUM as well as RASMUSSEN compare this species with *N. granulata* (J. SOWERBY 1818) from the Pliocene beds of England, Holland, and Belgium. The former author without reservation refers the shells from the siderite oolite to *var. gracilis* HARMER. The similarity to the figure in HARMER (1914, Pl. V, f. 3) of this subspecies is fairly great, while the other subspecies and the typical form, of which last-mentioned form there is a picture in RASMUSSEN (op. cit., Pl. II, f. 5) of a shell in the collection of D.G.U., differs conspicuously from the shells from Sæd. As emphasized in 1958 the more or less pronounced coarseness of the sculpture may be connected with the character of the sediment in which the animal lived. Forms which stay in the littoral zone on sandy or gravelly bottom, as is well-known, develop thicker shells with a coarsened sculpture, whereas forms which live on muddy bottom maintain a finer sculpture. As the English crag formations are coarse-grained and the Mica Clay at Sæd is very fine-grained and argillaceous, it will not be unnatural if there are essential differences in the degree of fineness of the sculpture in the same species in the two regions. However, more thorough comparative studies on the relation of the Sæd forms to *N. granulata* are needed before identity or non-identity can be decided with certainty. For the time being I therefore regard the species from Sæd as new.

Distribution: North Sea Basin. Miocene. Denmark: Gram Formation.

Genus: *Neoguraleus* POWELL 1939.
Type: *Drillia sinclairi* GILLIES.

Neoguraleus sæthensis nov. sp.

1958. *Daphnella tenella* MAYER; RASMUSSEN, Sæd, p. 13, Pl. I, f. 7.

Diagnosis. A *Neoguraleus* with rather a small apical angle and 5–6 rather prominent narrow spiral ribs which pass over 12–14 rather narrow collabral ribs. No adapical depression.

Holotype. The shell pictured in RASMUSSEN 1958, Pl. I, f. 7, is the holotype. Locus typicus: Sæd. 167.4. Depth: 70–82 m. Stratum typicum: Gram Clay.

Age: Upper Miocene. Depository: Danmarks Geologiske Undersøgelse, Charlottenlund, Denmark.

Derivatio nominis. Named after the village Sæd, south of Tønder (North Slesvig, Denmark), first (1237) recorded as Sæth, near which two borings have been made from which the material of this species has been obtained.

Material. Gram Clay.

Sæd.	167.4.	70 –82 m.	: 2 shells
–	167.445.	91.50–91.75 –	: 1 shell
–	–	91.75–92.00 –	: 1 shell
–	–	92.00–92.25 –	: 2 shells
–	–	92.25–92.70 –	: 1 shell

Description. Shell small, slender, fusiform.

The protoconch fairly large in relation to the rest of the shell, comprising 2–3 highly convex whorls. The initial whorl slightly sinistral, downwards (abapically) bent, smooth. The medial whorl likewise smooth. Terminal whorl with opisthocyrt, filiform collabral ribs (number: 15–20), which are crossed by 4–5 spiral threads parallel to the sutures. The distances between the collabral ribs as well as the spiral ribs between them are nearly equally great.

Whorls of the teleoconch moderately convex with a spiral ornamentation comprising 5–6 narrow, but prominent ribs, between which there are 1, 2, or 3 very faint spiral threads. On the last whorl and its ramp towards the neck of the canal, and on this neck, there are up to 20 narrow spiral ribs, between which, in agreement with the sculpture on the rest of the whorls of the teleoconch, there are 1–3 faint spiral threads. The collabral sculpture comprises 12–13 vigorous ribs, which are somewhat narrower than their intervals and often somewhat arched adapically, as their course is conformal with the growth lines. These have their sinus situated a little adapically to the middle of the whorls and are often just as prominent as the faint spiral threads between the main spirals. Because of the crossing between these equally vigorous threads and the disintegration into small, faint nodes due to it, we mainly see numerous such nodes in a regular arrangement in the intervals between the main spirals and the collabral ribs. The spiral ornamention passes over the collabral ribs, but is often weakened somewhat by the passage.

Labrum sharp-edged, simple. Labium smooth, well-defined towards the neck of the canal and but little spread over it. Aperture elongate-oval, passing evenly into the short, rather broad canal.

Remarks. This species has previously (1958, loc. cit.) by me been referred to *Daphnella tenella* MAYER, from which, however, it differs by not having any carina and by having the main spiral ribs distributed equally all over the whorl.

N. tenella has 4–6 spiral ribs on the carina and the abapical part of the whorl (see further SORGENFREI 1958, pp. 279–281, Pl. 59, f. 199a–b, Pl. 61, f. 199).

N. calais (KAUTSKY) has the same slender form and regularly convex whorls as *N. sæthensis*, but has numerous dense, faint spiral threads on the surface of the whorls of the teleoconch (concerning the species see KAUTSKY 1925, p. 187, Pl. 12, f. 13–14 and SORGENFREI 1958, pp. 278–279, Pl. 59, f. 198a–c).

N. kochi (v. KOENEN) differs from *N. sæthensis* by having a carina, by the fact that the whorls of the teleoconch are covered by numerous dense, faint spiral threads and by having a slightly wider apical angle.

Measurements.

	Length	Diameter of the shell	Length	Diameter of the protoconch	Length of aperture
Sæd. 167.4a	2.8 mm.	1.3 mm.	0.6 mm.	0.7 mm.	1.3 mm.
– –	4.7 –	1.9 –	0.7 –	0.7 –	2.1 –

Distribution. North Sea Basin. Miocene. Denmark: Gram Formation.

BIOSTRATIGRAPHY

The chief purpose of the present investigations, as mentioned in the introduction to the Geological Part, is a biostratigraphical evaluation and a possible classification of the Younger Miocene clay series in Denmark, based on the molluscan faunas. The investigations, however, have also been supplemented by an analysis of the faunas found in the upper marine beds under the clay series. Such a continuous marine series has only been found in a very few localities known, and of these even only two have supplied statistically sufficient material, viz. the localities at Hoddemark (the slopes of the Karlsgårde Canal and the borehole "Hodde I", D.G.U. File No. 113.33a) and a borehole at Enderupskov (D.G.U. File No. 141.196).

Method

At the analyzing of the molluscan faunas all determinable as well as all indeterminable forms are entered in a list and the number of individuals stated. The greater part of the material, especially from the large number of boreholes, consists of fragments only (cf. figs. 97, 98, and 99).

In the case of the pelecypoda all complete valves and all defective shells with hinges preserved, and all fragments comprising the umbo part, have been counted as half an individual. In a number of cases, however, a division into right and left valves has been made. The number of shells in the group in which the largest number was found, then has determined the number of individuals. If the material has yielded characteristic fragments, without remnants of the hinge region, of species which have not been demonstrated in the material of the fragments with parts of the hinge region, only a single whole individual has been counted.

In the case of the scaphopoda no complete specimen has been found, but

Fig. 97. Molluscan assemblage sorted out from wash residue of silty Gram Clay. Locality: Sæd. 167.445. Depth: 92.00–92.25 m. Fraction 2. × 5

Phot. Chr. Westergaard

Fig. 98. Molluscan assemblage sorted out from wash residue of Gram Clay. Locality: Gram. 141.277. Depth: 7.65–8.05 m. Fraction 2. × 5

Phot. Chr. Westergaard

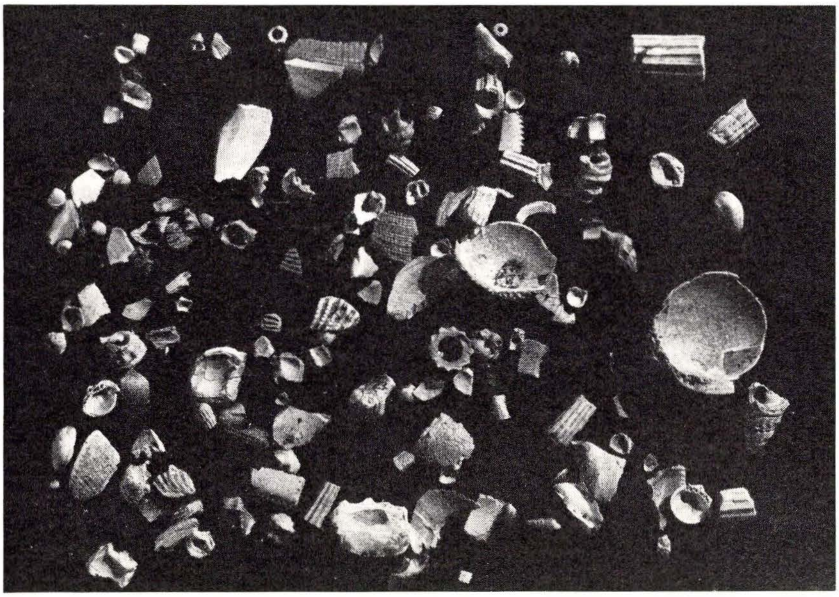


Fig. 99. Molluscan assemblage sorted out from wash residue of Hodde Clay. Locality: Gram. 141.277. Depth: 33,05–33,40 m. Fraction 2. × 5

Phot. Chr. Westergaard

only larger or smaller fragments. Mostly these are but small. In such cases there has been an estimated count of five fragments per individual. The basis of the number of individuals thus in the case of this group of molluscs is to a higher degree due to an estimate than is the case in the other two groups.

As regards the gastropoda all complete shells and all fragments with a preserved protoconch have been counted as individuals. Besides there are occasionally characteristic fragments of shells which do not belong to any of the other species. These fragments have also been included, but only counted as a single individual if no special conditions make it probable that there are more.

In certain cases the number of individuals thus has been estimated, if it has not been possible to verify it on the basis of the fragments available. However, the truth can hardly be far from the figures stated, and the small oscillations which, of course, there must be in both directions, presumably almost cancel out.

Besides the number of individuals the percentage representation of the various species in the available molluscan fauna is stated in several of the lists of analysis.

The main purpose of the analyses is partly to create a background to an estimate of the special characters of the various faunas by means of the dominant species, partly so accurate a characterization as possible of the composition of species in the fauna preserved. The former method forms the basis of a quantitative, the latter of a qualitative evaluation of the faunas. In what follows, great importance has been attached to a distinction between these two points of view.

The quantitative investigations constitute the chief basis of the setting-up of the assemblage zones mentioned in the following sections of the paper.

In agreement with the Statement of Principles of Stratigraphic Classification and Terminology (see HEDBERG, ed. 1961, p. 22) I understand by *assemblage zone* "the body of strata characterized by a certain natural assemblage or association of fossil forms." The term assemblage zone is identical with the expression *faunizone* (see TROELSEN & SORGENFREI 1956, p. 149).

The assemblage zones are named after one or two of the most characteristic or dominant species of the molluscan assemblages in question.

The Marine Deposits immediately below the Hodde Clay

Rich faunas of molluscs have in several places been found in the marine strata under the Hodde Formation. Most of these belong in the Arnum Formation, the faunas of which in other localities in Jutland have been discussed thoroughly by TH. SORGENFREI (1958).

In the slopes of the canal and the boreholes at Hoddemark (see p. 98) there are not only shell beds with the assemblages of the Arnum Formation, but at the base of the Hodde Clay there is also a shell bed which contains an assemblage of molluscs which has been shown to occur in very few other places in Denmark. The locality at Hoddemark therefore is especially suitable to throw light on the development of faunas from the Arnum Formation to the Hodde Formation. Before the result of the analyses of the faunas in the Younger Miocene clay series are represented and evaluated, the various shell beds at Hoddemark will be mentioned in some detail, the more so as in this way we shall have an opportunity to follow the fauna development from the strata of the Arnum Formation described by SORGENFREI to the strata of the clay series.

I. The Molluscan Faunas of the Arnum Formation in the Hoddemark Section

1. Shell Bed III (+ IV) at Hoddemark

Fauna analysis.

The basis of the analysis of Shell Bed III (+ IV) (see p. 100) is constituted by a sample ("Sample No. 36") taken in situ from the shell bed. Its weight was 258.5 g. and its volume about 260 cu. cm. In Table 1 those species are also listed which are found in my private collection from Shell Bed III, and from a destroyed bed very close to the finding-place of Shell Bed III. The two places from which my collections originate, have been named Locality 1 and Locality 2.

Table 1. **Shell Bed III (+ IV) Hoddemark**

		Shell Bed III Sample 36		Private collections	
		Number	Percentage	Locality 1	Locality 2
1.	*Nucula cf. nucleus* (LINNÉ)	1	0.03	+	+
2.	*Nuculana pygmaea* (MÜNSTER)	160	4.91	+	+
3.	*Nuculana westendorpii* (NYST & W.)	1	0.03	.	+
4.	*Nuculana emarginata* (LAMARCK)	.	.	+	+
5.	*Yoldia glaberrima* (MÜNSTER)	32	0.98	+	+
6.	*Arca diluvii* LAMARCK	1	0.03	.	+
7.	*Pecten cf. brummelii* NYST	.	.	.	+
8.	*Kellyella rotunda* SORGENFREI	2	0.06	+	.
9.	*Laevicardium sp.*	2	0.06	.	.
10.	*Cardium hanseatum* KAUTSKY	1	0.03	.	.
11.	*Spisula subtruncata* (DA COSTA)	6	0.18	.	+
12.	*Abra prismatica* (MONTAGU)	1	0.03	.	+
13.	*Saxicava arctica* (LINNÉ)	1	0.03	+	.
14.	*Varicorbula gibba* (OLIVI)	519	15.91	+	+
15.	*Cadulus gadus* (MONTAGU)	13	0.40	+	+
16.	*Dentalium michelotti* HOERNES	.	.	+	.
17.	*Circulus praecedens* (KOENEN)	.	.	.	+
18.	*Putilla gottscheana* (KOENEN)	4	0.12	.	.
19.	*Alvania pseudopartschi* ANDERSON	1	0.03	.	.
20.	*Archimediella subangulata* (BROCCHI)	3	0.09	+	+
21.	*Architectonia caracollata* (LAMARCK)	.	.	+	.
22.	*Bittium tenuispina* SORGENFREI	15	0.46	+	+
23.	*Acirsa lanceolata* (BROCCHI)	1	0.03	+	.
24.	*Acrilla amoena* (PHILIPPI)	.	.	.	+
25.	*Scala frondicula* (WOOD)	1	0.03	.	.
26.	*Strombiformis taurinensis* (SACCO)	4	0.12	+	+
27.	*Niso acarinatoconica* (COSSM. PEYR)	.	.	.	+
28.	*Aporrhais alata* (EICHWALD)	137	4.20	+	+
29.	*Polinices olla* (DE SERRES)	.	.	.	+
30.	*Polinices affinis* (GMELIN)	.	.	+	.
31.	*Natica tigrina* GRATELOUP	.	.	.	+
	Naticidae indet.	134	4.11	.	.
32.	*Ficus conditus* (BRONGNIART)	.	.	+	+
33.	*Murex inornatus* BEYRICH	1	0.03	.	+
34.	*Typhis fistulosus* (BROCCHI)	3	0.09	.	+
35.	*Tritonalia coelata* (DUJARDIN)	.	.	+	.
36.	*Pyrene nassoides* (GRATELOUP)	.	.	.	+
37.	*Nassa tenuistriata* (BEYRICH)	2	0.06	+	+
38.	*Nassa schlotheimi* (BEYRICH)	201	6.16	+	+
39.	*Nassa facki* (KOENEN)	4	0.12	+	+
40.	*Nassa cimbrica* RAVN	1699	52.07	+	.
41.	*Streptochetus cf. sexcostatus* (B.)	1	0.03	.	.
42.	*Ancilla obsoleta* (BROCCHI)	1	0.03	+	+
43.	*Oliva minutissima* (KAUTSKY)	.	.	.	+
44.	*Narona cancellata* (LINNÉ)	.	.	+	.

Table 1 (continued) Shell Bed III (+ IV). Hoddemark (continued)

		Shell Bed III Sample 36		Private collections	
		Number	Percentage	Locality 1	Locality 2
45.	*Narona varicosa* (BROCCHI)	2	0.06	+	.
46.	*Admete fusiformis* (CANTRAINE)	1	0.03	.	+
47.	*Conus dujardini* DESHAYES	3	0.09	+	+
48.	*Gemmula badensis* (R. HOERNES)	1	0.03	.	+
49.	*Gemmula stoffelsi* (NYST)	1	0.03	+	+
50.	*Gemmula zimmermanni* (PHILLIPPI)	.	.	+	+
51.	*Fusiturris duchastelii* (NYST)	2	0.06	+	+
52.	*Fusiturris inermis* (HOERNES)	.	.	+	+
53.	*Bathytoma cataphracta* (BROCCHI)	1	0.03	.	+
54.	*Clavatula boreointerrupta* KAUTSKY	.	.	.	+
55.	*Clavatula obliquiplicatula* KAUTSKY	.	.	.	+
56.	*Genota ramosa* (BASTEROT)	.	.	.	+
57.	*Inquisitor borealis* (KAUTSKY)	.	.	+	+
58.	*Splendrillia selenkae* (KOENEN)	.	.	.	+
59.	*Asthenotoma pannus* (BASTEROT)	1	0.03	+	+
60.	*Brachytoma grateloupi* (PEYROT)	.	.	.	+
61.	*Brachytoma obtusangula* (BROCCHI)	2	0.06	+	+
62.	*Neoguraleus calais* (KAUTSKY)	13	0.40	+	+
63.	*Neoguraleus tenella* (MAYER)	22	0.67	+	+
64.	*Pleurotomoides johannae* (PEYROT)	.	.	.	+
65.	*Pleurotomoides simplex* SORGENFREI	.	.	.	+
66.	*Pleurotomoides campanulata* SORGENFREI	.	.	.	+
67.	*Philbertia sinuosula* SORGENFREI	.	.	.	+
68.	*Terebra hoernesi* BEYRICH	9	0.27	+	+
69.	*Acteon semistriatus* (BASTEROT)	4	0.12	+	+
70.	*Chrysallida cimbrica* (KAUTSKY)	1	0.03	.	+
71.	*Chrysallida nodifera* SORGENFREI	11	0.34	+	.
72.	*Odostomia conoidea* (BROCCHI)	1	0.03	.	+
73.	*Eulimella cf. concinna* SORGENFREI	.	.	+	.
74.	*Pyramidella plicosa* BRONN	1	0.03	.	.
75.	*Ringicula buccinea* (BROCCHI)	213	6.53	+	+
76.	*Cylichna cylindracea* (PENNANT)	.	.	+	.
77.	*Acera bellardii* (KOENEN)	.	.	.	+
78.	*Rhizorus acuminatus* (BRUGUIERE)	7	0.21	+	+
79.	*Retusa elongata* (EICHWALD)	8	0.25	+	+
80.	*Acteocina lajonkaireana* (BASTEROT)	1	0.03	+	.
81.	*Schaphander lignarius* (LINNÉ)	1	0.03	.	.
82.	*Roxania utriculus* (BROCCHI)	1	0.03	+	+
83.	*Vaginella depressa* DAUDIN	4	0.12	+	+
	In all:	3263	99.97 %		

Qualitative evaluation.

The list of species includes only forms which have previously been known from the Arnum Formation in Denmark, with the exception of *Circulus praecedens* and *Acirsa lanceolata*, which, however, both occur in the North German Hemmoor Stufe, which is paralleled to the Arnum Formation. As to the distribution of the species outside Denmark and their occurrence in the Danish localities so far described reference may be made to SORGENFREI's list of species (1958, Table 14, pp. 422–435). The specific names in my Table 1 are not always identical with the names in SORGENFREI's table, as, in certain cases, I have preferred the taxonomic terms in GLIBERT and ANDERSON, but a comparison shows that there is a distinct identity between the assemblage of species in Shell Bed III (+IV) at Hoddemark and the assemblages in the localities described by SORGENFREI.

A certain difference asserts itself between the faunas from Locality 1 and Locality 2, from which my private collections originate. This does not appear conspicuously clearly from Table 1, as the number of individuals per species is not stated, importance only being attached to collect as many different species as possible. The main difference consists in the absence of such an important species as *Nassa cimbrica* in Locality 2. Furthermore there were in this occurrence some more species of Turridae than in Locality 1. Several of these species were represented by rather large, beautiful specimens. The two localities therefore seem to contain slightly deviating assemblages of molluscs. The faunas, however, are so much alike and much like the fauna in Sample 36, that there can be no just doubt that they are all contemporaneous with the fauna of the Arnum Formation.

Quantitative evaluation.

It appears from Table 1 that the following seven species are dominant in the fauna in Sample 36:

1. *Nassa cimbrica*	52 per cent.	5. *Nuculana pygmaea*	5 per cent.
2. *Varicorbula gibba*	16 –	6. *Aporrhais alata*	4 –
3. *Ringicula buccinea*	6.5 –	7. Naticidae indet.	4 –
4. *Nassa schlotheimi*	6 –		

There is obviously a great predominance of *Nassa cimbrica*, just as *Varicorbula gibba* also plays a quantitatively great part as compared with the other species.

The molluscan assemblage therefore can be characterized as a *Varicorbula gibba-Nassa cimbrica* assemblage. A corresponding assemblage has been recorded by SORGENFREI in the Arnum Formation at Glejbjerg, Gram by, and Toftlund (see SORGENFREI 1958).

Biostratigraphical conclusion.

Shell Bed III (+ IV) at Hoddemark thus according to what precedes must be placed in the *Nassa cimbrica* species zone of the Arnum Formation (cf. SORGENFREI 1958).

2. Shell Bed II at Hoddemark and the Shell Bed in the Borehole at Enderupskov

Fauna analysis.

Shell Bed II at Hoddemark (see p. 100) mainly contains crushed and rolled shells. Only a privately collected sample has been analyzed from this bed. Because of the unsatisfactory state of preservation of the material a supplementary analysis of a smaller sample (not weighed) from the depth of 54 m. from a borehole at Enderupskov (South Jutland; D.G.U. File No. 141.196; see p. 156) has been made. As appears from the analyses and the evaluations there are so great points of similarity between the two fauna sections that it seems justifiable to discuss them under one head.

Table 2. **Shell Bed II, Hoddemark and Enderupskov, 54 m**

		Enderupskov		Shell Bed II	
		Number	Percentage	Number	Percentage
1.	*Nucula sp.*	58	4.11	10	3.5
2.	*Nuculoma hanseata* (KAUTSKY)	1	0.09	.	.
3.	*Nuculana pygmaea* (MÜNSTER)	114	9.75	5	1.8
4.	*Nuculana emarginata* (LAMARCK)	2	0.17	.	.
5.	*Yoldia glaberrima* (MÜNSTER)	19	1.63	5	1.8
6.	*Arca diluvii* LAMARCK	3	0.26	1	0.4
7.	*Ostrea sp.*	1	0.09	.	.
8.	*Kellyella rotunda* SORGENFREI	23	1.97	.	.
9.	*Kellyella patera* SORGENFREI	2	0.17	.	.
10.	*Sportella cimbrica* KAUTSKY	2	0.17	.	.
11.	*Thyasira flexuosa* (MONTAGU)	3	0.26	.	.
12.	*Codokia jutensis* SORGENFREI	2	0.17	.	.
13.	*Erycina degrangei* COSSM. & PEYR.	2	0.17	.	.
14.	*Erycina coarctata* (WOOD)	1	0.09	.	.
15.	*Laevicardium sp.*	.	.	1	0.4
16.	*Cardium hanseatum* KAUTSKY	3	0.26	.	.
17.	*Gouldia minima* (MONTAGU)	2	0.17	.	.
18.	*Ervilia pusilla* (PHILIPPI)	21	1.80	.	.
19.	*Spisula subtruncata* (DA COSTA)	145	12.40	18	5.3
20.	*Donax intermedius* (HOERNES)	1	0.09	.	.
21.	*Abra prismatica* (MONTAGU)	11	0.94	.	.
22.	*Angulus donacinus* (LINNÉ)	2	0.17	.	.
23.	*Angulus fallax* BEYRICH	1	0.09	.	.
24.	*Pharus saucatsensis* DES MOULINS	1	0.09	.	.
25.	*Saxicava arctica* (LINNÉ)	8	0.68	.	.
26.	*Varicorbula gibba* (OLIVI)	42	3.59	.	.
27.	*Lentidium donaciformis* (NYST)	6	0.51	.	.
28.	*Cuspidaria cuspidata* (OLIVI)	2	0.17	.	.
29.	*Cadulus gadus* (MONTAGU)	9	0.77	12	4.3
30.	*Archimediella subangulata* (BR.)	17	1.45	.	.
31.	*Bittium tenuispina* SORGENFREI	64	5.47	3	1.1

Table 2 (cont.) Shell Bed II, Hoddemark and Enderupskov, 54 m. (cont.)

		Enderupskov		Shell Bed II	
		Number	Percentage	Number	Percentage
32.	*Niso acarinatoconica* COSSM. & P.	1	0.09	.	.
33.	*Strombiformis taurostricta* C. & P.	1	0.09	.	.
34.	*Polinices olla* (DE SERRES)	13	1.11	.	.
35.	*Natica beyrichi* v. KOENEN	3	0.26	.	.
36.	*Natica praeclausa* KAUTSKY	39	3.34	.	.
	Naticidae indet.	.	.	23	8.2
37.	*Sigaretus sp.*	1	0.09	.	.
38.	*Ficus cf. conditus* (BRONGNIART)	.	.	1	0.4
39.	*Nassa tenuistriata* (BEYRICH)	7	0.60	12	4.3
40.	*Nassa schlotheimi* (BEYRICH)	173	14.80	46	16.3
41.	*Nassa facki* v. KOENEN	7	0.60	4	1.4
42.	*Nassa pölsense* (AUINGER)	50	4.28	19	6.7
43.	*Dorsanum boreobaccatum* KAUTSKY	2	0.17	.	.
44.	*Oliva minutissima* KAUTSKY	1	0.09	.	.
45.	*Conus sp.*	1	0.09	.	.
46.	*Gemmula stoffelsi* (NYST)	13	1.11	12	4.3
47.	*Gemmula zimmermanni* (PHILIPPI)	.	.	13	4.6
48.	*Fusiturris duchastelii* (NYST)	2	0.17	.	.
49.	*Turricula steinvorthi* (v. KOENEN)	1	0.09	1	0.4
50.	*Clavatula ursulae* (HOERN. & AUING)	5	0.43	12	4.3
51.	*Inquisitor borealis* (KAUTSKY)	1	0.09	1	0.4
52.	*Brachytoma obtusangula* (BROCCHI)	1	0.09	.	.
53.	*Neoguraleus calais* (KAUTSKY)	1	0.09	.	.
54.	*Neoguraleus tenella* (MAYER)	1	0.09	4	1.4
55.	*Terebra basteroti* NYST	2	0.17	.	.
56.	*Terebra hoernesi* BEYRICH	56	4.79	42	14.9
57.	*Acteon semistriatus* (BASTEROT)	8	0.68	.	.
58.	*Chrysallida cf. cimbrica* (KAUT.)	.	.	1	0.4
59.	*Chrysallida nodifera* SORGENFREI	2	0.17	.	.
60.	*Odostomia conoidea* (BROCCHI)	1	0.09	6	2.1
61.	*Odostomia sp.*	2	0.17	.	.
62.	*Eulimella sp.*	.	.	1	0.4
63.	*Turbonilla costellata* (GRATELOUP)	1	0.09	.	.
64.	*Ringicula buccinea* (BROCCHI)	96	8.21	9	3.2
65.	*Rhizorus acuminatus* (BRUGUIÈRE)	7	0.60	.	.
66.	*Retusa elongata* (EICHWALD)	.	.	12	4.3
67.	*Retusa umbilicata* (MONTAGU)	12	1.03	.	.
68.	*Crenilabium terebelloides* (PHIL.)	1	0.09	.	.
69.	*Roxania utriculus* (BROCCHI)	1	0.09	.	.
70.	*Spiratella atlanta* (MØRCH)	72	6.16	.	.
71.	*Clio deflexa* (v. KOENEN)	2	0.17	.	.
72.	*Vaginella depressa* DAUDIN	14	1.20	8	2.9
	In all:	1169	99.23	282	99.5

Qualitative evaluation.

Each of the analyzed samples of the shell beds constitutes only a small part as compared with the quantity analyzed from Shell Bed III (Sample 36, see above, p. 196). Thus there is no reason to attach importance to the fact that certain species have not been found in both localities. As to Shell Bed II it must be emphasized that the great majority of the shells have been crushed and rolled. Therefore, it is mainly species with resistant shells which have been left in a determinable state. The two samples cannot be compared direct, partly because of the heterogeneous state of preservation, partly because the sample of Shell Bed II represents a somewhat larger volume than the samples from Enderupskov. Unfortunately neither the volume nor the weight was measured.

Shell Bed II is also found in the borehole Hodde I at a depth of 27.3–29.3 m. The shells in this bed, however, were still more crushed than those in the section at the canal; so no analysis of the fauna has been made.

As was the case of the fauna of Shell Bed III, it is possible to make a direct comparison between the fauna of Enderupskov and the fauna from the Arnum Formation described by SORGENFREI, and then it appears that all species with the exception of the following four, have been found in this formation: *Dorsanum boreobaccatum*, *Clavatula ursulae*, *Terebra basteroti*, and *Crenilabium terebelloides*. The three of the species, however, are known from the Hemmoor Stufe in North Germany (according to KAUTSKY 1925 and DITTMER 1959). *Clavatula ursulae* has been mentioned only from the Vienna Basin by HOERNES & AUINGER (1879–91). The assemblage of species shows with certainty that the two shell beds are contemporaneous with the Arnum Formation and the Hemmoor Stufe. At Enderupskov there are even the two species *Cardium hanseatum* and *Dorsanum boreobaccatum*, which GRIPP (1933, p. 54) records as guide fossils for the Hemmoor Stufe.

Two species particularly characteristic of the two samples are *Nassa pölsense* and *Clavatula ursulae*. The former is common and its comparatively large, almost globular shells are very conspicuous. The latter has a characteristic sculpture. Furthermore it is the species which has the largest shell, at any rate among the gastropoda in the two samples, where, for that matter, it is also rather common. This feature common to Shell Bed II at Hoddemark and the shell bed at Enderupskov is so characteristic that there is a certain probability that they belong to the same biostratigraphical zone. It should, however, be noted that as long as we know only these two localities situated far from each other, it is too early to pronounce with certainty on their contemporaneity.

Quantitative evaluation.

The analysis of the shell bed at Enderupskov, Table 2, shows that the following species are represented by the largest number of individuals:

Nassa schlotheimi	15 per cent.
Spisula subtruncata	12 –
Nuculana pygmaea	10 –

The assemblage of molluscs therefore must be characterized as a *Spisula subtruncata-Nassa schlotheimi* assemblage. If anything, it can be compared with the borehole at Glejbjerg (a depth of 42 m.) mentioned by SORGENFREI (1958), but the similarity only applies to the three species mentioned. As regards the other species the difference is fairly great.

The assemblage of molluscs from Enderupskov and Shell Bed II at Hoddemark seems to represent a faunal assemblage not formerly recorded from Denmark. From Schleswig-Holstein, where there may be strata with corresponding faunal assemblages, there are not yet quantitative analyses available with which comparisons may be made.

Biostratigraphical conclusion.

The shell bed in the borehole at Enderupskov and Shell Bed II at Hoddemark seem to be contemporaneous and belong to an assemblage zone within the Arnum Formation which has not yet been recorded from elsewhere in Denmark.

Because of the frequent occurrence of *Nassa pölsense*, which is otherwise rare in the Arnum Formation, it is suggested that the two shell beds for the time being are referred to a *Nassa pölsense* assemblage zone. According to experiences so far this zone seems to be situated stratigraphically higher than the biozones in the Arnum Formation described by SORGENFREI.

II. The Molluscan Fauna at the Base of the Hodde Clay

The shell bed found in the series of rhythmically deposited beds of sand and clay at the base of the Hodde Clay at Hoddemark is termed Shell Bed I. Especially it contains black Mica Clay of the same appearance as the Hodde Clay between the shells and in the cavities of these. The shells are of a darker brown colour than in the other shell beds, and large shells are considerably commoner than in these. There are also some small pebbles of quartz and bits of wood. The fauna thus must be supposed to originate from an environment somewhat different from the fauna in Shell Bed II and III (+ IV). Consequently its composition can in advance be expected to be deviating.

Analysis of the fauna.

From Shell Bed I a 246.8 g. sample from the canal section at Hoddemark (volume about 260 cu. cm.) and a sample of 238.3 g. from the borehole Hodde I (D.G.U. File No. 113.33a) at a depth of 18.9–19.5 m. (volume not determined), in which the same shell bed is represented. Furthermore, the species from Shell Bed I found in my private collection are listed in the table of analysis (Table 3). These shells have been collected in situ for the purpose of obtaining as many different species as possible.

Table 3. **Shell Bed I, Hoddemark**

		Canal section		Borehole 113.33.a 18.9–19.5 m.		Private collection
		Number	Percentage	Number	Percentage	
1.	*Nucula sp.*	44	1.0	18	1.0	+
2.	*Nuculoma hanseata* (KAUTSKY)	.	.	.	.	+
3.	*Nuculana pygmaea* (MÜNSTER)	125	2.9	62	3.6	+
4.	*Nuculana westendorpii* (NYST)	98	2.3	38	2.2	+
5.	*Yoldia glaberrima* (MÜNSTER)	192	4.5	64	3.7	+
6.	*Limopsis aurita* (BROCCHI)	16	0.4	5	0.3	+
7.	*Limopsis lamellata* LEHMANN	13	0.3	3	0.2	+
8.	*Pecten sp.*	1	0.0	1	0.1	+
9.	*Astarte goldfussi* HINSCH	6	0.1	2	0.1	+
10.	*Goodallia angulata* (LEHMANN)	1	0.0	.	.	.
11.	*Cardita chamaeformis* (SOWERBY)	6	0.1	2	0.1	+
12.	*Kellyella rotunda* SORGENFREI	1	0.0	.	.	.
13.	*Kellyella patera* SORGENFREI	.	.	1	0.1	.
14.	*Isocardia sp.*	4	0.1	.	.	+
15.	*Sportella cimbrica* KAUTSKY	1	0.0	.	.	.
16.	*Thyasira sp.*	1	0.0	.	.	.
17.	*Lucina sp.*	.	.	1	0.1	.
18.	*Erycina sp.*	.	.	1	0.1	.
19.	*Laevicardium cf. dingdense* (LEHMANN)	24	0.6	12	0.7	+
20.	*Cardium straeleni* GLIBERT	9	0.2	6	0.3	+
21.	*Chione multilamella* (LAMARCK)	.	.	.	.	+
22.	*Spisula subtruncata* (DA COSTA)	62	1.5	58	3.3	+
23.	*Abra prismatica* (MONTAGU)	57	1.3	42	2.4	+
24.	*Angulus fallax* (BEYRICH)	9	0.2	5	0.3	+
25.	*Varicorbula gibba* (OLIVI)	2	0.1	.	.	+
26.	*Teredo sp.*	1	0.0	1	0.1	.
27.	*Cuspidaria cuspidata* (OLIVI)	25	0.6	24	1.4	.
28.	*Cuspidaria costellata* (DESHAYES)	.	.	1	0.1	.
29.	*Cadulus gadus* (MONTAGU)	1	0.0	.	.	+
30.	*Dentalium dollfusi* v. KOENEN	53	1.2	16	0.9	+
31.	*Dentalium entale* L.	171	4.0	78	4.5	+
32.	*Architectonica cf. planulata* (GRATEL.)	.	.	.	.	+
33.	*Bittium tenuispina* SORGENFREI	14	0.3	5	0.3	+
34.	*Cerithiella genei* (MICH.)	.	.	1	0.1	.
35.	*Opalia vilandti* (MØRCH)	.	.	.	.	+
36.	*Strombiformis sp.*	.	.	1	0.1	.
37.	*Polinices catena johannae* (MAYER-EY.)	.	.	.	.	+
38.	*Polinices varians protracta* (EICH.)	.	.	2	0.1	+
	Naticidae indet.	348	8.1	122	7.0	+
39.	*Aporrhais alata* (EICHWALD)	.	.	.	.	+
40.	*Ficus conditus* (BRONGNIART)	.	.	1	0.1	+
41.	*Typhis pungens* (SOL.)	.	.	.	.	+
42.	*Lyrotyphis sejunctus* (SEMPER)	6	0.1	1	0.1	+
43.	*Anachis corrugata* (BROCCHI)	1	0.0	1	0.1	+
44.	*Nassa tenuistriata* (BEYRICH)	44	1.0	2	0.1	+

Table 3 (continued) Shell Bed I, Hoddemark (continued)

		Canal section		Borehole 113.33.a 18.9–19.5 m.		Private collection
		Number	Percentage	Number	Percentage	
45.	*Nassa bocholtensis* (BEYRICH)	.	.	.	.	+
46.	*Nassa fuchsi* v. KOENEN	255	5.9	74	4.3	+
47.	*Nassa schlotheimi* (BEYRICH)	119	2.8	57	3.3	+
48.	*Nassa facki* v. KOENEN	.	.	.	.	+
49.	*Nassa cimbrica* RAVN	1472	34.4	753	43.4	+
50.	*Nassa turbinella* (BROCCHI)	.	.	1	0.1	.
51.	*Streptochetus sexcostatus* (BEYR.)	15	0.4	2	0.1	+
52.	*Streptochetus sp. nova*	1	0.0	.	.	+
53.	*Streptochetus abruptus* (BEYRICH)	.	.	.	.	+
54.	*Aquilofusus festivus* (BEYRICH)	2	0.1	2	0.1	+
55.	*Aquilofusus beyrichi* (NYST)	.	.	.	.	+
56.	*Exilia contigua* (BEYRICH)	17	0.4	4	0.2	+
57.	*Ancilla obsoleta* (BROCCHI)	.	.	.	.	+
58.	*Oliva minutissima* (KAUTSKY)	1	0.0	.	.	+
59.	*Scaphella bolli* (KOCH)	.	.	.	.	+
60.	*Admete fusiformis* (CANTRAINE)	42	1.0	18	1.0	+
61.	*Admete sp. nova*	3	0.1	.	.	.
62.	*Conus dujardini* DESHAYES	14	0.3	1	0.1	+
63.	*Gemmula zimmermanni* (PHILIPPI)	126	2.9	33	1.3	+
64.	*Gemmula boreoturricula* (KAUT.)	32	0.8	6	0.3	+
65.	*Fusiturris duchastelii* (NYST)	77	1.8	9	0.5	+
66.	*Bathytoma cataphracta* (BROCCHI)	5	0.1	1	0.1	+
67.	*Turricula steinvorthi* (v. KOENEN)	.	.	.	.	+
68.	*Clavatula boreointerrupta* KAUTSKY	1	0.0	.	.	+
69.	*Acamptogenotia straeleni* GLIBERT	.	.	.	.	+
70.	*Inquisitor borealis* (KAUTSKY)	73	1.7	15	0.9	+
71.	*Inquisitor cimbrica* (KAUTSKY)	2	0.1	.	.	+
72.	*Splendrillia selenkae* (v. KOENEN)	3	0.1	.	.	.
73.	*Peratotoma hosiusi* (v. KOENEN)	15	0.4	6	0.3	+
74.	*Asthenotoma pannus* (BASTEROT)	1	0.0	1	0.1	+
75.	*Asthenotoma pannoides* (v. KOENEN)	26	0.6	5	0.3	+
76.	*Haedropleura maitreja* (SEMPER)	5	0.1	1	0.1	+
77.	*Neoguraleus tenella* (MAYER)	2	0.1	1	0.1	+
78.	*Pleurotomoides luisae* (SEMPER)	4	0.1	.	.	+
79.	*Teretia anceps* (EICHWALD)	5	0.1	1	0.1	+
80.	*Magnella andersoni* DITTMER	18	0.4	2	0.1	+
81.	*Philbertia sinuosula* SORGENFREI	1	0.0	1	0.1	+
82.	*Terebra hoernesi* BEYRICH	30	0.7	8	0.5	+
83.	*Terebra sp.*	.	.	2	0.1	+
84.	*Acteon semistriatus* (BASTEROT)	14	0.3	2	0.1	+
85.	*Chrysallida pygmaea* (GRATELOUP)	51	1.2	6	0.3	+
86.	*Chrysallida nodifera* SORGENFREI	66	1.3	25	1.4	+
87.	*Odostomia conoidea* (BROCCHI)	225	5.0	52	3.0	+
88.	*Eulimella cf. crassitesta* SORGENFREI	1	0.0	.	.	+
89.	*Eulimella sp.*	2	0.1	.	.	.

Table 3 (continued) Shell Bed I, Hoddemark (continued)

		Canal section		Borehole 113.33 a 18.9–19.5 m.		Private collection
		Number	Percentage	Number	Percentage	
90.	*Turbonilla lactea* (LINNÉ)	3	0.1	1	0.1	+
91.	*Turbonilla pseudoterebralis* (SACCO)	41	1.0	.	.	+
92.	*Turbonilla densecostata* PHILIPPI	.	.	5	0.3	.
93.	*Pyramidella plicosa* BRONN	1	0.0	.	.	+
94.	*Ringicula buccinea* (BROCCHI)	152	3.6	56	3.2	+
95.	*Cylichna cylindracea* (PENNANT)	4	0.1	1	0.1	+
96.	*Rhizorus acuminatus* (BRUGUIÈRE)	3	0.1	3	0.2	+
97.	*Retusa elongata* (EICHWALD)	.	.	1	0.1	+
98.	*Roxania utriculus* (BROCCHI)	15	0.4	1	0.1	+
99.	*Spiratella atlanta* (MØRCH)	1	0.0	.	.	.
100.	*Spirulirostra cf. hoernesi* v. KOENEN	.	.	1	0.1	+
	Gastrop. indet.	1	0.0	.	.	.
	In all:	4283	99.5	1735	100.1	

Qualitative evaluation.

A further examination of the list of species shows that all determinable species (exclusive of those new to science) with the exception of the following four have been recorded from the Hemmoor Stufe of North Germany and the Arnum Formation of Denmark (according to KAUTSKY 1925, SORGENFREI 1958, DITTMER 1959, and ANDERSON 1960).

Opalia vilandti
Streptochetus abruptus
Aquilofusus festivus
Spirulirostra hoernesi.

The first-mentioned of these species is well-known from the Gram Formation, but has also been found at Dingden according to v. KOENEN (1872). Perhaps also the shells mentioned in the literature as *Opalia straeleni* GLIBERT are identical with this species.

Streptochetus abruptus and *Aquilofusus festivus* according to K. GRIPP (1933, p. 92, and 1964, p. 121) are just the only two species which seem to be limited to the German Reinbek Stufe (= Dingden-Reinbeker Stufe).

Spirulirostra hoernesi, which has been recorded from several places in the Bremen region (KÖWING 1956) and the Hamburg region (GOTTSCHE 1901) in the Reinbek Stufe, also seems to be a guide fossil for this formation.

The occurrence of the three last-mentioned species therefore may be an indication that the fauna of Shell Bed I is of a later date than that of the Arnum Formation (in sensu SORGENFREI) and of the German Hemmoor Stufe.

Certain species in Shell Bed I, however, does not seem to have been recorded from the type localities of the Reinbek Stufe (Reinbek and Dingden). First of all, this applies to the dominant species, *Nassa cimbrica*, which according to SORGENFREI (1958) characterizes several of the molluscan assemblages of the Arnum Formation. Therefore, there is a possibility that the fauna in Shell Bed I rather represents an intermediary stage, as regards age, between the fauna in the Reinbek Stufe and that in the Hemmoor Stufe (respectively the Arnum Formation).

Quantitative evaluation.

The five commonest species in Shell Bed I according to the analyses are the following:

Nassa cimbrica	34.4 per cent.,	respectively	43.4 per cent.
Naticidae indet.	8.1 per cent.,	respectively	7.0 per cent.
Nassa fuchsi	5.6 per cent.,	respectively	4.3 per cent.
Yoldia glaberrima	4.5 per cent.,	respectively	3.7 per cent.
Dentalium entale	4.0 per cent.,	respectively	4.5 per cent.

From this list it is evident that *Nassa cimbrica* is the absolutely dominant species, for which reason the molluscan assemblage may be termed a *Nassa cimbrica* assemblage.

As mentioned above, *Nassa cimbrica* is characteristic of several of the assemblages of molluscs of the Arnum Formation.

Biostratigraphical conclusion.

Shell Bed I according to what precedes must be placed in a *Nassa cimbrica* species zone, the age of which seems to correspond to the latest part of the Hemmoor Stufe (respectively the Arnum Formation) or the earliest part of the Reinbek Stufe. A complete parallel has neither been recorded from Denmark nor from Germany.

As the shell bed also contains some shells of the important *Aquilofusus festivus*, it is proposed that the zone should be termed the *Nassa cimbrica-Aquilofusus festivus* assemblage zone.

III. The Molluscan Fauna in the Hodde Clay

In the sections of the Karlsgårde Canal at Hoddemark and in the borehole Hodde I, Shell Bed I is overlain by Hodde Clay, which contains comparatively few molluscs. This poverty in fossils seems on the whole to be characteristic of the Hodde Clay in its whole thickness in all places where it has been recorded. Here and there in the clay, however, there seem to be minor accumulations of crushed shells of molluscs, perhaps washed together, as appears from a borehole at Hygum in South Jutland (D.G.U. File No. 141.215).

The commonest thing is that the fauna in the Hodde Clay is poor in individuals as well as species. This implies that the comparatively small drilling samples as a rule contain very few molluscs. Large drilling samples, as available from the borehole of D.G.U. at Gram Brickworks in 1963 (File No. 141.277), of course contain some more fossils, but as compared with the contents of fossils in the Gram Clay, there are clearly smaller quantities. This appears from Table 10 as compared with Table 59 (especially the total number of individuals from each sample). The only outcrop in which there has been an opportunity to collect fossils in Hodde Clay, was the north wall of the easternmost clay pit of the brickworks of Måde. There, by an intense search of the wall, I succeeded in finding the fauna listed in Table 8 in a few days. The large number of shells of *Nassa fuchsi* was for the greater part found in a single place, where there was a concentration of juvenile shells of this species round a piece of wood embedded in the clay.

Fauna analyses.

In the following tables all the molluscs are listed which have been found in the boreholes examined and elsewhere. With the exception of the fauna listed in Table 8, all the molluscs have been obtained by washing of drilling samples. These and their volumes have been mentioned in detail in the descriptions of the various localities (see the Geological Part).

Table 4. **Store Langkjær and Østbæk**

		Store Langkjær 104.1158 19.1–20.1 m.	Østbæk 103.152 28 m.
1.	*Astarte sp.*	1	.
2.	*Spiratella valvatina* (REUSS)	2	2
	In all:	3	2

Table 5. **Leding. 93.155**

		19–27 m.	27–28 m.	31 m.	28–32 m.	Unknown depth
1.	*Nucula sp.*	1	2	1	1	3
2.	*Nuculana pygmaea* (MÜNSTER)	2	4	4	1	2
3.	*Nuculana westendorpii* (NYST)	.	.	2	.	4
4.	*Yoldia glaberrima* (MÜNSTER)	1	.	4	3	5
5.	*Limopsis aurita* (BROCCHI)	.	.	3	.	.
6.	*Limopsis lamellata* LEHMANN	.	2	.	.	3

Table 5 (continued) Leding. 93.155 (continued)

		19–27 m.	27–28 m.	31 m.	28–32 m.	Unknown depth
7.	*Astarte goldfussi* HINSCH	.	.	1	.	.
8.	*Goodallia angulata* (LEHMANN)	.	.	.	.	1
9.	*Cardita chamaeformis* (SOWERBY)	2	.	2	1	1
10.	*Isocardia sp.*	.	.	1	.	.
11.	*Laevicardium sp.*	.	1	4	1	2
12.	*Cardium straeleni* (GLIBERT)	.	.	2	.	.
13.	*Spisula subtruncata* (DA COSTA)	2	1	2	.	2
14.	*Abra cf. prismatica* (MONTAGU)	1	.	2	1	2
15.	*Angulus cfr. fallax* (BEYRICH)	.	.	3	.	.
16.	*Varicorbula gibba* (OLIVI)	.	.	1	.	.
17.	*Cuspidaria cuspidata* (OLIVI)	.	.	3	1	2
18.	? *Cadulus gadus* (MONTAGU)	1	2	3	.	.
19.	*Dentalium dollfusi* v. KOENEN	.	1	6	3	3
20.	*Dentalium entale* L.	1	4	5	3	3
–	*Dentalium indet.*	1	.	.	.	.
21.	*Aporrhais alata* (EICHWALD)	1	.	.	.	.
22.	*Polinices protracta* (EICHWALD)	.	.	.	.	1
–	Naticidae indet.	1	3	14	9	11
23.	*Semicassis sp.*	.	.	1	.	.
24.	*Nassa tenuistriata* (BEYRICH)	.	.	1	.	2
25.	*Nassa fuchsi* v. KOENEN }	.	?3	?15	1	12
26.	*Nassa bocholtensis* (BEYRICH) }					
27.	*Nassa schlotheimi* (BEYRICH)	.	.	9	1	6
28.	*Nassa cimbrica* RAVN	.	.	5	.	6
29.	*Aquilofusus festivus* (BEYRICH)	.	.	?1	.	1
30.	*Exilia contigua* (BEYRICH)	.	.	4	2	2
31.	*Admete fusiformis* (CANTRAINE)	.	1	2	.	1
32.	*Gemmula zimmermanni* (PHILIPPI)	.	.	4	1	4
33.	*Gemmula stoffelsi* (NYST)	.	.	.	.	1
34.	*Gemmula boreoturricula* (KAUTSKY)	.	.	6	.	1
35.	*Fusiturris duchastelii* (NYST)	1	.	5	.	2
36.	*Fusiturris inermis* (HÖRNES)	.	.	1	.	.
37.	*Turricula steinvorthi* (v. KOENEN)	?1	.	.	.	1
38.	*Acamptogenotia cf. straeleni* GLIBERT	.	.	1	.	1
39.	*Inquisitor borealis* (KAUTSKY)	1	.	1	?1	2
40.	*Splendrillia selenkae* (v. KOENEN)	.	.	1	.	.
41.	*Brachytoma sp.*	.	.	1	.	.
42.	*Teretia anceps* (EICHWALD)	.	.	1	.	.
43.	*Terebra hoernesi* BEYRICH	.	.	.	1	.
44.	*Chrysallida nodifera* SORGENFREI	.	.	.	.	1
45.	*Odostomia conoidea* (BROCCHI)	2	1	3	1	5
46.	*Turbonilla pseudoterebralis* (SACCO)	.	1	?1	.	1
47.	*Ringicula buccinea* (BROCCHI)	1	3	14	5	11
48.	*Retusa elongata* (EICHWALD)	.	3	.	.	.
49.	*Roxania utriculus* (BROCCHI)	.	.	.	.	1
	In all:	20	32	140	37	106

Table 6. **Lønborg. 102.55**

		17.3–18.3 m.	18.3–19.3 m.	19.3–20.3 m.	20.3–21.3 m.	21.3–22.3 m.
1.	*Nucula sp.*	.	.	.	.	1
2.	*Nuculana pygmaea* (MÜNSTER)	.	.	.	.	5
3.	*Nuculana westendorpii* (NYST)	.	.	.	.	1
4.	*Yoldia glaberrima* (MÜNSTER)	.	.	.	.	1
5.	*Limopsis lamellata* LEHMANN	1	1	.	.	.
6.	*Astarte sp.*	.	.	.	.	1
7.	*Goodallia angulata* (LEHMANN)	1	.	.	.	.
8.	*Cardita cf. chamaeformis* (SOWERBY)	.	1	.	.	.
9.	*Laevicardium sp.*	.	.	.	.	3
10.	*Abra cf. prismatica* (MONTAGU)	.	.	.	.	1
11.	*Spisula subtruncata* (DA COSTA)	.	.	.	.	5
12.	*Varicorbula gibba* (OLIVI)	.	.	1	.	.
13.	*Cuspidaria cuspidata* (OLIVI)	.	.	.	.	1
14.	*Dentalium dollfusi* v. KOENEN	.	1	.	.	2
15.	*Dentalium entale* L.	.	.	.	.	1
16.	*Nassa fuchsi* v. KOENEN	1	.	?1	1	.
17.	*Nassa cimbrica* RAVN	.	.	.	.	3
18.	*Streptochetus sp.*	.	1	.	.	.
19.	*Acteon sp*	.	.	.	.	1
20.	*Ringicula buccinea* (BROCCHI)	1	.	1	.	1
	In all:	4	4	3	1	27

Table 7. **Odderup, Grøde and Hodde**

		Odderup 103.150 24.8–25.6 m.	Grøde Karlsgårde Canal	Hodde 113.33 a. 18.5–18.9 m.
1.	*Nuculana pygmaea* (MÜNSTER)	6	.	1
2.	*Nuculana westendorpii* (NYST)	1	.	.
3.	*Yoldia glaberrima* (MÜNSTER)	.	.	2
4.	*Limopsis aurita* (BROCCHI)	1	2	.
5.	*Limopsis lamellata* LEHMANN	.	.	5
6.	*Astarte goldfussi* HINSCH	?4	1	2
7.	*Cardita chamaeformis* (SOWERBY)	5	1	.
8.	*Isocardia sp.*	1	3	.
9.	*Cardium sp.*	1	.	.
10.	*Chione multilamella* (LAM.)	.	?1	.
11.	*Spisula subtruncata* (DA COSTA)	?1	.	1
12.	*Cuspidaria cuspidata* (OLIVI)	1	.	.
13.	*Dentalium dollfusi* v. KOENEN	11	2	.
14.	*Dentalium entale* L.	1	.	2
15.	Naticidae indet.	3	.	1

Table 7 (continued) Odderup, Grøde and Hodde (continued)

		Odderup 103.150 24.8–25.6 m.	Grøde Karlsgårde Canal	Hodde 113.33 a 18.5–18.9 m.
16.	*Nassa bocholtensis* (BEYRICH)	.	2	1
17.	*Nassa fuchsi* v. KOENEN	7	.	.
18.	*Nassa cimbrica* RAVN	.	.	5
19.	*Exilia contigua* (BEYRICH)	1	.	1
20.	*Gemmula zimmermanni* (PHILIPPI)	4	.	2
21.	*Gemmula boreoturricula* (KAUTSKY)	1	.	1
22.	*Fusiturris duchastelii* (NYST)	.	1	3
23.	*Bathytoma cataphracta jugleri* (PHILIPPI)	.	2	.
24.	*Inquisitor borealis* (KAUTSKY)	.	2	.
25.	*Tahusyrinx corneti* (v. KOENEN)	1	?1	.
26.	*Chrysallida nodifera* SORGENFREI	.	.	2
27.	*Turbonilla costellata* (GRATELOUP)	.	.	2
28.	*Ringicula buccinea* (BROCCHI)	7	1	2
29.	*Acera bellardii* (v. KOENEN)	1	.	1
	In all:	58	19	34

Table 8. **Måde Brickworks**

		North-western clay pit	South-western clay pit	Eastern clay pit. North wall
1.	*Nuculana pygmaea* (MÜNSTER)	.	.	1
2.	*Limopsis aurita* (BROCCHI)	6	.	29
3.	*Astarte goldfussi* HINSCH	3	.	25
4.	*Goodallia angulata* (LEHMANN)	.	.	1
5.	*Cardita chamaeformis* (SOWERBY)	3	.	30
6.	*Isocardia sp.*	.	.	5
7.	*Abra sp.*	.	.	1
8.	*Angulus cf. fallax* (BEYRICH)	.	.	1
9.	*Dentalium dollfusi* v. KOENEN	3	.	17
10.	*Polinices catena* (DA COSTA)	?1	.	15
11.	*Lyrotyphis sejunctus* (SEMPER)	.	.	2
12.	*Nassa bocholtensis* (BEYRICH)	.	.	6
13.	*Nassa fuchsi* v. KOENEN	.	.	165
14.	*Exilia contigua* (BEYRICH)	.	.	2
15.	*Streptochetus abruptus* (BEYRICH)	2	.	1
16.	*Aquilofusus festivus* (BEYRICH)	.	.	1
17.	*Gemmula zimmermanni* (PHILIPPI)	.	1	13
18.	*Gemmula boreoturricula* (KAUTSKY)	.	.	2
19.	*Fusiturris duchastelii* (NYST)	1	.	10
20.	*Bathytoma cataphracta jugleri* (PHILLIPPI)	.	.	6

Table 8 (continued) **Måde Brickworks** (continued)

		North-western clay pit	South-western clay pit	Eastern clay pit. North wall
21.	*Turricula steinvorthi* (v. KOENEN)	.	.	1
22.	*Tahusyrinx corneti* (v. KOENEN)	.	.	2
23.	*Haedropleura maitreja* (SEMPER)	.	.	3
24.	*Splendrillia selenkae* (v. KOENEN)	.	.	1
25.	*Microdrillia serratula* (BELLARDI)	.	.	3
26.	*Borsonia uniplicata* (NYST)	.	.	2
27.	*Ringicula buccinea* (BROCCHI)	1	.	13
28.	*Acera bellardii* (v. KOENEN)	.	.	2
29.	*Spiratella valvatina* (REUSS)	.	.	1
	Pelecypoda indet.	.	.	1
	Gastropoda indet.	.	.	4
	In all:	20	1	366

Table 9. **Various localities in North Slesvig**

		Brøstrup D.G.U. File No. 141.255, 30.3 m.	Rødding				Grønnebæk D.G.U. File No. 141.205, 20 m.	Enderupskov D.G.U. File No. 141.196, 35 m.
			D.G.U. File No. 141.241 28.0–33.0 m.	D.G.U. File No. 141.242 32 m.	D.G.U. File No. 141.243 30 m.	D.G.U. File No. 141.243 34.5 m.		
1.	*Limopsis lamellata* LEHMANN	2	.	.	3	.	.	.
	Limopsis sp. indet.	.	.	.	.	.	2	1
2.	*Astarte goldfussi* HINSCH	.	?1	.	1	.	?1	.
3.	*Cardita cf. chamaeformis* SOWERBY	.	.	.	.	?1	1	1
4.	*Cardium sp.*	.	.	.	.	.	.	1
5.	*Dentalium sp.*	.	1	.	1	1	.	1
6.	*Natica sp.*	.	.	.	2	.	1	1
7.	*Nassa fuchsi* (v. KOENEN)	.	1	1	1	?1	?1	1
8.	*Admete fusiformis* (CANTRAINE)	.	.	.	.	.	.	1
9.	*Gemmula sp.*	.	.	1	.	.	1	1
10.	*Bathytoma sp.*	.	1	.	.	.	.	.
11.	*Haedropleura maitreja* (SEMPER)	.	1	.	.	.	.	.
12.	*Odostomia sp.*	.	.	.	.	.	.	1
13.	*Spiratella valvatina* (REUSS)	.	.	2	2	.	5	6
	Gastropoda indet.	.	1	3	2	.	.	.
	In all:	2	6	7	12	3	12	15

Table 10. **Gram. 141.277.** (25.50–36.10 m.)

		25.50–26.00 m.	26.00–26.50 m.	26.50–27.00 m.	27.00–27.50 m.	27.50–28.00 m.	28.00–28.50 m.	28.50–29.00 m.	29.00–29.50 m.	29.50–30.00 m.	30.00–30.50 m.	30.50–30.95 m.	30.95–31.35 m.	31.35–31.65 m.	31.65–31.95 m.	31.95–32.30 m.	32.30–32.70 m.	32.70–33.05 m.	33.05–33.40 m.	33.40–33.80 m.	33.80–34.25 m.	34.25–34.70 m.	34.70–35.00 m.	35.00–35.30 m.	35.30–35.70 m.	35.70–36.10 m.
1.	*Nucula sp.*	.	1	1	.	.	1	.	1	1	.	.	.	.	.	.	.	.	.		.	.	.	.	.	.
2.	*Nuculana pygmaea* (MÜNSTER)	.	.	.	7	3	7	3	7	6	6	3	1	.	1	1	1	1	1	.	1	4	1	.	3	.
3.	*Nuculana westendorpii* (NYST)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	1	1	1	1	.
4.	*Yoldia glaberrima* (MÜNSTER)	.	1	1	1	.	1	1	1	1	1	1	.	.	.	1	.	.	.		.	.	.	.	.	.
5.	*Limopsis aurita* (BROCCHI)	.	.	.	5	.	.	.	8	.	.	4	.	.	.	.	.	.	.	.	.	.	4	4	4	1
6.	*Limopsis lamellata* LEHMANN	.	.	.	.	8	22	5	.	5	4	.	1	1	1	4	6	3	6	2	9	15	.	.	.	.
7.	*Volsella phaseolina* (PHILIPPI)	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8.	*Astarte goldfussi* HINSCH	.	?1	?1	2	3	5	5	5	3	6	3	1	1	1	2	1	1	3	1	3	7	1	3	3	.
9.	*Goodallia angulata* (LEHMANN)	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
0.	*Cardita chamaeformis* (SOWERBY)	1	.	?1	.	1	14	3	7	11	12	4	2	1	1	.	3	.	5	1	1	3	2	2	2	.
1.	?*Kellyella sp.*	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.	*Isocardia sp.*	.	.	.	.	.	1	1	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.	*Erycina sp.*	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4.	*Laevicardium sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.
5.	*Cardium straeleni* (GLIBERT)	.	.	.	1	.	1	1	1	1	2	.	1	1	.	1	.	.	1	.	8	4	2	.	3	.
6.	?*Chione multilamella* (LAMARCK)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
7.	*Abra sp.*	.	.	.	.	.	.	.	.	1	.	.	.	.	1	.	.	.	.	.	.	1	.	1	1	.
8.	*Varicorbula gibba* (OLIVI)	.	.	.	.	.	.	1	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
9.	*Thracia sp.*	.	.	.	1	.	1	1	.	1	.	1	.	.	.	.	.	.	1	.	.	.	1	1	1	.
0.	*Cuspidaria cuspidata* (OLIVI)	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
1.	*Cadulus gadus* (MONTAGU)	.	1	.	2	1	1	1	2	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.	*Dentalium dollfusi* v. KOENEN	1	1	4	2	2	3	1	7	4	7	2	?1	4	1	1	2	1	3	1	5	3	2	.	1	.
3.	*Dentalium entale* L.	.	.	.	.	.	2	.	2	2	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4.	*Trochus sp.*	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5.	*Circulus praecedens* (v. KOENEN)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
6.	*Putilla gottscheana* (v. KOENEN)	.	.	.	.	.	.	.	1	.	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.
7.	*Triphora fritschi* v. KOENEN	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8.	*Aporrhais alata* (EICHWALD)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	?1	.	1	.
9.	*Polinices protracta* (EICHWALD)	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
0.	*Natica koeneni* SACCO	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Naticidae indet.	.	.	.	.	.	1	1	3	.	3	1	2	1	1	1	.	1	1	1	.	.	2	.	2	.
1.	*Lyrotyphis sejunctus* (SEMPER)	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	1	1	.	.	.	1	.
2.	*Nassa fuchsi* v. KOENEN	.	.	.	1	.	1	2	15	7	22	5	17	4	2	9	1	2	1	1	4	3	3	.	.	.
3.	*Nassa cf. schlotheimi* (BEYRICH)	.	.	.	.	.	.	.	1	1	.	?1	1	.	.	1	.	.	.	.	.	.	.	.	.	.
4.	*Nassa cf. cimbrica* RAVN	.	.	.	.	.	.	.	.	4	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5.	*Exilia contigua* (BEYRICH)	.	.	.	.	.	.	.	.	.	?1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6.	*Streptochetus sexcostatus* (BEYRICH)	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1	.	1	.	.	.	1	.	.	1	.
7.	*Uromitra cf. wirtzi* HINSCH	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8.	*Admete fusiformis* (CANTRAINE)	.	.	.	.	.	.	.	.	2	3	1	4	3	.	1	1	.	1	.	.	1	.	.	.	.
9.	*Gemmula zimmermanni* (PHILIPPI)	.	.	.	.	.	.	.	4	3	1	2	1	1	1	?2	.	1	3	.	1	2	1	1	2	.
0.	*Gemmula boreoturricula* (KAUTSKY)	.	.	.	.	.	.	.	.	1	.	.	.	.	.	?1	.	.	.	.	.	.	.	.	.	.
–	*Gemmula indet.*	.	.	.	.	1	1	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
1.	*Fusiturris duchastelii* (NYST)	.	.	.	2	1	.	.	1	1	2	1	.	1	1	.	1	.	1	1	1	.	2	1	1	.

Table 10 (continued) **Gram.** 141.277. 25.50–36.10 m. (continued)

		25.50–26.00 m.	26.00–26.50 m.	26.50–27.00 m.	27.00–27.50 m.	27.50–28.00 m.	28.00–28.50 m.	28.50–29.00 m.	29.00–29.50 m.	29.50–30.00 m.	30.00–30.50 m.	30.50–30.95 m.	30.95–31.35 m.	31.35–31.65 m.	31.65–31.95 m.	31.95–32.30 m.	32.30–32.70 m.	32.70–33.05 m.	33.05–33.40 m.	33.40–33.80 m.	33.80–34.25 m.	34.25–34.70 m.	34.70–35.00 m.	35.00–35.30 m.	35.30–35.70 m.
42.	*Bathytoma cataphr. jugleri* (PH.)	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
43.	*Tahusyrinx corneti* (v. KOENEN)	.	.	.	.	.	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
44.	*Haedropleura maitreja* (SEMPER)	.	.	.	.	.	.	.	.	1	2	.	3	1	.	.	.	.	.	.	.	1	.	.	.
45.	?*Splendrillia selenkae* (v. KOENEN)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
46.	*Microdrillia serratula* (BELLARDI)	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
47.	*Brachytoma obtusangula* (BROCCHI)	.	.	.	.	.	?1	.	.	.	.	.	.	.	.	.	.	?1	.	.	.	1	.	1	.
48.	*Pleurotomoides sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
49.	*Philbertia sinuosula* SORGENFREI	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
50.	*Peratotoma hosiusi* (v. KOENEN)	.	.	.	.	.	.	1	2	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
51.	*Odostomia conoidea* (BROCCHI)	.	.	.	2	2	.	.	1	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
52.	*Odostomia mutinensis* (SACCO)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	.	.	.
53.	*Eulimella sp.*	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.
54.	*Turbonilla costellata* (GRATELOUP)	.	.	.	.	.	.	.	?1	?2	.	?2	2	.	.	?1	.	.	.	.	.	1	1	.	1
55.	*Turbonilla pseudoterebralis* (SACCO)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	2	2	.	.
56.	*Ringicula buccinea* (BROCCHI)	.	.	1	.	.	1	.	1	3	1	1	1	1	.	.	2	.	4	2	1	3	1	2	1
57.	*Spiratella valvatina* (REUSS)	.	.	3	41	10	37	149	51	42	15	10	10	1	.	1	.	1	1	2	3	.	2	.	.
58.	*Spiratella atlanta* (MØRCH)	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Pelecypoda indet.	.	.	.	.	.	3	.	3	2	.	.	.	1	.	.	.	.	.	.	.	1	.	2	.
	Gastropoda indet.	.	.	.	.	.	8	1	5	10	.	2	1	3	1	6	1	1	1	.	3	.	.	.	.
	Mollusca indet.	.	.	.	.	.	.	3	.	.	.	2	6	.	.	.	3	.	6	3	.	.	.	.	3
	In all:	3	7	12	69	33	113	184	132	119	98	54	55	29	12	36	24	14	43	19	42	56	29	20	35

Table 11. **Hygum and Tønder**

		Hygum 141.215 26.2–32.8 m.	Tønder 76 m.	Tønder 166.398 85 m.	85.5 m.	90 m.
1.	*Nuculana pygmaea* (MÜNSTER	2	.	.	.	.
2.	*Limopsis aurita* (BROCCHI)	2*)	1	.	1	.
3.	*Astarte cf. goldfussi* HINSCH	1*)	?1	.	.	.
4.	*Cardita chamaeformis* (SOWERBY)	1*)	.	1	.	.
5.	*Isocardia sp.*	3*)	.	.	.	.
6.	*Laevicardium sp.*	.	.	.	.	1
7.	*Dentalium cf. dollfusi* v. KOENEN	2	.	.	1	.
8.	*Trochus sp.*	1	.	.	.	.
9.	?*Aporrhais alata* (EICHWALD)	.	.	.	1	.
10.	Naticidae indet.	1	.	.	.	.
11.	*Nassa fuchsi* (v. KOENEN)	4	.	1	.	.
12.	*Nassa sp.*	.	.	1	.	.

Table 11 (continued) Hygum and Tønder (continued)

		Hygum 141.215 26.2–32.8 m.	Tønder 166.398 76 m.	85 m.	85.5 m.	90 m.
13.	*Admete fusiformis* (CANTRAINE)	1	.	.	.	.
14.	*Gemmula zimmermanni* (PHILIPPI)	3	1	.	.	.
15.	*Gemmula boreoturricula* (KAUTSKY)....	1	.	.	.	.
16.	*Microdrillia serratula* (BELLARDI)......	1	.	.	.	.
17.	*Pleurotomoides cf. luisae* (SEMPER).....	1	.	.	.	.
18.	*Turbonilla cf. pseudoterebralis* (SACCO) .	1	.	.	?1	.
19.	*Ringicula buccinea* (BROCCHI).........	.	.	.	1	1
20.	*Spiratella atlanta* (MØRCH)...........	1	.	.	.	.
	In all:..........	26	3	3	5	2

*) Numerous fragments are available, but only a few with the umbonal part and with remnants of the hinge.

Table 12. **Hajstrup**

		Core 154′–174′ 0.98–1.20 m. below top of core	Core 174′–194′ 0.00–0.30 m. below top of core	0.30–0.65 m. below top of core	0.65–0.80 m. below top of core	0.80–1.25 m. below top of core	Core 194′–214′ 0.00–0.15 m. below top of core	0.15–0.55 m. below top of core	Core 214′–234′ 0.00–0.55 m. below top of core
1.	*Nucula sp.*	.	.	.	.	.	.	.	1
2.	*Nuculana pygmaea* (MÜNSTER)...	.	2	.	.	1	2	.	2
3.	*Nuculana westendorpii* (NYST)....	.	.	.	.	1	1	.	2
4.	*Limopsis aurita* (BROCCHI).......	.	2	.	.	.	.	.	.
5.	*Limopsis lamellata* LEHMANN	.	2	2	1	4	.	.	6
6.	*Astarte goldfussi* HINSCH........	.	.	.	.	2	.	.	.
7.	*Goodallia angulata* (LEHMANN)...	.	.	.	.	1	.	.	.
	Astarte sp. indet...............	.	2	?1	?1	.	1	.	1
8.	*Cardita chamaeformis* (SOWERBY)	.	8	.	.	.	2	.	.
	Cardita sp. indet.	1	.	.	.	.	.	.	1
9.	*Cardium straeleni* GLIBERT	.	.	.	.	.	.	.	1
	Cardium sp. indet	.	.	.	.	.	1	.	.
10.	*Spisula subtruncata* (DA COSTA) *var.*	.	.	.	.	.	.	.	1
11.	*Abra sp.*......................	.	1	.	.	.	.	.	.
12.	*Angulus cf. fallax* (BEYRICH)	.	.	.	.	.	.	.	1
13.	*Varicorbula gibba* (OLIVI)	.	.	.	.	.	.	.	1
14.	*Cuspidaria costellata* (DESHAYES) .	.	.	.	.	.	.	1	.
15.	*Dentalium dollfusi* v. KOENEN	.	3	.	.	.	.	.	.
	Dentalium sp. indet.............	.	.	1	.	1	.	.	1

Table 12 (continued) Hajstrup (continued)

		Core 154′–174′	Core 174′–194′				Core 194′–214′		Core 214′–234′
		0.98–1.20 m. below top of core	0.00–0.30 m. below top of core	0.30–0.65 m. below top of core	0.65–0.80 m. below top of core	0.80–1.25 m. below top of core	0.00–0.15 m. below top of core	0.15–0.55 m. below top of core	0.00–0.55 m. below top of core
16.	?*Cadulus gadus* (MONTAGU)	.	.	.	.	.	.	1	1
17.	*Putilla gottscheana* (v. KOENEN)	.	.	1	1	.	.	.	.
18.	Naticidae indet.	.	.	1	.	1	.	.	4
19.	*Nassa fuchsi* v. KOENEN	cf. 1	4	7	3	8	.	.	6
20.	*Nassa schlotheimi* (BEYRICH)	.	.	.	.	.	.	.	1
21.	*Nassa cimbrica* RAVN	.	.	.	.	.	.	.	6
	Nassa sp. indet.	.	.	.	.	.	1	.	.
22.	*Streptochetus sexcostatus* (BEYRICH)	.	.	.	.	1	.	.	2
23.	*Exilia contigua* (BEYRICH)	.	.	.	.	.	.	.	1
24.	*Gemmula cf. rotata* (BROCCHI)	.	.	2	.	3	.	.	1
25.	*Fusiturris duchastelii* (NYST)	.	?1	.	.	.	.	.	1
26.	*Inquisitor obeliscus* (DES MOULINS)	.	.	.	.	.	.	.	1
27.	*Splendrillia selenkae* (v. KOENEN)	.	.	.	.	1	.	.	.
28.	*Microdrillia serratula* (BELLARDI)	.	.	.	.	1	.	.	.
29.	*Asthenotoma pannoides* (v. KOENEN)	.	.	.	.	.	.	.	1
30.	?*Clavatula sp.*	.	.	1	.	.	.	.	.
31.	*Pleurotomoides luisae* (SEMPER)	.	.	.	.	1	.	.	.
32.	*Terebra hoernesi* BEYRICH	.	.	.	.	.	.	.	1
33.	*Chrysallida pygmaea* (JEFFREYS)	.	.	.	.	.	1	.	.
34.	*Odostomia sp.*	.	.	.	.	1	.	.	.
35.	*Ringicula sp.*	.	1	.	.	.	.	.	.
36.	*Acera bellardii* (v. KOENEN)	.	1	?1	.	4	.	.	1
37.	*Spiratella valvatina* (REUSS)	.	1	8	2	1	.	.	7
	Turridae indet.	.	1	1	.	.	.	.	.
	Pelecyp. indet.	.	.	.	.	.	2	.	3
	Gastrop. indet.	.	.	.	.	.	.	.	.
	Moll. indet.	.	.	.	.	.	.	4	.
	In all:	2	29	26	8	32	11	6	55

Qualitative evaluation.

An analysis of the qualitative properties of the fauna can best be made from a complete fauna list. Therefore, a classification of all recorded species of molluscs in the Hodde Clay in Denmark and their occurrence elsewhere has been made in Table 13.

In certain cases the character of the drilling samples suggests that the sample does not consist of pure Hodde Clay, but of Hodde Clay with intermixed material from a sand bed or an alternating series of beds of clay and sand underlying the Hodde Clay.

This applies to two boreholes, viz. that at Leding (File No. 93.155) and that at Hajstrup (File No. 167.235).

As to the borehole at Leding the sample materials from the depths of 31 m. and 28–32 m. clearly contain Hodde Clay as well as quartz sand and quartz gravel, which is highly suggestive of a sequence of strata corresponding to conditions around Shell Bed I at Hoddemark. The information about the boring is too insufficient to confirm this supposition, but at any rate the presence of pure Hodde Clay is out of the question, for which reason the species found in the two samples mentioned as well as the sample without statement of depth are not included in Table 13.

The lowest core from the borehole at Hajstrup (from 214′–234′) contains material of Hodde Clay and quartz sand and gravel kneaded together (thus with many pebbles of quartz gravel). So the fauna found in the core does not originate exclusively from pure Hodde Clay either and therefore has not been included in Table 13.

The strata under the depth of 90 m. in the borehole at Tønder (File No. 166.398) contain a little sand and cannot be considered as Hodde Clay proper, either. Therefore the fauna from these samples has not been included in Tables 11 and 13.

Table 13. **The Molluscan Fauna of the Hodde Clay in Denmark**

		Denmark			Germany				Belgium
						Reinbek Stufe			
		Arnum Formation	Shell Bed I Hoddemark	Gram Formation	Hemmoor Stufe	Reinbek	Dingden	Twistringen	Anversien
1.	*Nucula sp.*	.	.	.	.	.	.	.	.
2.	*Nuculana pygmaea* (Münster)	+	+	+	+	+	+	+	+
3.	*Nuculana westendorpii* (Nyst)	+	+	.	+	+	+	+	+
4.	*Yoldia glaberrima* (Münster)	+	+	+	+	+	+	+	+
5.	*Limopsis aurita* (Brocchi)	+	+	+	+	+	+	+	+
6.	*Limopsis lamellata* Lehmann	.	+	.	+	.	+	.	.
7.	*Volsella phaseolina* (Philippi)	.	.	+	+	.	.	.	.
8.	*Astarte goldfussi* Hinsch	+	+	.	+	?	+	+	+
9.	*Goodallia angulata* (Lehmann)	?	.	.	?	.	+	.	?
10.	*Cardita chamaeformis* (Sowerby)	.	+	.	+	.	+	+	+
11.	*?Kellyella sp.*	.	.	.	.	.	.	.	.
12.	*Isocardia sp.*	.	.	.	.	.	.	.	.
13.	*Erycina sp.*	.	.	.	.	.	.	.	.
14.	*Laevicardium sp.*	.	.	.	.	.	.	.	.
15.	*Cardium straeleni* Glibert	?	+	+	+	.	+	+	+

Table 13 (cont.) The Molluscan Fauna of the Hodde Clay in Denmark (cont.)

		Denmark			Germany				Belgium
						Reinbek Stufe			
		Arnum Formation	Shell Bed I Hoddemark	Gram Formation	Hemmoor Stufe	Reinbek	Dingden	Twistringen	Anversien
16.	*Chione multilamella* (LAMARCK)	+	+	.	+	+	+	+	+
17.	*Spisula subtruncata* (DA COSTA)	+	+	+	+	+	+	+	+
18.	*Abra cf. prismatica* (MONTAGU)	+	+	+	.	+	.	+	.
19.	*Angulus cf. fallax* (BEYRICH)	+	+	.	+	+	.	.	+
20.	*Varicorbula gibba* (OLIVI)	+	+	+	+	+	+	+	+
21.	*Thracia sp.*	.	.	.	.	.	.	.	.
22.	*Cuspidaria cuspidata* (OLIVI)	+	+	+	+	+	.	.	+
23.	?*Cadulus gadus* (MONTAGU)	+	+	?	+	.	.	.	.
24.	*Dentalium dollfusi* v. KOENEN	+	+	.	+	.	+	+	.
25.	*Dentalium entale* L.	.	+	+	+	.	.	.	.
26.	*Trochus sp.*	.	.	.	.	.	.	.	.
27.	*Circulus praecedens* (v. KOENEN)	.	.	.	+	.	.	.	+
28.	*Putilla gottscheana* (v. KOENEN)	+	.	+	.	.	.	.	.
29.	*Triphora fritschi* v. KOENEN	.	.	+	+	.	.	+	.
30.	*Aporrhais alata* (EICHWALD)	+	+	+	+	+	+	+	+
31.	*Polinices catena* (DA COSTA)	+	+	+	+	+	+	+	+
32.	*Polinices protracta* (EICHWALD)	+	+	+	+	+	+	+	+
33.	*Natica koeneni* SACCO	.	.	+	.	.	.	.	.
34.	*Lyrotyphis sejunctus* (SEMPER)	+	+	+	+	.	.	+	+
35.	*Nassa fuchsi* v. KOENEN	+	+	.	+	?	.	.	.
36.	*Nassa ?schlotheimi* (BEYRICH)	+	+	.	+	.	.	.	.
37.	*Nassa bocholtensis* (BEYRICH)	+	+	+	+	+	+	+	+
38.	*Nassa cimbrica* RAVN	+	+	.	+	.	.	.	.
39.	*Streptochetus abruptus* (BEYRICH)	.	+	.	.	+	+	+	.
40.	*Streptochetus ?sexcostatus* (BEYRICH)	+	+	.	+	+	+	+	+
41.	*Exilia contigua* (BEYRICH)	.	+	.	+	+	+	+	.
42.	*Aquilofusus festivus* (BEYRICH)	.	+	.	.	.	+	+	.
43.	*Uromitra cf. cimbrica wirtzi* HINSCH	.	.	+	+	+	.	.	+
44.	*Admete fusiformis* (CANTRAINE)	+	+	+	+	.	.	+	+
45.	*Gemmula zimmermanni* (PHILIPPI)	+	+	.	+	+	+	+	+
46.	*Gemmula boreoturricula* (KAUTSKY)	+	+	.	+	+	+	+	+
47.	*Fusiturris duchasteli* (NYST)	+	+	.	+	.	+	+	+
48.	*Bathytoma cataphracta jugleri* (PHILIPPI)	.	+	.	+	+	+	+	+
49.	*Turricula steinvorthi* (v. KOENEN)	+	+	.	+	+	+	+	+
50.	*Tahusyrinx corneti* (v. KOENEN)	.	.	.	+	.	.	+	+
51.	?*Clavatula sp.*	.	.	.	.	.	.	.	.
52.	*Inquisitor borealis* (KAUTSKY)	+	+	+	+	+	+	+	+
53.	*Splendrillia selenkae* (v. KOENEN)	+	+	.	+	+	+	+	cf.
54.	*Haedropleura maitreja* (SEMPER)	.	+	+	+	.	+	.	.
55.	*Microdrillia serratula* (BELLARDI)	.	.	+	+	.	.	.	.

Table 13 (cont.) The Molluscan Fauna of the Hodde Clay in Denmark (cont.)

		Denmark			Germany				Belgium
						Reinbek Stufe			
		Arnum Formation	Shell Bed I Hoddemark	Gram Formation	Hemmoor Stufe	Reinbek	Dingden	Twistringen	Anversien
56.	*Peratotoma hosiusi* (v. KOENEN) ..	.	+	.	+	.	.	+	.
57.	*Brachytoma obtusangula* (BROCCHI)	+	.	+	+	+	.	+	+
58.	*Borsonia uniplicata* (NYST)	.	.	.	+	.	+	.	+
59.	*Pleurotomoides luisae* (SEMPER)...	cf.	+	+	+	.	.	.	.
60.	*Philbertia sinuosula* SORGENFREI ..	+	+	+	.	.	.	.	.
61.	*Acteon sp.*	.	.	.	.	.	.	.	.
62.	*Chrysallida nodifera* SORGENFREI .	+	+	.	.	.	.	.	.
63.	*Chrysallida pygmaea* (GRATELOUP)	+	+	+	+	.	cf.	+	cf.
64.	*Odostomia conoidea* (BROCCHI)...	+	+	+	+	.	.	.	+
65.	*Odostomia mutinensis* (SACCO) ...	+	.	.	.	.	.	.	.
66.	*Eulimella sp.*	.	.	.	.	.	.	.	.
67.	*Turbonilla costellata* (GRATELOUP)	+	.	+	+	.	.	.	.
68.	*Turbonilla pseudoterebralis* (SACCO)	+	+	.	+	.	.	+	.
69.	*Ringicula buccinea* (BROCCHI)....	+	+	+	+	+	+	+	+
70.	*Retusa elongata* (EICHWALD)	+	+	+	+	.	.	.	+
71.	*Acera bellardii* (v. KOENEN)	.	.	.	+	.	.	+	.
72.	*Roxania utriculus* (BROCCHI).....	+	+	.	+	+	.	+	+
73.	*Spiratella valvatina* (REUSS)......	cf.	.	.	+	.	.	+	+
74.	*Spiratella atlanta* (MØRCH)......	+	+	+	+	.	.	.	.

So far thus 74 species of molluscs from the Hodde Clay are known, but this number must be considered as quite accidental because of the comparatively few samples of clay so far available, and because only a single locality transiently has been accessible for collection.

A comparison with the molluscan faunas of the Arnum Formation and the Hemmoor Stufe is made difficult by the difference in facies between these two equivalent, mainly sandy formations and the Hodde Clay. The column headed "Hemmoor Stufe", however, besides the species which also occur in KAUTSKY's material from Hemmoor, contains the species which have been found by DITTMER at the South Slesvig boreholes as well. These have penetrated both the beds of clay and those of sand, and the species which preferably live in clayey facies, thus have also been included in DITTMER's lists of fauna.

However, it is doubtful whether any of these lists include species from pure beds of clay. In order to obtain sufficient material from such a stratum of clay, a fairly large quantity of clay must be washed, and the sorting out of fossils must be made under the microscope according to fairly the same method as that used in the case of Hodde Clay and Gram Clay, and this method does not seem to have been used formerly at the study of the faunas of the Miocene. The argillaceous beds mentioned by DITTMER seem to be in part silty and therefore as regards facies do not seem to be completely comparable with the Hodde Clay.

As regards the Hemmoor occurrence, it should be noted that KAUTSKY's material not only includes shells from the Hemmoor Stufe, but also shells from the Reinbek Stufe and the Upper Miocene Mica Clay.

Of the 17 species not yet recorded from the Arnum Formation, 14 have been found in the Hemmoor Stufe. The remaining three species are the following: *Natica koeneni*, *Streptochetus abruptus*, and *Aquilofusus festivus*. Of these *Natica koeneni* has so far been mentioned only from the Upper Miocene formations of Germany (Langenfeld Stufe, Gram Stufe, and Sylt Stufe) and from the Gram Formation in Denmark. The other two species, as mentioned at the qualitative evaluation of Shell Bed I, p. 206, seem to have been restricted to the Reinbek Stufe.

The relation to the fauna in Shell Bed I must be considered on the background of the fact that only a few samples of this stratum from only one locality have been examined. The 13 species from the Hodde Clay which have not so far been recorded from Shell Bed I, therefore may very well prove to occur in the many samples of the shell bed which have not yet been examined. Therefore, it is doubtful how great importance may be attached to the absence of these species. On the other hand, it is remarkable that the important species *Streptochetus abruptus* and *Aquilofusus festivus* occur in both strata. Therefore, it must be concluded that Shell Bed I and the Hodde Clay hardly are distant from each other in age and probably belong to approximately the same chronostratigraphical subsection of the Miocene.

The molluscan fauna of the German Reinbeker Stufe has not so far been worked up together.[1] But there are lists of fossils from the chief localities.

The type locality at *Reinbek* east of Hamburg has repeatedly been described in the literature, earliest by ZIMMERMANN (1847), but in most detail by C. GOTTSCHE (1878).

The fossiliferous beds mainly consist of a sandstone, rust-coloured in a weathered condition, pale yellow to grey in a fresh state, with numerous molluscs overlain by black, micaceous alum-earth. The strata cropped out in 1846, when two sections were dug into the ranges of hills on both sides of the river Bille during the preparatory work at the Hamburg–Berlin railway while, at the same time, a large pit was dug on the north side of the valley. Later, Upper Miocene Mica Clay was found at Friederichsruh NE of Reinbek. The contact between this and the other layers mentioned does not seem to have been observed.

[1] Unfortunately I have been unable to consider H. J. ANDERSON's great new work on "Die miocäne Reinbek-Stufe in Nord- und Westdeutschland und ihre Mollusken-Fauna" (Fortschr. Geol. Rheinl. u. Westf. Bd. 14, pp. 31–368, 52 Tafeln, Krefeld, Dec. 1964). This book was published after my manuscript had been finished.

The molluscan fauna in the Reinbek Sandstone has been described in the work of GOTTSCHE mentioned, but the determinations have not been revised as a whole. GOTTSCHE's list has been used under the head of "Reinbek" in Table 13.

According to GRIPP (1933, p. 90) the sandstone horizon has later been found in boreholes in the Reinbek region and at Hamburg, mostly, however, in the shape of loose, unconnected sand with numerous species of molluscs. GOTTSCHE (1901, p. 27) mentions some of the species found in sand deposits in one of the pits of the brickworks at Langenfelde (Hamburg), but otherwise there are no recent, published investigations of the molluscan faunas at Reinbek and Hamburg available.

In sediments of Mica Clay in other places in North Germany molluscan faunas have been found with nearly the same composition as that in the Reinbek Sandstone. The chief finding-place of this facies type was formerly *Dingden* at Bocholt, which is situated about 70 km. WSW of Münster, immediately SE of the Dutch-German frontier. Molluscs from this region have been mentioned by BEYRICH (1853–56), v. KOENEN (1872, 1882), and LEHMANN (1892–93). Recently a fossil list for the locality Königsmühle east of Dingden has been published (ANDERSON 1958). There is there in the bed of a brook close to the watermill a bluff in the lower parts of which silty Mica Clay with numerous shells of molluscs can be seen. ANDERSON's list has been used under the head of "Dingden" in Table 13.

Clay facies of a type which is more similar to the facies of the Hodde Clay, are known from numerous localities in the Bremen region. These localities have been investigated more closely and described by K. KÖWING (1956), who at the same time gives lists of fossils for each of the localities. For these lists reference is made to KÖWING's work. In this place we shall only consider that of the localities which has yielded most fossils and has been investigated most thoroughly, viz. the clay pit of a brickworks (owned by O. SUNDER) at *Twistringen*, well over 30 km. SW of Bremen.

The locality has been thoroughly described in the above-mentioned work by KÖWING (pp. 73–78) and by HINSCH (1962). The Miocene sediments consist of an alternating sequence of silty Mica Clay and more or less argillaceous silt. The colours vary from greyish green to black. The wash residues contain alternating quantities of pyrite and glauconite and often an abundance of quartz grains. Thus it is not a case of a pronounced series of clay, which must be kept in mind at a comparison of the molluscan fauna in the Hodde Clay with that of Twistringen. The difference, however, is not greater than a comparison being of value for the judging of the fauna of the Hodde Clay and its age.

Table 14 is a list of, partly, the species and their number of individuals published by the two authors mentioned, partly the species which I (together with TH. SORGENFREI) collected in the locality on April 26, 1959.

Table 14. **Twistringen**

No.	Species	According to Köwing 1956	According to Hinsch (1962): Number of specimens	According to Hinsch (1962): Percentage	Collections 26/4 1959: Number of specimens	Shell Bed I Hoddemark	Hodde Clay
1.	*Nucula laevigata* Sowerby	.	1	.	.	.	.
2.	*Nuculana pygmaea* (Münster)	+	150	7.0	.	+	+
3.	*Nuculana westendorpii* (Nyst)	+	20	0.9	9	+	+
4.	*Yoldia glaberrima* (Münster)	+	.	.	1	+	+
5.	*Arca cf. diluvii* (Lamarck)	.	3	0.1	.	.	.
6.	*Limopsis aurita* (Brocchi)	+	250	11.6	70	+	+
7.	*Limopsis anomala* (Eichwald)	+	20	0.9	8	.	+
8.	*Pinna pectinata* Linné	.	2	.	.	.	.
9.	*Pecten gérardi* Nyst	.	2	.	?1	?	.
10.	*Ostrea sp.*	+	.	.	.	.	.
11.	*Astarte gracilis convexior* Anderson	+	85	4.0	41	.	.
12.	*Astarte goldfussi* Hinsch	.	2	0.1	.	+	+
13.	*Cardita chamaeformis* Sowerby/ *C. orbicularis* (Sowerby)	+	32	1.5	10	+	+
14.	*Isocardia forchhammeri* Beck	+	20	0.9	9	?	?
15.	*Cyprina sp.*	+	.	.	.	.	.
16.	*Cardium straeleni* Glibert	+	4	0.2	.	+	+
17.	*Chione multilamella* Lamarck	+	6	0.3	1	+	+
18.	*Angulus sp.*	.	.	.	2	.	?
19.	*Spisula subtruncata triangula* Renieri	.	1	.	.	+	+
20.	*Abra prismatica* (Montagu)	.	1	.	.	+	+
21.	*Varicorbula gibba* (Olivi)	+	20	0.9	13	+	+
22.	*Dentalium dollfusi* v. Koenen	+	110	5.1	10	+	+
23.	*Calliostoma elegantulum mülleri* (v. Koenen)	.	2	0.1	.	.	?
24.	*Circulus praecedens* (v. Koenen)	.	.	.	1	.	+
25.	*Cingula proxima laevigata* (v. Koenen)	.	1	.	.	.	.
26.	*Archimediella subangulata* Brocchi	.	5	0.2	1	.	.
27.	*Vermetus arenarius* Linné	.	2	0.1	.	.	.
28.	*Bittium spina* Partsch	+	145	6.7	10	.	.
29.	*Cerithiopsis vignali* Cossmann & Peyrot	.	3	0.1	.	.	.
30.	*Triphora fritschi* v. Koenen	.	7	0.3	.	.	+
31.	*Cirsotrema crassicostata* (Deshayes)	.	1	.	1	.	.
32.	*Pliciscala miopusilla* Kautsky	.	2	.	1	?	.
33.	*Niso acarinatoconica* Cossmann & Peyrot	.	1	.	.	.	.
34.	*Xenophora deshayesii* Michelotti	+	.	.	.	.	.
35.	*Aporrhais alata* Eichwald	+	16	0.7	5	+	+
36.	*Natica tigrina* (Defrance) Grateloup	+	8	0.4	.	.	.
37.	*Natica koeneni* Sacco	.	.	.	3	.	+
38.	*Polinices catena* (Da Costa)/ *Polinices protracta* (Eichwald)	?	70	3.2	10	+	+
39.	*Eocypraea vöslauensis* (Sacco)	.	1	.	.	.	.
40.	*Trivia cf. densecostata* Schilder	+	1	.	.	.	.

		According to Köwing 1956	According to Hinsch (1962) Number of specimens	Percentage	Collections 26/4 1959 Number of specimens	Shell Bed I Hoddemark	Hodde Clay
41.	*Semicassis sp.*	+	.	.	1	.	.
42.	*Galeodea echinophora* (LINNÉ)	.	2	.	1	.	.
43.	*Ficus conditus* (BRONGNIART)	.	1	.	1	+	.
44.	*Murex spinicosta* BRONN	.	1	.	.	.	.
45.	*Typhis pungens* (SOL.)	.	1	.	.	+	.
46.	*Lyrotyphis sejunctus* (SEMP.)	+	12	0.6	4	+	+
47.	*Pyrene nassoides* (GRATELOUP)	+	1	.	1	.	.
48.	*Acamptochetus submitraeformis* (D'ORBIGNY)	+	1	.	.	.	.
49.	*Euthria antwerpiensis* GLIBERT	.	1	.	.	.	.
50.	*Nassa facki* v. KOENEN	.	3	0.1	.	+	.
51.	*Nassa bocholtensis* (BEYRICH)	+	325	15.0	30	+	+
52.	*Nassa turbinella* (BROCCHI)	.	17	0.8	.	+	.
53.	*Exilia contigua* (BEYRICH)	.	12	0.6	10	+	+
54.	*Aquilofusus festivus* (BEYRICH)	+	10	0.5	1	+	+
55.	*Aquilofusus beyrichi* (NYST)	.	1	.	.	+	.
56.	*Streptochetus hosiusi* (BEYRICH)	+	.	.	.	.	.
57.	*Streptochetus sexcostatus* (BEYRICH)	+	3	0.1	4	+	+
58.	*Streptochetus abruptus* (BEYRICH)	+	45	2.1	9	+	+
59.	*Lathyrus rothi* (BEYRICH)	.	1	.	.	.	.
60.	*Mitra grateloupi* D'ORBIGNY	.	1	.	.	.	.
61.	*Vexillum aciculum* (NYST)	.	1	.	2	.	.
62.	*Scaphella bolli* (KOCH)	+	5	0.2	1	+	.
63.	*Admete fusiformis* (CANTRAINE)	.	7	0.3	.	+	+
64.	*Conus antediluvianus* BRUGUIÈRE	+	35	1.6	19	.	.
65.	*Conus dujardini* DESHAYES	+	1	.	1	+	.
66.	*Gemmula zimmermanni* (PHILIPPI)	+	225	10.4	97	+	+
67.	*Gemmula cf. trifasciata* (HÖRNES)	.	9	0.4	6	.	.
68.	*Gemmula boreoturricula* (KAUTSKY)	.	30	1.4	25	+	+
69.	*Gemmula stoffelsi* (NYST)	.	16	0.7	.	.	.
70.	*Fusiturris duchastelii* (NYST)	+	75	3.5	41	+	+
71.	*Bathytoma cataphracta jugleri* (PHILIPPI)	+	75	3.5	41	+	+
72.	*Turricula steinvorthi* (v. KOENEN)	+	16	0.7	4	+	+
73.	*Tahusyrinx corneti* (v. KOENEN)	+	3	0.1	1	.	+
74.	*Clavatula obliquiplicatula* KAUTSKY	.	2	.	.	.	.
75.	*Acamptogenotia straeleni* GLIBERT	+	12	0.6	3	+	.
76.	*Inquisitor borealis* (KAUTSKY)	+	14	0.6	12	+	+
77.	*Inquisitor cimbrica* (KAUTSKY)	.	18	0.8	.	+	.
78.	*Splendrillia selenkae* (v. KOENEN)	+	4	0.2	4	+	+
79.	*Elaeocyma diensti* (KAUTSKY)	.	1	.	.	.	.
80.	*Asthenotoma pannoides* (v. KOENEN)	.	.	.	1	+	.
81.	*Peratotoma hosiusi* (v. KOENEN)	.	6	0.3	14	+	+
82.	*Microdrillia serratula* (BELLARDI)	.	.	.	1	.	+

Table 14 (continued) Twistringen (continued)

		According to Köwing 1956	According to Hinsch (1962)		Collections 26/4 1959	Shell Bed I Hoddemark	Hodde Clay
			Number of specimens	Percentage	Number of specimens		
83.	*Brachytoma grateloupi* (Peyrot)	.	1	.	.	.	.
84.	*Brachytoma obtusangula* (Brocchi)	.	3	.	.	.	+
85.	*Borsonia uniplicata* (Nyst)	.	.	.	4	.	+
86.	*Teretia anceps* (Eichwald)	.	2	.	.	+	.
87.	*Magnella andersoni* Dittmer	.	2	.	.	+	.
88.	*Metuonella grippi* (Kautsky)	.	2	.	.	.	.
89.	*Terebra acuminita* Borson	+	.	.	12	.	.
90.	*Terebra hoernesi* Beyrich	.	12	0.6	.	+	.
91.	*Chrysallida pygmaea* Grateloup	.	2	.	.	+	+
92.	*Eulimella acicula* (Philippi)	+	2	.	1	.	.
93.	*Pyramidella plicosa* (Bronn)	+	33	1.5	4	+	.
94.	*Turbonilla lactea* (Linné)	.	15	0.7	.	+	.
95.	*Turbonilla densecostata* (Philippi)	.	2	.	.	+	.
96.	*Turbonilla amoena* Cossmann & Peyrot	.	25	1.2	.	.	.
97.	*Turbonilla pseudoterebralis* Sacco	+	3	0.1	.	+	+
98.	*Ringicula buccinea* (Brocchi)	+	45	2.1	30	+	+
99.	*Acera bellardii* (v. Koenen)	.	12	0.6	3	.	+
100.	*Roxania utriculus* (Brocchi)	.	10	0.5	.	+	+
101.	*Spiratella valvatina* Reuss	+	.	.	.	.	+
102.	*Spirulirostra hoernesi* v. Koenen	+	.	.	2	+	.

Many of these species have not yet been recorded from Shell Bed I or from Hodde Clay. This applies to 45 and 52, respectively, of a total number of 98 determinable species.

Certain characteristic qualitative features, however, are common to the various localities. This applies to the occurrence of the guiding forms of the Reinbek Stufe: *Aquilofusus festivus*, *Streptochetus abruptus*, and *Spirulirostra hoernesi*.

The comparatively large number of species from Twistringen as compared with the number of species from the Hodde Clay is first of all due to the fact that the Twistringen sediments do not reflect quite the same reducing environment as Hodde Clay, and they are also considerably more silty. This has probably conditioned better possibilities of life for the fauna and given occasion for its relatively greater abundance of species.

It is not least important to compare the fauna of the Hodde Clay with that of the Gram Clay, as it is here a case of rather concordant facies condition. According to Table 13 a large number of species have not been recorded from Gram Clay, viz. 29 determinable species. Thus there is a qualitatively closer agreement with the fauna in the Arnum Formation, the Hemmoor Stufe, and

Shell Bed I at Hoddemark than with that in the Upper Miocene Gram Formation, which is furthermore emphasized by the complete absence of those species which characterize the molluscan fauna in the latter formation: *Astarte reimersi* (resp. *A. vetula*), *Cardita orbicularis*, *Nassa syltensis* (resp. *N. holsatica*), *Aquilofusus luneburgensis*, *A. semiglaber*, *A. puggaardi*, *Narona rothi* (resp. *N. lyrata*), etc. (see the section on the qualitative evaluation of the fauna of the Gram Clay on pp. 314–318).

Conclusion. The fauna of the Hodde Clay must all in all be regarded as clearly Middle Miocene and as later than that of the Arnum Formation and the Hemmoor Stufe. This is also in agreement with the lithostratigraphical position of the clay between Shell Bed I and the glauconitic basal bed of the Gram Clay. Otherwise, it must be considered in part equivalent to the fauna of the Reinbek Stufe in Germany.

Quantitative evaluation. The available analyses of the fauna of the Hodde Clay are based on a comparatively small number of individuals. Therefore, it is not possible to obtain a sure picture of the quantitative conditions. The occurrence at Måde (Table 8) and the borehole at Gram Brickworks (Table 10), however, give certain impressions, which it will probably prove possible to confirm in future when a more abundant material is available.

The borehole at Gram Brickworks thus shows that the following species appear in the largest number and are found in most or nearly all drilling samples.

Nuculana pygmaea	*Nassa fuchsi*
Limopsis lamellata	*Admete fusiformis*
Astarte goldfussi	*Gemmula zimmermanni*
Cardita chamaeformis	*Fusiturris duchastelii*
Cardium straeleni	*Ringicula buccinea*
Dentalium dollfusi	*Spiratella valvatina.*

The other analyses from the Hodde Clay confirm that especially *Limopsis lamellata*, *Dentalium dollfusi*, and *Spiratella valvatina* are common.

These quantitative conditions especially seem to stand out in fairly large samples which have been washed and from which all molluscs have been sorted out. Collections made in an outcrop, as at Måde Brickworks (Table 8), suggest that *Limopsis aurita*, *Astarte goldfussi*, *Cardita chamaeformis*, and *Nassa fuchsi* are among the forms most commonly found of the large species.

It appears from Table 14 that the following species are commonest in the occurrence at Twistringen:

Nuculana pygmaea	*Nassa bocholtensis*
Limopsis aurita	*Gemmula zimmermanni*
Astarte gracilis convexior	*Fusiturris duchastelii*
Dentalium dollfusi	*Bathytoma cataphracta jugleri*
Bittium spina	*Ringicula buccinea*
Polinices catena and *P. protracta*	

Thus there seems to be quite a good agreement between the fauna of the Hodde Clay and that of Twistringen. It should, however, be noted that the species *Limopsis aurita* and *L. lamellata* and *Nassa fuchsi* and *N. bocholtensis*, respectively, mutually correspond to each other and perhaps are identical.

Bittium spina according to HINSCH (1962) is especially common in a certain zone: *Bittium* Schichten. This species has not so far been recorded from the Danish Hodde Clay.

HINSCH (loc. cit.) divides the Twistringen section as regards biofacies into eight zones, each with its characteristic faunal assemblage. The lowest and oldest is with some doubt referred to the Hemmoor Stufe, all the others to the Reinbek Stufe.

Another German locality, *Woltrup* near Bersenbrück, has been mentioned by HINSCH in the same work. There *Nassa cimbrica* occurs in the lower part of the section and both *Aquilofusus festivus* and *Streptochetus abruptus* have been found in several specimens in the pit of the brickworks. The upper strata are therefore assumed to belong to the Reinbek Stufe and the lower strata to the Hemmoor Stufe. In a transitional zone both *Nassa cimbrica* and *Aquilofusus festivus* have been found. As this, as mentioned above (see Table 3), is also the case in Shell Bed I at Hoddemark, it is doubtful whether HINSCH is right in his view that the two last-mentioned species are indicators of the presence of the two formations at Woltrup. According to experiences from Denmark *Nassa cimbrica* seems to occur into the lower parts of the Hodde Clay and not to disappear until *Aquilofusus festivus* and *Streptochetus abruptus* have made their appearance.

The commonest species at Woltrup are

Nuculana pygmaea	*Nassa bocholtensis*
Limopsis aurita	*Gemmula zimmermanni*
Astarte gracilis convexior	*Fusiturris duchastelii*
Dentalium dollfusi	*Bathytoma cataphracta*
	Ringicula buccinea.

This is in good agreement with the frequency of species in the faunas from Twistringen and the Hodde Clay.

Conclusion. So far there is too little material available for a thorough elucidation of quantitative conditions concerning the molluscan fauna of the Hodde Clay, just as it is not yet possible to make a biostratigraphical classification.

There seems to be a certain agreement with the frequencies of species in the faunas of the two North German localities Twistringen and Woltrup, which for qualitative reasons are placed in the Reinbek Stufe.

Biostratigraphical conclusion. The fauna of the Hodde Clay is either of almost the same age as or a little younger than the fauna of Shell Bed I at Hoddemark, which again is later than the biozones of the Arnum Formation so far known.

It includes two species, *Aquilofusus festivus* and *Streptochetus abruptus*, which are considered to be restricted to the Middle Miocene Reinbek Stufe set up in North Germany, for which reason the Hodde Formation probably is in part equivalent to this stage.

As distinct from the fauna of the Gram Formation, the fauna of the Hodde Clay, besides by the two species mentioned, is especially characterized by the following species:

Limopsis lamellata
Astarte goldfussi
Cardita chamaeformis
Dentalium dollfusi
Nassa fuchsi
Exilia contigua
Gemmula zimmermanni
Fusiturris duchastelii
Bathytoma cataphracta jugleri
Tahusyrinx corneti
Splendrillia selenkae
Acera bellardii
Spiratella valvatina.

It is not yet possible to classify the Hodde Clay section biostratigraphically by means of the molluscs, but because of the quantitative conditions it is suggested that the whole of the Hodde Clay should be comprised by a *Nassa fuchsi-Limopsis lamellata* assemblage zone, these two species being the most frequent species of molluscs in the clay.

IV. The Molluscan Fauna in the Glauconite Clay at the Base of the Gram Clay

In the green Glauconite Clay overlying the Hodde Clay, only a few fragments of molluscs have been found in the borehole at Gram Brickworks (D.G.U. File No. 141.277). It is a question of the interval from 22.5 to 25.5 m., the species of which are listed in Table 59, p. 273.

The total of eight determinable species are not decidedly characteristic of the fauna of the Gram Clay, but still the presence of *Neoguraleus kochi* indicates a greater interdependence on the fauna of the Gram Formation than on that of the Hodde Formation, as this species is common in the Gram Clay, but never has been recorded from the Hodde Clay. In the latter only a single shell of *Brachytoma obtusangula* has been found.

In the borehole at Gram Brickworks the species *Dentalium dollfusi*, which is characteristic of the Hodde Clay, was found in the sample from 25.5–26.0 m. Because of this fact and considering the above-mentioned findings in the Glauconite Clay, I prefer to draw the line between the Gram Formation and the Hodde Formation at 25.5 m. in the Gram borehole. This is also in agreement with my view previously advanced (Rasmussen 1959, p. 121, and 1961 b, p. 35), that Glauconite Clay constitutes the basal layer of Gram Clay.

V. The Molluscan Fauna in the Gram Clay

The available material of molluscs from the Gram Clay, collected in outcrops as well as washed from drilling samples, is quite considerable.

In the following tables the material is arranged geographically, as far as possible, starting with the northernmost and westernmost localities in Region I and ending with the southernmost localities in Region V.

Region I

Table 15. **Skærum Mølle**

		Collector uncertain (probably V. Madsen)	Collector uncertain (probably P. Harder)	Collected by H. Ødum	Collected by Eigil Hansen 1911	Collected by the author	Other collectors	Total number
1.	*Nucula (sp. & georgina* SEMPER)	9	1	8	.	1	1	20
2.	*Nuculana pygmaea* (MÜNSTER)	.	1	1	.	.	.	2
3.	*Yoldia glaberrima* (MÜNSTER)	.	.	1	.	.	.	1
4.	*Limopsis aurita* (BROCCHI)	7	3	8	.	.	.	18
5.	*Chlamys clavata* (POLI)	2	.	6	1	.	.	9
6.	?*Anomia sp.*	.	.	1	.	.	.	1
7.	*Astarte reimersi* SEMPER	29	4	30	.	33	2	98
8.	*Goodallia esbjergensis nov. sp.*	.	4	.	.	1	.	5
9.	*Cardita orbicularis* (SOWERBY)	.	8	2	.	1	.	11
10.	*Isocardia forchhammeri* BECK	3	.	4	.	1	1	9
11.	*Cardium papillosum* (POLI)	.	1	.	.	.	.	1
12.	*Dentalium cf. michelotti* HÖRNES	.	1	.	.	.	.	1
13.	*Archimediella cochlias* (BAYAN)	.	.	5	.	11	.	16
14.	*Turritella tricarinata* (BROCCHI)	.	2	3	.	.	.	5
15.	*Xenophora testigera* (BRONN)	1	1	1	.	1	.	4
16.	*Polinices catena* (DA COSTA)	.	3	4	.	2	.	9
17.	*Natica koeneni* SACCO	.	.	.	.	.	Min. Mus.	.
18.	*Galeodea echinophora* (L.)	2	.	1	1	.	.	4
19.	*Semicassis miolaevigata* (SACCO)	.	.	.	.	.	Min. Mus.	.
20.	*Liomesus ventrosus* (BEYRICH)	.	.	.	1	.	.	1
21.	*Sipho distinctus* (BEYRICH)	1	.	3	.	1	.	5
22.	*Aquilofusus semiglaber* (BEYRICH)	2	1	9	1	.	.	13
23.	*Aquilofusus puggaardi* (BEYRICH)	.	.	1	.	1	.	2
24.	*Narona rothi* (SEMPER)	.	.	4	.	.	.	4
25.	*Conus antediluvianus* BRUGUIÈRE	1	.	2	.	.	.	3
26.	*Gemmula badensis* (R. HOERNES)	1	.	5	1	2	.	9
27.	*Gemmula annae* (HOERN. & AUING)	2	2	6	.	.	.	10
28.	*Bathytoma cataphracta* (BROCCHI)	2	1	5	1	1	.	10
29.	*Spirotropis modiola* (JAN)	.	1	.	.	.	.	1
30.	*Neoguraleus kochi* (v. KOENEN)	.	1	.	.	.	.	1
31.	*Pleurotomoides luisae* (SEMPER)	.	.	.	.	1	.	1
32.	*Spiratella atlanta* (MØRCH)	.	1	.	.	.	.	1
	In all:	62	36	110	6	57	4	275

Table 16. **Lillelund. 73.88**

		28.5–49.5 m.	49.5–62.0 m.	Total number
1.	*Nucula georgiana* SEMPER	1	1	2
2.	*Limopsis aurita* (BROCCHI)	3	1	4
3.	*Astarte reimersi* SEMPER	8	7	15
4.	*Goodallia esbjergensis nov. sp.*	2	2	4
5.	*Cardita orbicularis* (SOWERBY)	2	1	3
6.	*Turritella tricarinata* (BROCCHI)	45	12	57
7.	*Polinices sp.*	.	1	1
8.	*Galeodea echinophora* (L.)	.	1	1
9.	*Uromitra cimbrica* (OPPENHEIM)	1	.	1
10.	*Gemmula badensis* (R. HOERN.)	6	.	6
11.	*Bathytoma cataphracta* (BROCCHI)	.	1	1
12.	*Brachytoma obtusangula* (BROCCHI)	2	.	2
13.	*Asthenotoma sp.*	1	.	1
14.	*Pleurotomoides luisae* (SEMPER)	1	.	1
	In all:	72	27	99

Table 17. **Vinding and Aulum**

		Vinding (74.329) 76 m.	Aulum (74.321)					
			9.40–10.40 m.	10.40–11.40 m.	11.40–12.40 m.	12.40–13.40 m.	13.40–14.40 m.	Total number
1.	*Nuculana pygmaea* (MÜNSTER)	.	1	.	1	.	.	2
2.	*Limopsis sp.*	1	.	.	.	.	.	.
3.	*Astarte cf. reimersi* SEMPER	1	1	1	1	1	1	5
4.	*Goodallia esbjergensis nov. sp.*	.	.	1	1	.	1	3
5.	*Cardita orbicularis* (SOWERBY)	.	.	1	1	.	.	2
6.	*Cardium sp.*	.	.	.	.	1	.	1
7.	*Abra sp.*	1	.	.	1	.	.	1
8.	*Cuspidaria costellata* (DESHAYES)	.	.	.	1	.	.	1
9.	*Siphonodentalium cf. lobatum* (SOWERBY)	.	.	.	1	1	.	2
10.	*Putilla gottscheana* (V. KOENEN)	.	.	.	.	1	.	1
11.	*Sipho distinctus* (BEYRICH)	1	.	.	.	.	.	.
12.	*Brachytoma obtusangula* (BROCCHI)	.	.	.	.	1	.	1
13.	*Pleurotomoides luisae* (SEMPER)	.	.	.	.	1	.	1
14.	*Spiratella atlanta* (MØRCH)	1	.	.	1	.	.	1
–	Gastropoda indet.	.	1	1	.	.	.	2
	In all:	5	3	4	8	6	2	23

Table 18. **Lille Spåbæk and Grønbjærg**

		Lille Spåbæk	Grønbjærg
1.	*Nucula georgiana* SEMPER	3	.
2.	*Amussium sp.*	1	.
3.	*Limopsis aurita* (BROCCHI)	1	.
4.	*Astarte reimersi* SEMPER	25	27
5.	*Isocardia forchhammeri* BECK	3	2
6.	*Archimediella cochlias* (BAYAN)	1	1
7.	*Natica koeneni* SACCO	1	.
8.	*Galeodea echinophora* (L.)	.	1
9.	*Sipho distinctus* (BEYRICH)	2	1
10.	*Aquilofusus eximius* (BEYRICH)	1	.
11.	*Aquilofusus semiglaber* (BEYRICH)	1	1
12.	*Aquilofusus puggaardi* (BEYRICH)	1	.
13.	*Gemmula badensis* (R. HOERNES)	2	.
14.	*Gemmula annae* (HOERN. & AUING)	2	1
15.	*Spirotropis modiola* (JAN)	1	1
16.	*Spiratella atlanta* (MØRCH)	.	3
–	Gastr. indet.	1	.
	In all:	46	38

Table 19. **Boreholes on map sheets M 2403, M 2404 and M 2503**

	Map sheet	M 2403		M 2404					M 2503							
	D.G.U. File No.	83.210	83.377	84.763	84.766	84.770	84.233	84.238	83.104	83.127	83.591	83.597	83.602	83.197		
	Locality names	Kjærgårde	Muldbjerg	Kodal	Kodal	Kodal	Fjaldene	Fjaldene	Spjald	Spjald	Randbæk	Randbæk	Randbæk	Brejning Kro		
	Depths	3.0–15.0 m.	13.6–15.0 m.	3.1–13.7 m.	1.4–11.0 m.	9.3–15.0 m.	0.6–10.7 m.	1.0–15.0 m.	3.1–15.0 m.	2.6–15.0 m.	3.8–15.0 m.	2.1–15.0 m.	1.6–15.0 m.	40.5 m.	42–45 m.	Total number
1.	*Nucula georgiana* SEMPER	.	1	1	1	.	.	1	1	1	1	1	2	.	.	10
2.	*Nuculana pygmaea* (MÜNSTER)	.	.	.	.	1	.	.	.	.	.	2	1	1	.	5
3.	?*Yoldia glaberrima* (MÜNSTER)	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
4.	*Limopsis aurita* (BROCCHI)	.	.	.	.	.	.	.	.	2	.	.	.	1	2	5
5.	*Astarte cf. vetula* PHILIPPI	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2
6.	*Astarte reimersi* SEMPER	2	2	1	.	1	1	2	1	2	2	11	2	3	.	30
7.	*Goodallia esbjergensis nov. sp.*	1	.	.	.	.	.	.	.	1	2	.	.	1	1	6
8.	*Cardita orbicularis* (SOWERBY)	.	.	.	.	1	.	.	.	.	.	1	2	2	2	8
9.	*Isocardia forchhammeri* BECK	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1
10.	*Cardium papillosum* (POLI)	.	.	.	.	.	.	.	.	1	.	1	.	1	1	4
11.	*Spisula subtruncata* (DA COSTA)	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1

Table 19 (continued) Boreholes on map sheets (continued)

Map sheet	M 2403		M 2404					M 2503							
D.G.U. File No.	83.210	83.377	84.763	84.766	84.770	84.233	84.238	83.104	83.127	83.591	83.597	83.602	83.197		
Locality names	Kjærgårde	Muldbjerg	Kodal	Kodal	Kodal	Fjaldene	Fjaldene	Spjald	Spjald	Randbæk	Randbæk	Randbæk	Brejning Kro		
Depths	3.0–15.0 m.	13.6–15.0 m.	3.1–13.7 m.	1.4–11.0 m.	9.3–15.0 m.	0.6–10.7 m.	1.0–15.0 m.	3.1–15.0 m.	2.6–15.0 m.	3.8–15.0 m.	2.1–15.0 m.	1.6–15.0 m.	40.5 m.	42–45 m.	Total number
12. *Abra cf. prismatica* (MONTAGU)	.	.	.	.	.	.	.	.	.	.	1	.	.	1	2
13. *Thracia sp.*	.	.	.	.	1	.	.	1	1	.	.	.	.	.	3
14. *Cuspidaria costellata* (DESHAYES)	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1
15. *Siphonodentalium cf. lobatum* (SOWERBY)	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
16. *Archimediella cochlias* (BAYAN)	.	.	.	.	.	.	.	2	.	1	1	1	.	.	5
17. *Turritella tricarinata* (BROCCHI)	.	.	1	.	.	.	.	.	1	.	.	1	1	2	6
18. *Polinices sp.*	.	.	.	.	.	.	.	.	.	.	1	1	.	1	3
19. ?*Sipho distinctus* (BEYRICH)	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1
20. *Nassa bocholtensis* (BEYRICH)	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
21. *Brachytoma obtusangula* (BROCCHI)	.	.	.	.	.	.	.	.	1	.	.	.	.	.	1
22. *Odostomia conoidea* (BROCCHI)	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1
23. *Retusa sp.*	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1
24. *Spiratella atlanta* (MØRCH)	.	.	.	.	.	.	.	.	3	.	4	.	1	.	8
– Gastropoda indet.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
In all:	3	3	3	1	4	1	4	5	13	6	25	10	13	17	108

Table 20. **Muldbjerg. 83.1006**

		5.0–6.0 m.	6.0–7.0 m.	7.0–8.0 m.	8.0–9.0 m.	9.0–10.0 m.	Total number
1.	*Nucula georgiana* SEMPER	1	1	.	.	1	3
2.	*Nuculana pygmaea* (MÜNSTER)	9	2	3	1	1	16
3.	?*Yoldia glaberrima* (MÜNSTER)	1	.	.	.	.	1
4.	*Limopsis anomala* (EICHWALD)	.	1	2	3	.	6
5.	*Astarte cf. vetula* PHILIPPI	.	.	.	.	3	3
6.	*Astarte reimersi* SEMPER	16	7	8	5	.	36
7.	*Goodallia esbjergensis nov. sp.*	.	15	12	5	4	36
8.	*Cardita orbicularis* (SOWERBY)	.	8	4	4	2	18
9.	*Isocardia forchhammeri* BECK	.	.	.	1	.	1

Table 20 (continued) Muldbjerg 83.1006 (continued)

		5.0–6.0 m.	6.0–7.0 m.	7.0–8.0 m.	8.0–9.0 m.	9.0–10.0 m.	Total number
10.	*Cardium papillosum* (POLI)	1	4	2	1	1	9
11.	*Abra cf. prismatica* (MONTAGU)	1	2	1	.	.	4
12.	*Varicorbula gibba* (OLIVI)	.	.	.	1	.	1
13.	*Thracia sp.*	.	.	1	1	.	2
14.	*Cuspidaria costellata* (DESHAYES)	.	1	.	.	.	1
15.	*Siphonodentalium cf. lobatum* (SOWERBY)	2	.	.	1	.	3
16.	*Solariella jutensis nov. sp.*	.	1	.	.	.	1
17.	*?Lacuna sp.*	.	.	.	1	.	1
18.	*Putilla gottscheana* (V. KOENEN)	4	.	.	.	1	5
19.	*?Archimediella cochlias* (BAYAN)	.	.	4	1	.	5
20.	*Turritella tricarinata* (BROCCHI)	10	2	.	.	1	13
21.	*Leiostraca glabra* (DA COSTA)	1	.	.	.	.	1
22.	*Sipho distinctus* (BEYRICH)	.	.	.	1	.	1
23.	*Gemmula badensis* (R. HÖRNES)	.	.	1	.	.	1
24.	*Gemmula annae* (HOERNES & AUINGER)	1	1	.	.	.	2
25.	*Brachytoma obtusangula* (BROCCHI)	.	.	.	1	2	3
26.	*Pleurotomoides luisae* (SEMPER)	.	.	.	.	1	1
27.	*?Odostomia sp.*	2	.	.	.	.	2
28.	*Turbonilla costellata* (GRATELOUP)	.	.	.	1	.	1
29.	*Ringicula buccinea* (BROCCHI)	.	.	1	.	.	1
30.	*Diaphana moerchi nov. sp.*	1	.	1	.	.	2
31.	*Spiratella atlanta* (MØRCH)	34	13	6	7	.	60
–	Pelecypoda indet.	5	.	1	2	.	8
–	Gastropoda indet.	3	.	.	.	1	4
	In all:	92	58	47	37	18	252

Table 21. **Kodal – Fjaldene. 84.1749**

		14.55–15.55 m.	15.55–16.55 m.	16.55–17.55 m.	17.55–18.55 m.	18.55–19.55 m.	19.55–20.55 m.	20.55–21.55 m.	21.55–22.55 m.	22.55–23.55 m.	Total number
1.	*Nucula sp.*	2	1	.	1	1	1	.	.	.	6
2.	*Nuculana pygmaea* (MÜNSTER)	4	4	3	3	3	1	.	1	.	19
3.	*Yoldia glaberrima* (MÜNSTER)	.	.	.	.	.	?1	.	1	.	2
4.	*Limopsis aurita* (BROCCHI)	.	.	.	4	3	11	6	1	3	28
5.	*Astarte vetula* PH. or *radiata* N. & W.	.	.	.	.	.	8	10	.	.	18
6.	*Astarte reimersi* SEMPER	16	12	5	6	8	4	5	5	9	70
7.	*Goodallia esbjergensis nov. sp.*	.	.	.	8	10	5	3	2	3	31
8.	*Cardita orbicularis* (SOWERBY)	1	2	1	1	3	5	5	4	3	25
9.	*Isocardia forchhammeri* BECK	1	.	.	.	.	.	1	1	.	3

Table 21 (continued) Kodal – Fjaldene. 84.1749 (continued)

		14.55–15.55 m.	15.55–16.55 m.	16.55–17.55 m.	17.55–18.55 m.	18.55–19.55 m.	19.55–20.55 m.	20.55–21.55 m.	21.55–22.55 m.	22.55–23.55 m.	Total number
10.	*Thyasira cf. flexuosa* (MONTAGU)	.	1	.	.	.	.	.	.	.	1
11.	*Cardium papillosum* (POLI)	.	2	2	2	1	1	2	.	.	10
12.	*Abra sp.*	1	1	.	.	.	2	1	.	.	5
13.	*Thracia sp.*	1	.	.	.	1	.	.	.	1	3
14.	*Siphonodentalium cf. lobatum* (SOWERBY)	.	1	1	.	.	.	.	.	.	2
15.	*Archimediella cochlias* (BAYAN)	.	3	5	7	7	.	.	.	.	22
16.	*Turritella tricarinata* (BROCCHI)	3	.	.	.	.	4	6	5	13	31
17.	*Polinices sp.*	1	1	1	2	1	1	2	.	.	9
18.	*Galeodea echinophora* (L)	.	.	.	.	.	.	.	1	.	1
19.	*Trophonopsis semperi* (v. KOENEN)	.	.	.	1	.	.	.	.	.	1
20.	*Lyrotyphis sejunctus* (SEMPER)	.	1	.	1	.	.	.	.	1	3
21.	*Sipho distinctus* (BEYRICH)	1	.	.	.	.	.	.	.	.	1
22.	*Nassa bocholtensis* (BEYRICH)	.	1	.	.	.	.	.	.	.	1
23.	*Aquilofusus sp.*	1	.	.	.	.	.	.	.	.	1
24.	*Narona sp.*	.	.	.	.	.	1	.	.	.	1
25.	*Admete fusiformis* (CANTRAINE)	.	.	.	.	.	.	1	.	.	1
26.	*Conus antediluvianus* BRUGUIERE	.	.	.	.	.	.	.	.	1	1
27.	*Gemmula badensis* (R. HOERNES)	.	.	.	1	1	1	2	2	.	7
28.	*Gemmula annae* (HÖRN. & AUING)	.	.	.	.	.	1	.	2	.	3
29.	*Bathytoma cataphracta* (BROCCHI)	.	.	.	1	.	1	.	1	.	3
30.	*Microdrillia serratula* (BELLARDI)	.	.	.	.	.	.	1	.	.	1
31.	*Brachytoma obtusangula* (BROCCHI)	.	1	.	.	1	.	3	2	1	8
32.	*Pleurotomoides luisae* (SEMPER)	.	.	1	.	1	.	1	.	.	3
33.	*Philbertia sp.*	.	.	.	.	.	.	.	.	1	1
34.	*Acteon sp.*	.	.	.	.	.	1	.	.	.	1
35.	*Odostomia conoidea* (BROCCHI)	2	1	.	.	.	.	.	.	.	3
36.	*Eulimella sp.*	.	1	.	.	.	.	.	.	.	1
37.	*Turbonilla costella* (GRATELOUP)	.	.	1	.	.	.	1	.	.	2
38.	*Retusa elongata* (EICHWALD)	.	1	.	1	.	.	.	.	.	2
39.	*Spiratella atlanta* (MØRCH)	37	17	4	10	5	20	13	.	2	108
	Gastropoda indet.	3	.	.	.	.	2	1	.	1	7
	Pelecypoda indet.	.	.	.	1	.	.	.	.	.	1
	In all:	74	51	24	50	46	71	64	28	39	447

Table 22. **Videbæk. 84.1748**

		14.95–15.95 m.	15.95–16.95 m.	16.95–17.95 m.	22.95–23.95 m.	23.95–24.95 m.	Total number
1.	*Nucula sp.*	1	1	5	1	.	8
2.	*Nuculana pygmaea* (MÜNSTER)	10	10	5	2	.	27
3.	*Yoldia glaberrima* (MÜNSTER)	.	1	.	.	.	1
4.	*Limopsis anomala* (EICHWALD)	.	.	.	11	5	16
5.	?*Chlamys clavata* (POLI)	.	.	.	.	1	1
6.	*Astarte cf. vetula* PHILIPPI	.	.	.	6	13	19
7.	*Astarte reimersi* SEMPER	6	22	14	.	.	42
8.	*Goodallia esbjergensis nov. sp.*	.	.	.	2	2	4
9.	*Cardita orbicularis* (SOWERBY)	.	.	1	4	4	9
10.	*Isocardia forchhammeri* BECK	.	.	.	.	1	1
11.	*Thyasira sp.*	1	.	.	.	.	1
12.	*Cardium papillosum* (POLI)	2	.	1	.	3	6
13.	*Abra cf. prismatica* (MONTAGU)	1	.	.	.	.	1
14.	*Thracia sp.*	1	1	1	1	1	5
15.	*Siphonodentalium cf. lobatum* (SOWERBY)	1	.	1	.	1	3
16.	?*Lacuna sp.*	.	.	2	2	.	4
17.	*Putilla gottscheana* (v. KOENEN)	.	.	.	.	1	1
18.	*Turritella tricarinata* (BROCCHI)	1	5	3	2	9	20
19.	*Polinices sp.*	7	3	1	1	3	15
20.	?*Galeodea echinophora* (L)	.	.	.	1	.	1
21.	*Lyrotyphis sejunctus* (SEMPER)	.	.	.	.	1	1
22.	*Sipho distinctus* (BEYRICH)	.	.	1	.	1	2
23.	*Uromitra cimbrica* (OPPENHEIM)	.	.	.	.	1	1
24.	*Admete fusiformis* (CANTRAINE)	.	.	.	.	1	1
25.	*Gemmula badensis* (R. HÖRNES)	.	1	3	1	1	6
26.	*Gemmula annae* (HÖRN. & AUING.)	.	.	.	1	1	2
27.	*Brachytoma obtusangula* (BROCCHI)	.	1	.	2	2	5
28.	*Neoguraleus kochi* (v. KOENEN)	.	.	.	1	.	1
29.	*Pleurotomoides luisae* (SEMPER)	.	.	2	.	1	3
30.	*Acteon sp.*	.	.	.	.	1	1
31.	*Odostomia conoidea* (BROCCHI)	3	5	6	.	.	14
32.	*Eulimella sp.*	.	.	1	.	.	1
33.	*Turbonilla costellata* (GRATELOUP)	.	.	.	1	.	1
34.	*Ringicula buccinea* (BROCCHI)	.	.	.	.	1	1
35.	*Retusa elongata* (EICHWALD)	.	.	.	.	2	2
36.	*Spiratella atlanta* (MØRCH)	16	33	13	19	6	87
	Pelecypoda indet.	2	.	.	.	.	2
	Gastropoda indet.	.	.	.	.	2	2
	In all:	52	83	60	58	65	318

Table 23. **Videbæk**

		1.4–15.0 m. 84.288	3.5–15.0 m. 84.313	5.6–15.0 m. 84.344	7.2–15.1 m. 84.358	2.2–15.0 m. 84.417	2.2–15.0 m. 84.456	2.0–10.8 m. 84.483	5.1–15.5 m. 84.492	7.7–15.0 m. 84.493	6.2– 9.0 m. 84.525	Total number
1.	*Nucula georgiana* SEMPER	.	1	.	1	1	1	.	1	1	2	8
2.	*Nuculana pygmaea* (MÜNSTER)	.	.	.	7	.	3	1	.	.	2	13
3.	*Limopsis aurita* (BROCCHI)	.	.	4	11	1	4	4	3	.	3	30
4.	*Astarte reimersi* SEMPER	1	3	13	22	7	21	9	23	1	6	106
5.	*Goodallia esbjergensis nov. sp.*	.	.	10	44	3	3	5	10	.	.	75
6.	*Cardita orbicularis* (SOWERBY)	.	.	3	6	1	4	4	1	.	2	21
7.	*Isocardia forchhammeri* BECK	.	.	.	.	1	.	1	1	1	1	5
8.	*Cardium papillosum* (POLI)	.	.	.	1	.	.	.	.	.	.	1
9.	*Thracia sp.*	.	.	.	1	.	.	.	.	.	.	1
10.	*Archimediella cochlias* (BAYAN)	.	.	.	.	18	8	.	27	.	1	54
11.	*Turritella tricarinata* (BROCCHI)	.	.	20	8	2	17	6	.	.	.	53
12.	*Polinices sp.*	.	.	1	3	1	3	3	.	.	.	11
13.	*Galeodea echinophora* (L.)	.	.	.	.	.	.	1	.	.	1	2
14.	*Lyrotyphis sejunctus* (SEMPER)	.	.	.	1	.	.	.	.	.	.	1
15.	*Sipho distinctus* (BEYRICH)	.	.	.	1	.	1	.	1	.	.	3
16.	*Aquilofusus puggaardi* (BEYRICH)	.	.	1	.	.	.	.	.	.	.	1
17.	*Gemmula badensis* (R. HÖRNES)	.	.	.	3	.	2	1	2	.	.	8
18.	*Gemmula annae* (HÖRN. & AUING.)	.	.	1	2	.	1	.	.	.	.	4
19.	*Bathytoma cataphracta* (BROCCHI)	.	.	1	.	.	.	.	1	.	.	2
20.	*Spirotropis modiola* (JAN)	.	.	.	.	.	.	1	.	.	.	1
21.	*Asthenotoma ravni nov. sp.*	.	.	.	.	.	1	.	.	.	.	1
22.	*Brachytoma obtusangula* (BROCCHI)	.	.	1	3	.	1	1	.	.	1	7
23.	*Pleurotomoides luisae* (SEMPER)	.	.	1	.	.	.	.	.	.	.	1
24.	*Acteon semistriatus* (BASTEROT)	.	.	.	2	.	.	.	.	.	.	2
25.	*Eulimella sp.*	.	.	.	.	.	1	.	.	.	.	1
26.	*Ringicula buccinea* (BROCCHI)	.	.	.	1	.	.	.	.	.	.	1
27.	*Spiratella atlanta* (MØRCH)	.	.	2	37	.	1	1	1	.	2	44
	Gastrop. indet.	.	.	.	2	3	.	.	.	.	.	5
	In all:	1	4	58	156	38	72	38	71	3	21	462

Table 24. **Videbæk. 84.1727**

		8.4–9.4 m.	9.4–10.4 m.	10.4–11.4 m.	11.4–12.4 m.	Total number
1.	*Nucula sp.*	.	.	1	.	1
2.	*Nuculana pygmaea* (MÜNSTER)	4	6	5	4	19
3.	*Limopsis aurita* (BROCCHI)	.	1	2	6	9
4.	*Astarte reimersi* SEMPER	6	10	9	6	31
5.	*Goodallia esbjergensis nov. sp.*	.	3	26	27	56
6.	*Cardita orbicularis* (SOWERBY)	1	1	1	4	7
7.	*Cardium papillosum* (POLI)	1	2	2	4	9

Table 24 (continued) Videbæk. 84.1727 (continued)

		8.4–9.4 m.	9.4–10.4 m.	10.4–11.4 m.	11.4–12.4 m.	Total number
8.	*Abra cf. prismatica* (MONTAGU)	.	.	.	3	3
9.	*Teredo sp.*	.	1	.	.	1
10.	*Thracia sp.*	1	1	1	.	3
11.	*Siphonodentalium cf. lobatum* (SOWERBY)	.	.	1	.	1
12.	*Putilla gottscheana* (v. KOENEN)	.	.	1	.	1
13.	*Archimediella cochlias* (BAYAN)	1	1	2	1	5
14.	*Xenophora testigera* (BRONN)	1	.	.	.	1
15.	*Natica koeneni* (SACCO)	.	.	.	1	1
16.	*Lyrotyphis sejunctus* (SEMPER)	.	.	.	1	1
17.	*Sipho distinctus* (BEYRICH)	.	.	.	1	1
18.	*Admete fusiformis* (CANTRAINE)	.	.	.	1	1
19.	*Brachytoma obtusangula* (BROCCHI)	.	.	.	1	1
20.	*Odostomia conoidea* (BROCCHI)	.	.	2	1	3
21.	*Retusa elongata* (EICHWALD)	1	.	2	.	3
22.	*Spiratella atlanta* (MØRCH)	27	17	9	8	61
–	Gastrop. indet.	.	1	.	2	3
	In all:	43	44	64	71	222

Table 25. **Møltrup Brickworks**

		leg. G.V.Olsen & L.B.R. 1959	leg. L.B.R. 1962	Sample of clay	Percentage	84.1509 4.6–18.7 m.
1.	*Nucula sp.*	1	1	3	2.1	.
2.	*Nuculana pygmaea* (MÜNSTER)	.	.	13	8.9	.
3.	*Limopsis aurita* (BROCCHI)	.	.	3	2.0	.
4.	*Astarte vetula* PHILIPPI	.	.	.	.	5
5.	*Astarte reimersi* SEMPER	25	18	12	8.2	.
6.	*Goodallia esbjergensis nov. sp.*	.	.	49	33.6	.
7.	*Cardita orbicularis* (SOWERBY)	.	1	.	.	.
8.	*Isocardia forchhammeri* BECK	1	1	.	.	.
9.	*Thyasira sp.*	.	.	2	1.4	.
10.	*Cardium papillosum* (POLI)	.	.	9	6.2	.
11.	*Abra cf. prismatica* (MONTAGU)	.	.	2	1.4	.
12.	*Thracia sp.*	.	.	1	0.7	.
13.	*Siphonodentalium cf. lobatum* (SOWERBY)	.	.	2	1.4	.
14.	*Putilla gottscheana* (v. KOENEN)	.	.	2	1.4	.
15.	*Archimediella cochlias* (BAYAN)	6	.	7	4.8	.
16.	*Turritella tricarinata* (BROCCHI)	.	.	.	.	1
17.	*Polinices sp.*	.	.	2	1.4	.
18.	*Galeodea echinophora* (L.)	.	1	.	.	1
19.	*Lyrotyphis sejunctus* (SEMPER)	.	.	1	0.7	.

Table 25 (continued) Møltrup Brickworks (continued)

		leg. G.V.Olsen & L.B.R. 1959	leg. L.B.R. 1962	Sample of clay	Percentage	84.1509 4.6–18.7 m.
20.	*Sipho distinctus* (BEYRICH)	1	.	.	.	.
21.	*Aquilofusus eximius* (BEYRICH)	1	.	.	.	.
22.	*Aquilofusus puggaardi* (BEYRICH)	1	.	.	.	.
23.	*Uromitra cimbrica* (OPPENHEIM)	1	.	.	.	.
24.	*Admete fusiformis* (CANTRAINE)	.	.	1	0.7	.
25.	*Gemmula badensis* (R. HÖRNES)	.	.	2	1.4	.
26.	*Gemmula annae* (HÖRN. & AUING.)	1	.	.	.	.
27.	*Bathytoma cataphracta* (BROCCHI)	1	1	.	.	.
28.	*Microdrillia serratula* (BELLARDI)	.	.	1	0.7	.
29.	*Brachytoma obtusangula* (BROCCHI)	.	1	3	2.0	.
30.	*Neoguraleus kochi* (v. KOENEN)	.	.	1	0.7	.
31.	*Odostomia conoidea* (BROCCHI)	.	.	1	0.7	.
32.	*Turbonilla costellata* (GRATELOUP)	.	.	2	1.4	.
33.	*Retusa elongata* (EICHWALD)	.	.	2	1.4	.
34.	*Spiratella atlanta* (MØRCH)	.	.	13	8.9	.
–	Pelecypoda indet.	.	.	3	2.1	.
–	Gastropoda indet.	.	.	9	6.2	.
	In all:	39	24	146	100.4	7

Table 26. **Boreholes in the Sunds-Herning area**

		Ll. Torup (85.379) 16.8–20.0 m.		Gjellerup 85.380	Tværmose 85.381	Gjellerup 85.382	Frølund 85.383
		Number of specimens	Percentage	13–20 m.	21.0–25.0 m.	16.8–19.0 m.	9.2–17.9 m.
1.	*Nucula cf. georgiana* SEMPER	1	0.3	2	.	.	4
2.	*Nuculana pygmaea* (MÜNSTER)	1	0.3	.	3	.	7
3.	*Yoldia glaberrima* (MÜNSTER)	1	0.3	.	.	.	.
4.	*Limopsis anomala* (EICHWALD)	36	11.5	.	2	.	3
5.	*Astarte cf. vetula* PHILIPPI	.	.	.	18	.	.
6.	*Astarte reimersi* SEMPER	56	17.5	4	.	1	20
7.	*Goodallia esbjergensis nov. sp.*	1	0.3	.	.	.	.
8.	*Cardita orbicularis* (SOWERBY)	26	8·3	.	2	.	5
9.	*Isocardia forchhammeri* BECK	1	0.3	1	1	.	3
10.	*Thyasira cf. flexuosa* (MONTAGU)	.	.	.	.	.	1
11.	*Cardium papillosum* (POLI)	23	7.3	1	2	.	3
12.	*Abra cf. prismatica* (MONTAGU)	1	0.3	.	.	.	.
13.	*Thracia sp.*	1	0.3	.	.	.	.
14.	*Siphonodentalium cf. lobatum* (SOWERBY)	3	1.0	.	.	.	1
15.	*Dentalium cf. michelotti* HÖRNES	.	.	.	1	.	.

Table 26 (continued) Boreholes in the Sunds-Herning area (cont.)

		Ll. Torup (85.379) 16.8–20.0 m.		Gjelle-rup 85.380	Tvær-mose 85.381	Gjelle-rup 85.382	Frø-lund 85.383
		Num-ber of speci-mens	Percen-tage	13–20 m.	21.0–25.0 m.	16.8–19.0 m.	9.2–17.9 m
16.	*Dentalium cf. badense* PARTSCH	.	.	.	1	.	.
17.	*Cingula inusitata* (BEETS)	2	0.6	.	.	.	.
18.	*Archimediella cochlias* (BAYAN)	.	.	6	.	.	.
19.	*Turritella tricarinata* (BROCCHI)	28	8.9	.	3	.	15
20.	*Triphora fritschi* (v. KOENEN)	1	0.3	.	.	.	.
21.	*Polinices sp.*	15	4.8	.	8	.	8
22.	*Lyrotyphis sejunctus* (SEMPER)	4	1.3	.	1	.	.
23.	*Nassa syltensis* (BEYRICH)	2	0.6	.	.	.	1
24.	*Sipho distinctus* (BEYRICH)	.	.	1	.	.	.
25.	*Aquilofusus semiglaber* (BEYRICH)	.	.	.	.	1	.
26.	*Aquilofusus cf. puggaardi* (BEYRICH)	1	0.3	.	.	.	.
27.	*Admete fusiformis* (CANTRAINE)	2	0.6	.	1	.	1
28.	*Conus antediluvianus* BRUGUIÈRE	3	1.0	.	.	.	1
29.	*Gemmula badensis* (R. HOERNES)	15	4.8	1	3	1	7
30.	*Gemmula annae* (HÖRN. & AUING.)	1	0.3	1	1	.	5
31.	*Bathytoma cataphracta* (BROCCHI)	1	0.3	1	.	.	.
32.	*Brachytoma obtusangula* (BROCCHI)	6	1.9	.	4	.	6
33.	*Neoguraleus kochi* (v. KOENEN)	3	1.0	.	.	.	1
34.	*Pleurotomoides luisae* (SEMPER)	6	1.9	.	1	.	1
35.	*Philbertia sinuosula* SORGENFREI	1	0.3	.	.	.	.
36.	*Acteon sp.*	1	0.3	.	?1	.	.
37.	*Odostomia conoidea* (BROCCHI)	1	0.3	.	.	.	.
38.	*Eulimella sp.*	1	0.3	.	.	.	.
39.	*Turbonilla costellata* (GRATELOUP)	8	2.5	.	.	.	1
40.	*Turbonilla sp.*	2	0.6	.	.	.	.
41.	*Ringicula buccinea* (BROCCHI)	3	1.0	1	1	.	1
42.	*Retusa elongata* (EICHWALD)	4	1.3	.	.	.	1
43.	*Spiratella atlanta* (MØRCH)	48	15.3	.	3	.	7
–	Pelecyp. indet.	4	1.3	.	.	.	.
–	Gastrop. indet.	.	.	.	.	.	.
	In all:	314	99.5	19	57	3	103

Table 27. **Gjødstrup. 85.861**

		45.0 m.	46.0 m.	47.0 m.	48.0 m.	49.0 m.	50.0 m.	51.0 m.	52.0 m.	53.0 m.	54.0 m.	55.0 m.	56.0 m.	57.0 m.	58.0 m.	Total Number
1.	*Nucula sp.*	.	1	1	.	.	.	.	.	.	.	.	.	.	.	2
2.	*Nuculana pygmaea* (MÜNSTER)	1	2	1	.	1	.	2	.	.	1	.	1	.	.	9
3.	*Limopsis aurita* (BROCCHI)	.	.	.	.	.	.	.	.	2	3	.	.	.	.	5
4.	*Astarte vetula* PHILIPPI	.	.	.	.	.	.	.	.	.	.	.	.	?2	3	5
5.	*Astarte reimersi* SEMPER	.	.	1	.	.	2	1	1	?1	2	?2	2	.	.	12
6.	*Goodallia esbjergensis nov. sp.*	.	.	.	.	.	.	2	.	.	.	.	.	1	.	3
7.	*Cardita orbicularis* (SOWERBY)	.	.	.	.	.	.	.	.	1	1	.	.	.	.	2
8.	*Thyasira cf. flexuosa* (MONTAGU)	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1
9.	*Cardium papillosum* (POLI)	.	.	.	1	1	.	.	.	.	1	.	1	1	.	5
10.	*Abra cf. prismatica* (MONTAGU)	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1
11.	*Thracia cf. ventricosa* PHILIPPI	.	.	1	.	.	1	.	.	.	1	.	.	.	.	3
12.	*Cuspidaria costellata* (DESHAYES)	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1
13.	*Siphonodentalium cf. lobatum* (SOWERBY)	.	1	.	.	.	.	.	1	.	.	.	.	.	.	2
14.	?*Lacuna sp.*	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1
15.	*Putilla gottscheana* (v. KOENEN)	4	.	1	1	1	.	.	.	2	1	.	1	.	1	12
16.	*Archimediella cochlias* (BAYAN)	.	.	.	1	3	1	.	.	.	.	.	.	.	.	5
17.	*Turritella tricarinata* (BROCCHI)	.	.	.	.	.	.	.	.	.	.	.	5	.	1	6
18.	*Polinices sp.*	.	.	1	.	.	1	.	1	.	.	1	1	1	.	6
19.	*Galeodea echinophora* (L.)	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1
20.	*Lyrotyphis sejunctus* (SEMPER)	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
21.	*Trophonopsis semperi* (v. KOENEN)	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1
22.	*Aquilofusus sp.*	.	.	.	1	.	.	.	.	.	5	1	.	.	.	7
23.	*Admete fusiformis* (CANTRAINE)	.	.	.	.	.	.	.	.	.	.	.	1	.	1	2
24.	*Gemmula badensis* (R. HOERNES)	.	1	.	.	.	.	.	1	.	2	2	.	.	.	6
25.	*Gemmula annae* (HOERN. & AUING.)	.	.	.	1	1	.	.	.	.	.	.	.	.	.	2
26.	*Brachytoma obtusangula* (BROCCHI)	.	.	.	.	.	1	.	.	.	.	.	1	.	.	2
27.	*Pleurotomoides luisae* (SEMPER)	.	.	1	.	.	.	.	.	.	.	.	1	.	.	2
28.	*Asthenotoma ravni nov. sp.*	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1
29.	*Neoguraleus kochi* (v. KOENEN)	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1
30.	*Odostomia conoidea* (BROCCHI)	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1
31.	*Retusa elongata* (EICHWALD)	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1
32.	*Spiratella atlanta* (MØRCH)	.	.	.	.	2	.	2	.	2	.	.	.	1	.	7
–	Pelecyp. indet.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	1
	In all:	5	8	7	5	10	6	7	5	9	20	7	14	7	7	117

Table 28. **Snejbjerg. 85.775**

		18.25–19.25 m.	19.25–20.25 m.	20.25–21.25 m.	21.25–22.25 m.	22.25–23.25 m.	23.25–24.25 m.	24.25–25.25 m.	25.25–26.25 m.	26.25–27.25 m.	27.25–28.25 m.	28.25–29.25 m.	29.25–30.25 m.	Total number
1.	*Nucula sp.*	.	.	.	.	2	.	.	.	.	.	1	.	3
2.	*Nuculana pygmaea* (MÜNSTER)	.	1	.	2	1	2	1	.	.	1	.	.	8
3.	*Yoldia glaberrima* (MÜNSTER)	.	1	.	.	.	.	.	.	.	.	.	.	1
4.	*Limopsis anomala* (EICHWALD)	.	.	.	.	.	.	.	.	.	.	1	1	2
5.	*Astarte reimersi* SEMPER	1	.	.	?1	?1	1	.	.	4	.	1	1	10
6.	*Goodallia esbjergensis nov. sp.*	.	.	.	.	.	.	.	.	.	.	1	1	2
7.	*Cardita orbicularis* (SOWERBY)	.	.	.	.	.	.	.	.	.	.	.	1	1
8.	*Isocardia forchhammeri* BECK	.	.	.	.	.	1	.	.	.	.	.	.	1
9.	*Cardium papillosum* (POLI)	.	1	.	.	2	.	.	1	.	.	1	.	5
10.	*Abra cf. prismatica* (MONTAGU)	.	.	1	.	2	.	1	.	.	.	1	.	5
11.	*Siphonodentalium cf. lobatum* (SOWERBY)	.	1	.	.	1	.	.	.	.	.	.	.	2
12.	*Turritella tricarinata* (BROCCHI)	.	1	.	.	.	.	1	1	.	.	.	.	3
13.	*Polinices sp.*	.	1	.	.	.	1	1	.	.	.	.	.	3
14.	*Sipho distinctus* (BEYRICH)	.	.	.	.	1	.	.	.	.	.	.	.	1
15.	*Gemmula badensis* (R. HOERNES)	.	.	.	?1	.	.	1	.	.	.	.	.	2
16.	*Neoguraleus kochi* (v. KOENEN)	.	.	.	.	.	.	1	.	.	.	.	.	1
17.	*Philbertia sp.*	.	.	.	.	.	.	.	.	.	.	1	.	1
18.	*Spiratella atlanta* (MØRCH)	.	.	.	.	.	1	.	.	.	1	.	1	3
–	Pelecyp. indet.	.	.	.	.	1	.	.	1	.	.	.	.	2
–	Gastrop. indet.	.	.	.	.	.	.	.	.	.	.	.	1	1
	In all:	1	6	1	4	11	6	6	3	4	2	7	6	57

Table 29. **Bording**

		86.177	86.215
1.	*Nucula sp.*	2	.
2.	*Nuculana pygmaea* (MÜNSTER)	1	.
3.	*Yoldia glaberrima* (MÜNSTER)	1	.
4.	*Limopsis aurita* (BROCCHI)	1	.
5.	*Astarte reimersi* SEMPER	8	.
6.	*Goodallia esbjergensis nov. sp.*	1	.
7.	*Cardita orbicularis* (SOWERBY)	3	1
8.	*Isocardia forchammeri* BECK	1	1
9.	*Cardium papillosum* (POLI)	3	1
10.	*Cuspidaria sp.*	1	.
11.	*Siphonodentalium cf. lobatum* (SOWERBY)	1	.
12.	*Turritella tricarinata* (BROCCHI)	4	.
13.	*Gemmula badensis* (R. HÖRNES)	1	.
14.	*Spiratella atlanta* (MØRCH)	2	.
	In all:	30	3

Region II

Table 30. **Vester Høgild, Fasterholt Plantage and Sandfeldbjerg**

		Vester Høgild (95.1510b) 3.9–5.7 m.	Fasterholt Plantage (95.849) 4.1–14.0 m.	Sandfeldbjerg (clay pit) leg. E. Dalgas 1869
1.	*Limopsis aurita* (BROCCHI)	1	.	.
2.	*Astarte reimersi* SEMPER	7	3	2
3.	*Cardita orbicularis* (SOWERBY)	4	.	.
4.	*Isocardia forchhammeri* BECK	.	1	.
5.	*Pygocardia rustica* (SOWERBY)	.	.	2
6.	*Turritella tricarinata* (BROCCHI)	1	.	1
7.	*Xenophora sp.*	.	.	1
8.	*Polinices protracta* (EICHWALD)	.	.	1
9.	?*Natica koeneni* SACCO	.	.	1
10.	*Galeodea echinophora* (L.)	1	.	.
11.	*Sipho distinctus* (BEYRICH)	.	.	3
12.	*Aquilofusus semiglaber* (BEYRICH)	.	.	2
13.	*Narona rothi* (SEMPER)	.	.	1
14.	*Conus antediluvianus* BRUGUIÈRE	.	.	1
15.	*Gemmula annae* (HOERN. & AUINGER)	.	.	4
16.	*Bathytoma cataphracta* (BROCCHI)	.	.	1
17.	*Acamptogenotia intorta* (BROCCHI)	.	.	2
18.	*Retusa elongata* (EICHWALD)	1	.	.
19.	*Spiratella atlanta* (MØRCH)	1	?1	.
	In all:	16	5	22

Table 31. **Brande Brickworks**

		Collections 1947, 1961–63		Sample of clay							
				Fraction 1 > 2.5 mm		Fraction 2		Fraction 3 < 0.5 mm		Total number	
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
1.	*Nucula sp.*	9	5.6	1	2.0	25	5.7	12	6.7	38	5.7
2.	*Nuculana pygmaea* (MÜNSTER)	8	5.0	.	.	147	33.4	43	23.9	190	28.4
3.	*Yoldia glaberrima* (MÜNSTER)	2	1.3	2	4.1	18	4.1	3	1.7	23	3.4
4.	*Limopsis aurita* (BROCCHI)	1	0.6	.	.	.	.	.	.	.	.
5.	*Volsella phaseolina* (PHILIPPI)	.	.	.	.	1	0.2	.	.	1	0.1
6.	*Chlamys clavata* (POLI)	3	1.9	.	.	1	0.2	.	.	1	0.1
7.	*Astarte reimersi* SEMPER	33	20.6	15	30.6	21	4.8	4	2.2	40	6.0
8.	*Goodallia esbjergensis nov. sp.*	1	0.6	.	.	.	.	.	.	.	.
9.	*Isocardia forchhammeri* BECK	9	5.6	.	.	1	0.2	.	.	1	0.1
10.	*Thyasira cf. flexuosa* (MONTAGU)	.	.	1	2.0	2	0.5	.	.	3	0.4
11.	*Cardium papillosum* (POLI)	3	1.9	.	.	28	6.4	8	4.4	36	5.4

Table 31 (continued) Brande Brickworks (continued)

		Collections 1947, 1961–63		Sample of clay							
				Fraction 1 > 2.5 mm		Fraction 2		Fraction 3 < 0.5 mm		Total number	
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
12.	*Cardium sp.*	2	1.2	1	2.0	.	.	.	.	1	0.1
13.	*Spisula subtruncata* (DA COSTA)	1	0.6	.	.	1	0.2	.	.	1	0.1
14.	*Abra cf. prismatica* (MONTAGU)	.	.	.	.	11	2.5	3	1.7	14	2.1
15.	*Thracia cf. ventricosa* PHILIPPI	.	.	1	2.0	1	0.2	.	.	2	0.3
16.	*Cuspidaria cuspidata* (OLIVI)	1	0.6	.	.	2	0.5	.	.	2	0.3
17.	*Siphonodentalium cf. lobatum* (SOWERBY)	2	1.3	1	2.0	24	5.5	8	4.4	33	4.9
18.	*Circulus hennei* GLIBERT	.	.	.	.	2	0.5	.	.	2	0.3
19.	*Putilla gottscheana* (v. KOENEN)	1	0.6	.	.	26	5.9	77	42.8	103	15.4
20.	*Archimediella cochlias* (BAYAN)	3	1.9	9	18.4	11	2.5	.	.	20	3.0
21.	*Turritella tricarinata* (BROCCHI)	7	4.4	3	6.1	.	.	2	1.1	5	0.7
22.	*Leiostraca glabra* (DA COSTA)	1	0.6	.	.	1	0.2	.	.	1	0.1
23.	*Natica koeneni* SACCO	1	0.6	.	.	2	0.5	.	.	2	0.3
24.	*Polinices sp.*	12	7.5	2	4.1	37	8.4	6	3.3	45	6.7
25.	*Semicassis miolaevigata* (SACCO)	3	1.9	.	.	.	.	.	.	.	.
26.	*Murex spinicosta* BRONN	1	0.6	.	.	1	0.2	.	.	1	0.1
27.	*Lyrotyphis sejunctus* (SEMPER)	.	.	1	2.0	1	0.2	.	.	2	0.3
28.	*Sipho distinctus* (BEYRICH)	4	2.5	1	2.0	.	.	.	.	1	0.1
29.	*Nassa bocholtensis* (BEYRICH)	1	0.6	.	.	2	0.5	.	.	2	0.3
30.	*Nassa syltensis* (BEYRICH)	.	.	1	2.0	1	0.2	.	.	2	0.3
31.	*Aquilofusus semiglaber* (BEYRICH)	9	5.6	.	.	.	.	.	.	.	.
32.	*Narona rothi* (SEMPER)	1	0.6	.	.	1	0.2	.	.	1	0.1
33.	*Admete fusiformis* (CANTRAINE)	1	0.6	.	.	3	0.7	1	0.6	4	0.6
34.	*Conus antediluvianus* BRUGUIÈRE	10	6.3	2	4.1	1	0.2	.	.	3	0.4
35.	*Gemmula badensis* (R. HOERNES)	10	6.2	4	8.2	1	0.2	.	.	5	0.7
36.	*Gemmula annae* (HOERN. & AUING.)	4	2.5	.	.	.	.	.	.	.	.
37.	*Bathytoma cataphracta* (BROCCHI)	4	2.5	1	2.0	.	.	.	.	1	0.1
38.	*Brachytoma obtusangula* (BROCCHI)	1	0.6	3	6.1	4	0.9	.	.	7	1.0
39.	*Neoguraleus kochi* (v. KOENEN)	2	1.2	.	.	2	0.5	.	.	2	0.3
40.	*Pleurotomoides luisae* (SEMPER)	.	.	.	.	3	0.7	.	.	3	0.4
41.	*Philbertia reticulata* (RENIERI)	1	0.6	.	.	.	.	.	.	.	.
42.	*Chrysallida semireticulata* SORGENFREI	.	.	.	.	1	0.2	.	.	1	0.1
43.	*Odostomia conoidea* (BROCCHI)	6	3.7	.	.	14	3.1	3	1.7	17	2.5
44.	*Eulimella scillae* (SCACCHI)	.	.	.	.	1	0.2	.	.	1	0.1
45.	*Turbonilla sp.*	1	0.6	.	.	.	.	1	0.6	1	0.1
46.	*Ringicula buccinea* (BROCCHI)	.	.	.	.	2	0.5	.	.	2	0.3
47.	*Cylichna cylindracea* (PENNANT)	1	0.6	.	.	.	.	.	.	.	.
48.	*Retusa sp.*	.	.	.	.	4	0.9	2	1.1	6	0.9
49.	*Spiratella atlanta* (MØRCH)	.	.	.	.	34	7.7	4	2.2	38	5.7
–	Pelecypoda indet.	.	.	.	.	1	0.2	3	1.7	4	0.6
	In all:	160	99.6	49	99.7	439	99.7	180	100.1	668	98.9

Table 32. **Drantum. 104.1241**

		36.0–40.0 m.		40.0–44.0 m.		46.0–50.0 m.		51.4–51.8 m.	
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
1.	*Nucula georgiana* SEMPER	14	2.2	5	1.7	1	0.8	.	.
2.	*Nuculana pygmaea* (MÜNSTER)	140	21.5	80	27.8	2	1.6	1	2.4
3.	*Yoldia glaberrima* (MÜNSTER)	35	5.4	9	3.1	.	.	.	.
4.	*Limopsis aurita* (BROCCHI)	3	0.5	.	.	3	2.4	.	.
5.	*Chlamys clavata* (POLI)	1	0.2	.	.	.	.	.	.
6.	*Astarte reimersi* SEMPER	26	4.0	24	8.3	16	12.7	9	22.0
7.	*Goodallia esbjergensis nov. sp.*	1	0.2	.	.	2	1.6	19	46.3
8.	*Cardita orbicularis* (SOWERBY)	.	.	.	.	2	1.6	.	.
9.	*Isocardia forchhammeri* BECK	2	0.3	4	1.4	.	.	1	2.4
10.	*Thyasira sp.*	1	0.2	.	.	.	.	.	.
11.	*Cardium papillosum* (POLI)	58	8.9	45	15.6	2	1.6	3	7.3
12.	*Spisula subtruncata* (DA COSTA)	3	0.5	2	0.7	.	.	.	.
13.	*Abra sp.*	7	1.1	8	2.8	.	.	4	9.8
14.	*Varicorbula gibba* (OLIVI)	.	.	.	.	1	0.8	.	.
15.	*Thracia sp.*	2	0.4	1	0.3	.	.	.	.
16.	*Cuspidaria cuspidata* (OLIVI)	1	0.2	1	0.3	.	.	.	.
17.	*Siphonodentalium cf. lobatum* (SOWERBY)	35	5.4	6	2.1	1	0.8	.	.
18.	*Circulus hennei* GLIBERT	1	0.2	1	0.3	.	.	.	.
19.	*Putilla gottscheana* (v. KOENEN)	4	0.6	1	0.3	.	.	.	.
20.	*Archimediella cochlias* (BAYAN)	11	1.7	2	0.7	35	27.8	.	.
21.	*Archimediella subangulata* (BROCCHI)	.	.	.	.	8	6.3	.	.
22.	*Turritella tricarinata* (BROCCHI)	23	3.5	9	3.1	.	.	.	.
23.	*Opalia vilandti* (MØRCH)	1	0.2	.	.	.	.	.	.
24.	*Natica spp.*	62	9.5	16	5.6	3	2.4	.	.
25.	?*Galeodea sp.*	1	0.2	.	.	.	.	.	.
26.	*Semicassis miolaevigata* (SACCO)	.	.	.	.	1	0.8	.	.
27.	*Ficus sp.*	.	.	.	.	.	.	1	2.4
28.	?*Murex sp.*	1	0.2	.	.	.	.	.	.
29.	*Lyrotyphis sejunctus* (SEMPER)	3	0.5	3	1.0	2	1.6	.	.
30.	*Sipho distinctus* (BEYRICH)	1	0.2	.	.	2	1.6	.	.
31.	*Nassa bocholtensis* (BEYRICH)	2	0.3	.	.	.	.	.	.
32.	*Nassa syltensis* (BEYRICH)	2	0.3	1	0.3	1	0.8	.	.
33.	*Aquilofusus semiglaber* (BEYRICH)	.	.	.	.	1	0.8	.	.
34.	*Uromitra cimbrica* (OPPENHEIM)	.	.	.	.	1	0.8	.	.
35.	*Admete fusiformis* (CANTRAINE)	6	0.9	.	.	.	.	.	.
36.	*Conus antediluvianus* BRUGUIÈRE	8	1.2	1	0.3	2	1.6	.	.
37.	*Gemmula badensis* (R. HÖRNES)	16	2.5	6	2.1	14	11.1	1	2.4
38.	*Gemmula annae* (HÖRNES & AUINGER)	7	1.1	4	1.4	2	1.6	.	.
39.	*Bathytoma cataphracta* (BROCCHI)	1	0.2	2	0.7	3	2.4	.	.
40.	*Spirotropis modiola* (JAN)	?1	0.2	.	.	1	0.8	.	.
41.	*Brachytoma obtusangula* (BROCCHI)	6	0.9	3	1.0	5	4.0	.	.
42.	*Neoguraleus kochi* (SEMPER)	14	2.2	1	0.3	1	0.8	.	.
43.	*Pleurotomoides luisae* (SEMPER)	6	0.9	2	0.7	4	3.2	.	.
44.	*Philbertia reticulata* (RENIERI)	2	0.3	1	0.3	.	.	.	.
45.	*Philbertia sinuosula* SORGENFREI	.	.	.	.	1	0.8	.	.
46.	*Acteon sp.*	2	0.3	.	.	.	.	.	.
47.	*Odostomia conoidea* (BROCCHI)	69	10.6	9	3.1	2	1.6	.	.

Table 32 (continued) Drantum. 104.1241 (continued)

		36.0–40.0 m. Number	36.0–40.0 m. Percentage	40.0–44.0 m. Number	40.0–44.0 m. Percentage	46.0–50.0 m. Number	46.0–50.0 m. Percentage	51.4–51.8 m. Number	51.4–51.8 m. Percentage
48.	*Eulimella sp.*	1	0.2	.	.	.	.	.	.
49.	*Leiostraca sp.*	1	0.2	.	.	.	.	.	.
50.	*Chrysallida pygmaea* (GRATELOUP)	2	0.3	.	.	.	.	.	.
51.	*Turbonilla costellata* (SACCO)	7	1.1	.	.	1	0.8	.	.
52.	*Retusa elongata* (EICHWALD)	6	0.9	1	0.3	.	.	.	.
53.	*Spiratella atlanta* (MØRCH)	53	8.1	39	13.5	6	4.8	2	4.9
–	Pelecypoda indet.	2	0.3	1	0.3	.	.	.	.
	In all:	651	100.8	288	99.4	126	100.3	41	99.9

Table 33. **Nyholm. 104.1166**

		4.2– 5.2 m.	5.2– 6.2 m.	6.2– 7.2 m.	7.2– 8.2 m.	8.2– 9.2 m.	9.2–10.2 m.	10.2–11.2 m.	11.2–12.2 m.	12.2–13.2 m.	13.2–14.2 m.	14.2–15.2 m.	15.2–16.2 m.	16.2–17.2 m.	17.2–18.2 m.	18.2–19.2 m.	19.2–20.2 m.	22.6–23.5 m.	Total number
1.	*Nucula sp.*	.	.	.	.	.	1	1	.	2	1	.	1	.	1	1	.	1	9
2.	*Nuculana pygmaea* (MÜNSTER)	2	1	3	1	2	2	5	2	4	.	1	1	1	.	.	.	4	29
3.	*Yoldia glaberrima* (MÜNSTER)	1	.	1	1	.	.	1	.	.	.	.	.	.	.	.	.	1	5
4.	*Limopsis aurita* (BROCCHI)	1	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	2
5.	*Astarte reimersi* SEMPER	.	.	.	.	.	?1	2	.	.	.	1	2	.	1	.	1	1	9
6.	*Goodallia esbjergensis nov. sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1
7.	*Cardita orbicularis* (SOWERBY)	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	.	.	3
8.	*Thyasira sp.*	.	.	.	.	.	.	.	1	.	.	1	.	.	.	.	.	.	2
9.	*Cardium papillosum* (POLI)	1	.	.	1	.	.	1	1	.	1	1	1	.	.	.	.	1	8
10.	*Abra cf. prismatica* (MONTAGU)	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	1	3
11.	*Thracia cf. ventricosa* PHILIPPI	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1
12.	*Siphonodentalium cf. lobatum* (SOWERBY)	1	2	.	.	2	.	1	1	1	.	1	1	.	.	1	.	2	13
13.	*Archimediella cochlias* (BAYAN)	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1
14.	*Turritella sp.*	.	.	.	.	.	.	.	.	.	1	1	1	.	.	1	.	.	4
15.	Naticidae indet.	.	1	1	2	1	.	.	.	1	1	.	.	.	.	.	.	1	8
16.	*Nassa syltensis* (BEYRICH)	.	.	.	.	?1	.	.	1	.	.	.	.	.	.	.	.	.	2
17.	*Aquilofusus sp.*	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
18.	*Uromitra cimbrica* (OPPENHEIM)	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	1
19.	*Gemmula badensis* (R. HOERNES)	.	.	.	.	.	.	1	.	.	?1	.	1	.	1	.	.	.	4
20.	*Pleurotomoides luisae* (SEMPER)	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
21.	*Neoguraleus kochi* (v. KOENEN)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
22.	*Odostomia conoidea* (BROCCHI)	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3
23.	*Turbonilla sp.*	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1
24.	*Ringicula buccinea* (BROCCHI)	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	2
25.	*Retusa cf. elongata* (EICHWALD)	.	.	.	?1	1	.	.	.	.	.	.	.	.	.	.	.	.	2
26.	*Spiratella atlanta* (MØRCH)	.	.	.	.	.	.	.	.	.	.	.	1	.	2	.	.	.	3
	In all:	6	6	7	7	7	5	12	6	8	5	7	11	1	11	5	1	14	119

Table 34. **Store Langkjær and Hjortsballe**

		Store Langkjær (104.1158)				Hjortsballe (105.320) 3.4–8.2 m
		10.1–11.1 m.	12.1–13.1 m.	13.1–14.1 m.	Total number	
1.	*Nucula georgiana* SEMPER	.	.	.	.	1
2.	*Nuculana pygmaea* (MÜNSTER)	.	1	.	1	4
3.	*Limopsis aurita* (BROCCHI)	1	.	.	1	4
4.	*Astarte reimersi* SEMPER	2	1	.	3	23
5.	*Goodallia esbjergensis nov. sp.*	.	2	.	2	1
6.	*Cardita orbicularis* (SOWERBY)	.	.	.	.	9
7.	*Cardium sp.*	.	.	1	1	.
8.	*Spisula subtruncata* (DA COSTA)	.	.	1	1	.
9.	*Thracia cf. ventricosa* PHILIPPI	.	1	.	1	.
10.	*Siphonodentalium cf. lobatum* (SOWERBY)	1	.	.	1	.
11.	*Putilla gottscheana* (V. KOENEN)	1	.	.	1	.
12.	*Turritella tricarinata* (BROCCHI)	.	.	.	.	7
13.	*Polinices sp.*	.	.	.	.	1
14.	*Lyrotyphis sejunctus* (SEMPER)	.	.	.	.	1
15.	*Admete fusiformis* (CANTRAINE)	.	.	.	.	1
16.	*Conus antediluvianus* BRUGUIÈRE	.	.	.	.	1
17.	*Gemmula badensis* (R. HOERNES)	.	.	.	.	2
18.	*Bathytoma cataphracta* (BROCCHI)	.	.	.	.	1
19.	*Asthenotoma ravni nov. sp.*	.	.	.	.	1
20.	*Brachytoma obtusangula* (BROCCHI)	.	.	.	.	4
21.	*Pleurotomoides luisae* (SEMPER)	.	.	.	.	1
22.	*Retusa elongata* (EICHWALD)	.	.	.	.	1
23.	*Spiratella atlanta* (MØRCH)	.	.	1	1	2
	In all:	5	5	3	13	65

Table 35. **Skjerris gårde. 104.1165**

		7.5–8.5 m.	8.5–9.5 m.	9.5–10.5 m.	10.5–11.5 m.	11.5–12.5 m.	13.5–14.5 m.	Total number
1.	*Nuculana pygmaea* (MÜNSTER)	.	2	.	5	.	.	7
2.	*Astarte reimersi* SEMPER	.	1	1	2	?1	2	7
3.	*Goodallia esbjergensis nov. sp.*	.	.	.	.	1	.	1
4.	*Cardita orbicularis* (SOWERBY)	.	.	.	.	1	.	1
5.	*Isocardia forchhammeri* BECK	.	1	.	.	.	.	1
6.	*Cardium papillosum* (POLI)	.	1	.	.	.	.	1
7.	*Abra cf. prismatica* (MONTAGU)	.	.	.	.	1	.	1
8.	*Siphonodentalium cf. lobatum* (SOWERBY)	.	1	.	.	.	.	1
9.	*Archimediella cochlias* (BAYAN)	1	.	.	1	.	.	2
10.	*Turritella tricarinata* (BROCCHI)	.	1	.	.	.	.	1
11.	*Brachytoma obtusangula* (BROCCHI)	.	.	.	.	1	.	1
12.	*Spiratella atlanta* (MØRCH)	.	3	.	.	.	.	3
–	Pelecypoda indet.	.	.	.	.	1	.	1
	In all:	1	10	1	8	6	2	28

Region III

Table 36. **Leding. 93.155**

		10–12 m.	12–14 m.	16–17 m.	17–18 m.	18–19 m.	Total number
1.	*Nucula sp.*	1	.	1	.	.	2
2.	*Nuculana pygmaea* (MÜNSTER)	1	1	1	1	.	4
3.	*Limopsis aurita* (BROCCHI)	.	.	1	.	.	1
4.	*Astarte vetula* PHILIPPI	.	.	.	.	1	1
5.	*Astarte reimersi* SEMPER	2	1	2	1	.	6
6.	*Goodallia esbjergensis nov. sp.*	.	.	2	.	.	2
7.	*Cardita orbicularis* (SOWERBY)	1	4	1	.	1	7
8.	*Isocardia forchhammeri* BECK	1	.	.	.	.	1
9.	*Abra cf. prismatica* (MONTAGU)	.	.	.	1	.	1
10.	*Siphonodentalium cf. lobatum* (SOWERBY)	.	.	1	.	.	1
11.	*Putilla gottscheana* (v. KOENEN)	1	.	.	1	.	2
12.	?*Archimediella cochlias* (BAYAN)	1	.	.	1	.	2
13.	*Turritella tricarinata* (BROCCHI)	.	.	.	.	2	2
14.	*Natica koeneni* SACCO	.	.	.	.	1	1
–	Naticidae indet.	.	.	1	.	.	1
15.	*Brachytoma obtusangula* (BROCCHI)	.	1	.	.	.	1
16.	*Pleurotomoides luisae* (SEMPER)	.	1	.	.	.	1
17.	*Spiratella atlanta* (MØRCH)	1	.	.	2	1	4
	In all:	9	8	10	7	6	40

Table 37. **Alkærsig Brickworks**

		Clay pit		Borehole 93.101				
		Early coll.	leg. L.B.R. 1948	7.0 m.	8.0 m.	8.5 m.	9.0 m.	10.0 m.
1.	*Nucula georgiana* SEMPER	3	2	.	.	.	.	.
2.	*Nuculana pygmaea* (MÜNSTER)	1	.	.	.	.	.	.
3.	*Limopsis aurita* (BROCCHI)	30	3	.	.	.	.	.
4.	*Chlamys clavata* (POLI)	3	1	.	.	.	.	.
5.	*Astarte reimersi* SEMPER	73	29	.	1	2	1	1
6.	*Goodallia esbjergensis nov. sp.*	2	3	.	.	.	1	1
7.	*Cardita orbicularis* (SOWERBY)	3	4	.	.	.	1	.
8.	*Isocardia forchhammeri* BECK	4	2	.	.	.	.	.
9.	*Thyasira cf. flexuosa* (MONTAGU)	2	.	.	.	.	.	.
10.	*Cardium papillosum* (POLI)	.	.	.	1	1	1	.
11.	*Abra cf. prismatica* (MONTAGU)	.	.	.	1	.	.	.
12.	*Teredo sp.*	.	1	.	.	.	.	.
13.	*Siphonodentalium cf. lobatum* (SOWERBY)	1	.	.	.	.	.	.

Table 37 (continued) Alkærsig Brickworks (continued)

		Clay pit		Borehole 93.101				
		Early coll.	leg. L.B.R. 1948	7.0 m.	8.0 m.	8.5 m.	9.0 m.	10.0 m.
14.	*Archimediella cochlias* (BAYAN)	45	2	.	1	5	.	1
15.	*Turritella tricarinata* (BROCCHI)	.	1	.	.	.	.	.
16.	*Xenophora testigera* BRONN	.	1	.	.	.	.	.
17.	*Aporrhais alata* (EICHWALD)	1	.	.	.	.	.	.
18.	*Polinices catena* (DA COSTA)	1	1	.	.	.	.	.
–	Naticidae indet.	1	3	.	1	.	.	.
19.	*Galeodea echinophora* (L.)	2	1	.	.	.	.	1
20.	*Sipho distinctus* (BEYRICH)	12	1	.	.	.	.	.
21.	*Nassa bocholtensis* (BEYRICH)	1	1	.	.	.	.	.
22.	*Aquilofusus eximius* (BEYRICH)	.	1	.	.	.	.	.
23.	*Aquilofusus semiglaber* (BEYRICH)	4	1	.	.	.	.	.
24.	*Aquilofusus puggaardi* (BEYRICH)	7	1	.	.	.	.	.
25.	*Uromitra cimbrica* (OPPENHEIM)	2	.	.	.	.	.	.
26.	*Narona rothi* (SEMPER)	.	1	.	.	.	.	.
27.	*Conus antediluvianus* BRUGUIÈRE	3	2	.	.	.	.	.
28.	*Gemmula badensis* (R. HÖRNES)	2	5	.	.	.	.	.
29.	*Gemmula annae* (HÖRN. & AUING.)	3	4	.	.	.	.	.
30.	*Bathytoma cataphracta* (BROCCHI)	7	1	.	.	.	.	.
31.	*Spirotropis modiola* (JAN)	2	.	.	.	.	.	.
32.	*Brachytoma obtusangula* (BROCCHI)	1	2	.	.	.	.	.
33.	*Ringicula buccinea* (BROCCHI)	1	.	.	.	.	.	.
34.	*Spiratella atlanta* (MØRCH)	.	.	1	.	.	.	.
	In all:	217	74	1	5	8	4	4

Table 38. **Lønborg. 102.55**

		6.3–7.3 m.	7.3–8.3 m.	8.3–9.3 m.	9.3–10.3 m.	10.3–11.3 m.	11.3–12.3 m.	12.3–13.3 m.	Total number
1.	*Nucula georgiana* SEMPER	.	1	1	1	1	1	.	5
–	*Nucula sp.*	1	.	.	.	.	.	.	1
2.	*Nuculana pygmaea* (MÜNSTER)	?1	2	2	1	.	3	.	9
3.	*Astarte reimersi* SEMPER	?1	2	.	2	1	1	1	8
4.	*Goodallia esbjergensis nov. sp.*	2	.	.	.	.	.	.	2
5.	*Cardita orbicularis* (SOWERBY)	2	.	.	1	1	1	.	5
6.	*Isocardia forchhammeri* BECK	.	.	.	1	.	.	.	1
7.	*Abra cf. prismatica* (MONTAGU)	.	1	.	.	.	.	.	1
8.	*Siphonodentalium cf. lobatum* (SOWERBY)	.	1	.	.	.	.	.	1
9.	*Turritella tricarinata* (BROCCHI)	?1	1	.	.	.	?1	.	3
10.	Naticidae indet.	1	.	1	.	2	.	.	4

Table 38 (continued) Lønborg. 102.55 (continued)

		6.3–7.3 m.	7.3–8.3 m.	8.3–9.3 m.	9.3–10.3 m.	10.3–11.3 m.	11.3–12.3 m.	12.3–13.3 m.	Total number
11.	*Nassa bocholtensis* (BEYRICH)	?1	.	.	1	.	.	.	2
12.	*Gemmula badensis* (R. HOERNES) .	?1	.	.	.	1	.	.	2
13.	*Bathytoma cataphracta* (BROCCHI)	.	.	.	.	1	.	.	1
14.	*Brachytoma obtusangula* (BROCCHI)	.	.	.	.	.	1	.	1
15.	*Retusa elongata* (EICHWALD)	.	.	.	.	1	.	.	1
16.	*Spiratella atlanta* (MØRCH)	1	2	1	.	4	.	.	8
–	Mollusca indet.	.	3	.	.	2	.	.	5
	In all:	12	13	5	7	14	8	1	60

Table 39. **Forsum Brickworks**

		Old clay pit	New clay pit	Sample of clay (partly weathered) from the new clay pit
1.	*Nucula georgiana* SEMPER	1	1	.
2.	*Nuculana pygmaea* (MÜNSTER)	.	.	2
3.	*Limopsis aurita* (BROCCHI)	.	1	.
4.	*Chlamys clavata* (POLI)	.	1	1
5.	*Astarte reimersi* SEMPER	1	14	8
6.	*Cardita orbicularis* (SOWERBY)	.	1	2
7.	*Isocardia forchhammeri* BECK	1	1	2
8.	*Turritella tricarinata* (BROCCHI)	.	.	2
9.	*Archimediella cochlias* (BAYAN)	.	2	.
10.	*Natica sp.*	.	1	3
11.	*Galeodea echinophora* (L.)	.	1	.
12.	*Sipho distinctus* (BEYRICH)	.	1	.
13.	*Nassa bocholtensis* (BEYRICH)	.	1	2
14.	*Aquilofusus semiglaber* (BEYRICH)	.	1	.
15.	*Gemmula badensis* (HÖRNES)	.	1	1
16.	*Brachytoma obtusangula* (BROCCHI)	.	1	1
17.	*Odostomia conoidea* (BROCCHI)	.	.	2
	In all:	3	28	26

Table 40. **Odderup. 103.150**

		14.5–20.0 m.	Percentage	20.0–21.0 m.	Percentage
1.	*Nucula georgiana* SEMPER	4	1.9	.	.
2.	*Nuculana pygmaea* (MÜNSTER)	16	7.6	1	1.1
3.	*Yoldia glaberrima* (MÜNSTER)	1	0.5	1	1.1
4.	*Limopsis aurita* (BROCCHI)	1	0.5	2	2.1
5.	*Limopsis anomala* (EICHWALD)	.	.	6	6.4
6.	*Astarte vetula* PHILIPPI	.	.	2	2.1
7.	*Astarte reimersi* SEMPER	41	19.5	10	10.6
8.	*Goodallia esbjergensis nov. sp.*	10	4.8	25	26.6
9.	*Cardita orbicularis* (SOWERBY)	6	2.9	7	7.4
10.	*Thyasira sp.*	1	0.5	.	.
11.	?*Laevicardium sp.*	.	.	1	1.1
12.	*Cardium papillosum* (POLI)	1	0.5	1	1.1
13.	*Abra prismatica* (MONTAGU)	3	1.4	.	.
14.	*Thracia sp.*	2	1.0	2	2.1
15.	*Siphonodentalium cf. lobatum* (SOWERBY)	3	1.4	2	2.1
16.	*Archimediella cochlias* (BAYAN)	14	6.7	.	.
17.	*Turritella tricarinata* (BROCCHI)	15	7.1	2	2.1
18.	*Opalia vilandti* (MØRCH)	1	0.5	.	.
19.	?*Aporrhais sp.*	.	.	1	1.1
20.	*Natica sp.*	21	10.0	6	6.4
21.	*Lyrotyphis sejunctus* (SEMPER)	3	1.4	.	.
22.	*Trophonopsis semperi* (v. KOENEN)	1	0.5	.	.
23.	*Sipho distinctus* (BEYRICH)	1	0.5	.	.
24.	*Nassa bocholtensis* (BEYRICH)	1	0.5	.	.
25.	*Aquilofusus puggaardi* (BEYRICH)	1	0.5	.	.
26.	*Narona rothi* (SEMPER)	1	0.5	.	.
27.	*Conus antediluvianus* BRUGUIÈRE	1	0.5	1	1.1
28.	*Gemmula badensis* (HÖRNES)	4	1.9	4	4.3
29.	*Gemmula annae* (HÖRN. & AUINGER)	2	1.0	.	.
30.	*Brachytoma obtusangula* (BROCCHI)	3	1.4	4	4.3
31.	*Neoguraleus kochi* (v. KOENEN)	1	0.5	.	.
32.	*Pleurotomoides luisae* (SEMPER)	4	1.9	.	.
33.	*Philbertia reticulata* (RENIERI)	.	.	1	1.1
34.	*Odostomia conoidea* (BROCCHI)	12	5.7	.	.
35.	*Eulimella scillae* (SCACCHI)	1	0.5	.	.
36.	*Turbonilla sp.*	.	.	1	1.1
37.	*Ringicula buccinea* (BROCCHI)	1	0.5	1	1.1
38.	*Cylichna cylindracea* (PENNANT)	2	1.0	.	.
39.	*Diaphana moerchi nov. sp.*	.	.	1	1.1
40.	*Retusa elongata* (EICHWALD)	2	1.0	?1	1.1
41.	*Spiratella atlanta* (MØRCH)	29	13.8	11	11.7
	In all:	210	100.4	94	100.3

Table 41. **Oddum, Harkes, Østbæk and Stenderup**

		Oddum lignite pit	Harkes brick-works pit	Østbæk (103.152) 25.0 m.	Stenderup (113.36) 18.0–23.1 m.	Stenderup (113.36) 23.1–27.1 m.
1.	*Nucula georgiana* SEMPER	.	2	.	.	.
–	*Nucula sp.*	.	.	.	1	.
2.	*Nuculana pygmaea* (MÜNSTER)	.	5	.	.	.
3.	*Yoldia glaberrima* (MÜNSTER)	.	3	.	1	.
4.	*Astarte reimersi* SEMPER	2	6	2	1	.
5.	*Cardita cf. orbicularis* (SOWERBY)	.	.	1	.	.
6.	*Isocardia forchhammeri* BECK	.	1	.	.	.
7.	*Montacuta sp.*	.	1	.	.	.
8.	*Siphonodentalium cf. lobatum* (SOWERBY)	.	2	.	1	.
9.	*Archimediella cochlias* (BAYAN)	2	.	.	.	.
10.	*Turritella tricarinata* (BROCCHI)	.	12	.	1	1
11.	Naticidae indet.	.	3	.	.	.
12.	*Sipho distinctus* (BEYRICH)	.	3	.	.	.
13.	*Nassa bocholtensis* (BEYRICH)	.	2	.	.	.
14.	*Conus antediluvianus* BRUGUIÈRE	.	2	.	.	.
15.	*Gemmula badensis* (R. HOERNES)	.	6	.	.	.
16.	*Gemmula annae* (HOERN. & AUINGER)	.	7	.	.	.
17.	*Bathytoma cataphracta* (BROCCHI)	.	3	.	1	.
18.	*Brachytoma obtusangula* (BROCCHI)	.	2	.	.	.
19.	*Pleurotomoides luisae* (SEMPER)	.	1	.	.	.
20.	*Odostomia conoidea* (BROCCHI)	.	5	.	.	.
21.	*Ringicula buccinea* (BROCCHI)	1	.	.	.	.
	In all:	5	66	3	6	1

Table 42. **Ålbæk Eng. 102.59**

		18.8–19.8 m.	19.8–20.8 m.	20.8–21.8 m.	21.8–22.8 m.	22.8–23.8 m.	23.8–24.8 m.	24.8–25.8 m.	25.8–26.8 m.	Total number
1.	*Nucula sp.*	1	.	.	.	.	.	1	.	2
2.	*Nuculana pygmaea* (MÜNSTER)	2	1	3	1	1	1	1	.	10
3.	*Astarte reimersi* SEMPER	1	1	1	1	1	2	1	1	9
4.	*Cardita orbicularis* (SOWERBY)	1	1	.	.	.	.	.	.	2
5.	*Cardium papillosum* (POLI)	.	.	.	.	2	.	.	.	2
6.	*Abra cf. prismatica* (MONTAGU)	.	.	1	.	1	.	.	.	2
7.	*Siphonodentalium cf. lobatum* (SOW.)	.	.	.	2	2	1	1	.	6
8.	*Dentalium cf. michelotti* HÖRNES	.	1	.	.	.	.	.	.	1
9.	*Putilla gottscheana* (v. KOENEN)	.	.	.	.	2	.	2	.	4
10.	*Turritella tricarinata* (BROCCHI)	.	.	1	1	.	.	.	.	2
11.	*Leiostraca sp.*	.	.	.	.	.	1	.	.	1

Table 42 (continued) Ålbæk Eng. 102.59 (continued)

		18.8–19.8 m.	19.8–20.8 m.	20.8–21.8 m.	21.8–22.8 m.	22.8–23.8 m.	23.8–24.8 m.	24.8–25.8 m.	25.8–26.8 m.	Total number
12.	*Natica sp.*	.	1	1	.	.	.	.	.	2
13.	?*Aquilofusus sp.*	.	.	.	.	.	.	1	.	1
14.	*Gemmula badensis* (Hörnes)	.	1	.	.	.	.	.	.	1
15.	*Brachytoma obtusangula* (Brocchi)	.	.	.	1	.	1	.	.	2
16.	*Pleurotomoides luisae* (Semper)	.	.	.	.	.	1	.	.	1
17.	*Retusa elongata* (Eichwald)	.	.	.	.	1	.	.	.	1
18.	*Spiratella atlanta* (Mørch)	1	1	2	1	2	2	.	.	9
	In all:	6	7	9	7	12	9	7	1	58

Table 43. **Hesselho. 113.121**

		44.0–50.0 m.		50.0–56.0 m.		56.0–65.0 m.	
		Number of specimens	Percentage	Number of specimens	Percentage	Number of specimens	Percentage
1.	*Nucula georgiana* Semper	1	0.7	2	1.1	.	.
2.	*Nuculana pygmaea* (Münster)	15	9.8	17	9.5	2	1.2
3.	*Limopsis aurita* (Brocchi)	.	.	2	1.1	10	6.2
4.	*Chlamys clavata* (Poli)	1	0.7	1	0.6	.	.
5.	*Astarte reimersi* Semper	25	16.3	24	13.4	17	10.6
–	*Astarte sp.* indet.	.	.	.	.	5	3.1
6.	*Goodallia esbjergensis nov. sp.*	.	.	15	8.4	66	41.0
7.	*Cardita orbicularis* (Sowerby)	4	2.6	5	2.8	12	7.5
8.	*Isocardia forchhammeri* Beck	1	0.7	.	.	.	.
9.	*Thyasira sp.*	.	.	2	1.1	.	.
10.	*Cardium papillosum* (Poli)	.	.	1	0.6	.	.
11.	*Thracia sp.*	.	.	1	0.6	.	.
12.	*Siphonodentalium cf. lobatum* (Sowerby)	3	2.0	1	0.6	.	.
13.	*Archimediella cochlias* (Bayan)	.	.	33	18.4	11	6.8
14.	*Turritella tricarinata* (Brocchi)	18	11.8	.	.	5	3.1
15.	*Opalia vilandti* (Mørch)	.	.	1	0.6	.	.
16.	*Natica sp.*	18	11.8	9	5.0	7	4.3
17.	*Trophonopsis semperi* (v. Koenen)	.	.	1	0.6	.	.
18.	*Lyrotyphis sejunctus* (Semper)	1	0.7	2	1.1	.	.
19.	*Sipho distinctus* (Beyrich)	.	.	1	0.6	1	0.6
20.	*Nassa bocholtensis* (Beyrich)	1	0.7	4	2.2	.	.
21.	*Aquilofusus puggaardi* (Beyrich)	.	.	.	.	1	0.6
22.	*Narona rothi* (Semper)	.	.	1	0.6	.	.
23.	*Admete fusiformis* (Cantraine)	.	.	1	0.6	.	.

Table 43 (continued) Hesselho. 113.121 (continued)

		44.0–50.0 m.		50.0–56.0 m.		56.0–65.0 m.	
		Number of specimens	Percentage	Number of specimens	Percentage	Number of specimens	Percentage
24.	*Gemmula badensis* (R. HÖRNES)	8	5.2	2	1.1	3	1.9
25.	*Microdrillia serratula* (BELLARDI)	.	.	.	.	1	0.6
26.	*Brachytoma obtusangula* (BROCCHI)	3	2.0	8	4.5	2	1.2
27.	*Asthenotoma sp.*	.	.	.	.	1	0.6
28.	*Bathytoma cataphracta* (BROCCHI)	.	.	1	0.6	1	0.6
29.	*Pleurotomoides luisae* (SEMPER)	1	0.7	.	.	.	.
30.	*Philbertia sinuosula* SORGENFREI	.	.	.	.	1	0.6
31.	*Conus antediluvianus* BRUGUIÈRE	1	0.7	.	.	.	.
32.	*Odostomia conoidea* (BROCCHI)	8	5.2	7	3.9	2	1.2
33.	*Turbonilla costellata* GRATELOUP	.	.	2	1.1	1	0.6
34.	*Pyramidella plicosa* BRONN	.	.	2	1.1	.	.
35.	*Retusa elongata* (EICHWALD)	.	.	4	2.2	.	.
36.	*Spiratella atlanta* (MØRCH)	44	28.8	26	14.5	12	7.5
–	Gastr. indet.	.	.	1	0.6	.	.
–	Pelec. indet.	.	.	2	1.1	.	.
	In all:	153	100.4	179	100.2	161	99.8

Table 44. **Hauge**

		Collections in the clay pit			Sample of Gram Clay	
		Gram Clay		Glauconite Clay		
		Number	Percentage	Number	Number	Percentage
1.	*Nucula georgiana* SEMPER	4	1.2	2	9	1.9
2.	*Nuculana pygmaea* (MÜNSTER)	.	.	.	50	10.4
3.	*Limopsis aurita* (BROCCHI)	1	0.3	.	5	1.0
4.	*Chlamys clavata* (POLI)	3	0.9	1	.	.
5.	*Amussium sp.*	.	.	.	1	0.2
3.	*Astarte cf. vetula* PHILIPPI	.	.	3	.	.
7.	*Astarte reimersi* SEMPER	186	54.4	11	44	9.1
3.	*Goodallia esbjergensis nov. sp.*	.	.	.	146	30.2
9.	*Cardita orbicularis* (SOWERBY)	5	1.5	.	62	12.8
10.	*Isocardia forchhammeri* BECK	12	3.5	5	1	0.2
11.	*Cardium papillosum* (POLI)	.	.	.	6	1.2
12.	*Abra cf. prismatica* (MONTAGU)	.	.	.	3	0.6
13.	*Spisula subtruncata* (DA COSTA)	.	.	.	1	0.2
14.	*Varicorbula gibba* (OLIVI)	.	.	.	1	0.2
15.	*Thracia sp.*	.	.	.	1	0.2
16.	*Siphonodentalium cf. lobatum* (SOWERBY)	.	.	.	3	0.6

Table 44 (continued) Hauge. (continued)

		Collections in the clay pit			Sample of Gram Clay	
		Gram Clay		Glauconite Clay Number	Number	Percentage
		Number	Percentage			
17.	*Dentalium badense* PARTSCH	.	.	9	?1	0.2
18.	*Teinostoma pulchralis* (WOOD)	.	.	.	1	0.2
19.	*Circulus hennei* GLIBERT	1	0.3	1	.	.
20.	?*Lacuna sp.*	.	.	.	1	0.2
21.	*Putilla gottscheana* (V. KOENEN)	.	.	.	5	1.0
22.	*Cingula inusitata* (BEETS)	.	.	.	1	0.2
23.	*Archimediella cochlias* (BAYAN)	14	4.1	.	29	6.0
24.	*Turritella tricarinata* (BROCCHI)	2	0.6	6	.	.
25.	*Leiostraca sp.*	.	.	.	1	0.2
26.	*Polinices protracta* (EICHWALD)	.	.	1	.	.
27.	*Natica koeneni* SACCO	.	.	.	2	0.4
–	Naticidae indet.	4	1.2	.	15	3.1
28.	*Galeodea echinophora* (L.)	5	1.5	1	.	.
29.	*Lyrotyphis sejunctus* (SEMPER)	.	.	.	3	0.6
30.	*Sipho distinctus* (BEYRICH)	14	4.1	1	2	0.4
31.	*Nassa bocholtensis* (BEYRICH)	1	0.3	.	.	.
32.	*Aquilofusus semiglaber/eximius* (BEYRICH)	20	5.8	.	.	.
33.	*Aquilofusus puggaardi* (BEYRICH)	4	1.2	.	1	0.2
34.	*Uromitra cimbrica* (OPPENHEIM)	1	0.3	.	1	0.2
35.	*Narona rothi* (SEMPER)	2	0.6	.	.	.
36.	*Admete fusiformis* (CANTRAINE)	.	.	.	2	0.4
37.	*Conus antediluvianus* BRUGUIÈRE	7	2.3	2	.	.
38.	*Gemmula badensis* (HOERNES)	17	4.9	.	7	1.4
39.	*Gemmula annae* (HOERNES & AUINGER)	10	2.9	2	3	0.6
40.	*Bathytoma cataphracta* (BROCCHI)	23	6.7	1	1	0.2
41.	*Spirotropis modiola* (JAN)	.	.	.	1	0.2
42.	*Asthenotoma ravni nov. sp.*	.	.	.	1	0.2
43.	*Brachytoma obtusangula* (BROCCHI)	3	0.9	.	7	1.4
44.	*Neoguraleus kochi* (KOENEN)	.	.	.	1	0.2
45.	*Pleurotomoides luisae* (SEMPER)	3	0.9	.	3	0.6
46.	*Philbertia cf. sinuosula* SORGENFREI	.	.	.	1	0.2
47.	*Kleinella nordmanni* SORGENFREI	.	.	.	1	0.2
48.	?*Odostomia conoidea* (BROCCHI)	.	.	.	2	0.4
49.	*Turbonilla costellata* (GRATELOUP)	.	.	.	4	0.8
50.	*Pyramidella plicosa* BRONN	.	.	.	2	0.4
51.	*Ringicula buccinea* (BROCCHI)	.	.	.	20	4.1
52.	*Cylichna cylindracea* (PENNANT)	.	.	.	1	0.2
53.	*Retusa elongata* (EICHWALD)	.	.	.	5	1.0
54.	*Diaphana moerchi nov. sp.*	.	.	.	1	0.2
55.	*Spiratella atlanta* (MØRCH)	.	.	.	23	4.8
–	Pelecyp. indet.	.	.	.	1	0.2
	In all:	342	100.4	46	483	99.4

Table 45. **Tønding**

		Collections in the clay pit		Sample of Gram Clay	
		Number	Percentage	Number	Percentage
1.	*Nucula georgiana* SEMPER	2	1.2	.	.
	Nucula sp.	.	.	2	1.3
2.	*Nuculana pygmaea* (MÜNSTER)	1	0.6	15	9.6
3.	?*Pinna sp.*	.	.	1	0.6
4.	*Chlamys clavata* (POLI)	2	1.2	1	0.6
5.	*Astarte reimersi* SEMPER	107	62.9	26	16.6
6.	*Goodallia esbjergensis nov. sp.*	.	.	14	8.9
7.	*Cardita orbicularis* (SOWERBY)	1	0.6	7	4.5
8.	*Isocardia forchhammeri* BECK	2	1.2	.	.
9.	*Thyasira sp.*	.	.	1	0.6
10.	*Cardium papillosum* (POLI)	.	.	2	1.3
11.	*Abra cf. prismatica* (MONTAGU)	.	.	3	1.9
12.	*Teredo sp.*	.	.	1	0.6
13.	*Thracia sp.*	.	.	1	0.6
14.	*Siphonodentalium cf. lobatum* (SOWERBY)	.	.	3	1.9
15.	*Putilla gottscheana* (v. KOENEN)	.	.	11	7.0
16.	*Archimediella cochlias* (BAYAN)	7	4.1	8	5.1
17.	*Opalia vilandti* (MØRCH)	.	.	1	0.6
18.	*Natica koeneni* SACCO	2	1.2	.	.
	Naticidae indet.	.	.	7	4.5
19.	*Galeodea echinophora* (L.)	2	1.2	.	.
20.	*Sipho distinctus* (BEYRICH)	4	2.4	.	.
21.	*Aquilofusus semiglaber* (BEYRICH)	7	4.1	.	.
22.	*Aquilofusus puggaardi* (BEYRICH)	4	2.4	2	1.3
23.	*Conus antediluvianus* BRUGUIÈRE	6	3.5	.	.
24.	*Gemmula badensis* (R. HOERNES)	10	5.9	3	1.9
25.	*Gemmula annae* (HOERN. & AUING.)	4	2.4	.	.
26.	*Bathytoma cataphracta* (BROCCHI)	6	3.5	.	.
27.	*Asthenotoma ravni nov. sp.*	.	.	1	0.6
28.	*Brachytoma obtusangula* (BROCCHI)	1	0.6	4	2.5
29.	*Pleurotomoides luisae* (SEMPER)	1	0.6	2	1.3
30.	*Odostomia conoidea* (BROCCHI)	.	.	4	2.5
31.	*Ringicula buccinea* (BROCCHI)	.	.	1	0.6
32.	*Retusa elongata* (EICHWALD)	.	.	3	1.9
33.	*Diaphana moerchi nov. sp.*	.	.	1	0.6
34.	*Spiratella atlanta* (MØRCH)	.	.	27	17.2
	Mollusca indet.	1	0.6	5	3.2
	In all:	170	100.2	157	99.8

Table 46. **Karlsgårde Canal**

		Hoddemark Canal section	Grøde Canal section	Exact locality unknown	Hodde. Borehole 113.33.a. 9.0–10.0 m.
1.	*Nucula georgiana* SEMPER	1	1	1	.
2.	*Nuculana pygmaea* (MÜNSTER)	1	.	.	2
3.	*Limopsis aurita* (BROCCHI)	.	.	1	4
4.	*Chlamys clavata* (POLI)	1	.	2	.
5.	*Astarte vetula* PHILIPPI	.	.	.	10
6.	*Astarte reimersi* SEMPER	14	2	2	.
7.	*Goodallia esbjergensis nov. sp.*	.	.	.	13
8.	*Cardita orbicularis* (SOWERBY)	.	.	2	7
9.	*Isocardia forchhammeri* BECK	2	1	.	.
10.	*Cardium papillosum* (POLI)	.	.	.	1
11.	*Dentalium badense* PARTSCH	2	.	1	.
12.	*Teinostoma pulchralis* (WOOD)	.	.	.	1
13.	*Archimediella cochlias* (BAYAN)	8	1	2	.
14.	*Turritella tricarinata* (BROCCHI)	.	.	1	2
15.	*Xenophora testigera* BRONN	.	.	1	.
16.	*Aporrhais alata* (EICHWALD)	1	.	.	.
17.	*Natica koeneni* SACCO	.	.	1	.
18.	*Polinices catena* (DA COSTA)	.	.	1	?1
19.	*Galeodea echinophora* (L.)	2	1	1	.
20.	*Mitrella sp.*	.	.	1	.
21.	*Liomesus ventrosus* (BEYRICH)	.	.	1	.
22.	*Sipho distinctus* (BEYRICH)	4	.	1	.
23.	*Aquilofusus luneburgensis* (BEYRICH)	3	1	.	.
24.	*Aquilofusus semiglaber* (BEYRICH)	3	.	4	.
25.	*Aquilofusus puggaardi* (BEYRICH)	1	.	1	.
26.	*Aquilofusus sp.*	.	.	1	.
27.	*Lathyrus rothi* (BEYRICH)	1	.	1	.
28.	*Uromitra wirtzi* HINSCH	1	.	1	.
29.	*Scaphella bolli* (KOCH)	1	.	1	.
30.	*Narona rothi* (SEMPER)	.	.	1	.
31.	*Conus antediluvianus* BRUGUIÈRE	2	1	3	1
32.	*Gemmula badensis* (R. HÖRNES)	5	.	1	.
33.	*Gemmula annae* (HOERN. & AUING.)	.	.	1	.
34.	*Bathytoma cataphracta* (BROCCHI)	9	1	2	.
35.	*Acamptogenotia intorta* (BROCCHI)	.	.	1	.
36.	*Brachytoma obtusangula* (BROCCHI)	.	.	.	1
37.	*Pleurotomoides luisae* (SEMPER)	.	2	.	1
38.	*Spiratella atlanta* (MØRCH)	.	.	.	4
	In total:	62	11	37	48

Region IV

Table 47. **Esbjerg. 130.59**

		72.0 m.	72.5 m.	73.0–74.5 m.	75 m.	76.5–77.5 m.	78 m.	78.5 m.
1.	*Nucula sp.*	1	.	1	1	1	.	1
2.	*Limopsis aurita* (BROCCHI)	.	.	1	1	.	.	.
3.	*Astarte cf. vetula* PHILIPPI	.	1	1	.	.	.	.
4.	*Astarte reimersi* SEMPER	3	3	5	2	.	.	.
–	*Astarte sp.*	.	.	.	.	2	1	1
5.	*Cardita orbicularis* (SOWERBY)	1	1	1	.	?1	1	1
6.	*Isocardia sp.* (*cf. forchhammeri* BECK)	1	1	.	.	1	1	1
7.	*Varicorbula gibba* (OLIVI)	1	.	.	.	.	.	.
8.	*Thracia sp.*	.	.	.	.	1	.	.
9.	*Archimediella cochlias* (BAYAN)	.	1	.	.	1	2	.
10.	*Turritella tricarinata* (BROCCHI)	1	1	1	.	1	1	.
11.	Naticidae indet.	.	.	1	.	.	1	.
12.	?*Galeodea echinophora* (L.)	.	.	.	.	1	.	.
13.	*Lyrotyphis sejunctus* (SEMPER)	.	.	.	.	1	.	.
14.	*Nassa bocholtensis* (BEYRICH)	.	.	1	.	.	.	.
15.	*Nassa syltensis* (BEYR.) or *holsatica* (BEYR)	.	1	.	.	.	.	.
16.	*Nassa sp.* (*cf. cimbrica* RAVN)*)	.	.	1	.	.	.	.
17.	*Aquilofusus eximius* (BEYRICH)	.	.	1	.	.	.	.
18.	*Narona rothi* (SEMPER)	.	.	1	.	.	.	.
19.	*Admete fusiformis* (CANTRAINE)	.	.	.	.	.	1	.
20.	*Conus sp.*	1	.	.	.	.	.	.
21.	*Gemmula badensis* (R. HOERNES)	.	.	1	.	.	1	.
22.	*Gemmula annae* (HÖRN. & AUING.)	.	.	1	.	.	.	.
23.	*Bathytoma cataphracta* (BROCCHI)	.	1	.	.	.	.	.
24.	*Brachytoma obtusangula* (BROCCHI)	.	.	.	.	.	1	.
25.	*Terebra sp.**)	.	1	.	.	.	.	.
26.	*Odostomia conoidea* (BROCCHI)	.	1	1	.	.	.	.
	In all:	9	12	18	4	10	10	4

*) Possibly derivatives from the Middle Miocene beds. The main part of the material seems to be reworked.

Table 48. **Esbjerg**

		leg. P. Harder 1899		leg. H. Ødum		leg. L.B.R. 1940, 41 and 47	
		Number	Percentage	Number	Percentage	Number	Percentage
1.	*Nucula georgiana* SEMPER	3	0.13	2	1.0	8	1.1
2.	*Limopsis aurita* BROCCHI	29	1.29	3	1.5	.	.
3.	*Chlamys clavata* (POLI)	1	0.04	2	1.0	2	0.3
4.	*Astarte reimersi* SEMPER	387	17.16	46	23.2	418	55.1
5.	*Goodallia esbjergensis nov. sp.*	.	.	3	1.5	.	.
6.	*Cardita orbicularis* (SOWERBY)	.	.	4	2.0	.	.
7.	*Isocardia forchhammeri* BECK	3	0.13	2	1.0	2	0.3
8.	*Abra cf. prismatica* (MONTAGU)	.	.	1	0.5	.	.
9.	*Thracia ventricosa* PHILIPPI	.	.	.	.	.	. *)
10.	*Dentalium badense* PARTSCH	1	0.04	.	.	.	.
11.	*Archimediella cochlias* (BAYAN)	97	4.30	9	4.5	20	2.6
12.	*Archimediella cf. subangulata* (BROCCHI)	1	0.04	.	.	.	.
13.	*Turritella tricarinata* (BROCCHI)	2	0.09	10	5.1	.	.
14.	*Aporrhais alata* (EICHWALD)	1	0.04	.	.	.	.
15.	*Xenophora testigera* (BRONN)	.	.	.	.	.	. *)
16.	*Polinices catena* (DA COSTA)	8	0.35	.	.	.	.
17.	*Natica koeneni* SACCO	2	0.09	.	.	.	.
18.	*Galeodea echinophora* (L.)	5	0.22	4	2.0	6	0.8
19.	*Semicassis miolaevigata* (SACCO)	1	0.04	.	.	.	.
20.	*Lyrotyphis sejunctus* (SEMPER)	1	0.04	.	.	.	.
21.	*Liomesus ventrosus* (BEYRICH)	3	0.13	.	.	.	.
22.	*Sipho distinctus* (BEYRICH)	303	13.43	26	13.1	48	6.6
23.	*Nassa bocholtensis* (BEYRICH)	5	0.22	.	.	.	.
24.	*Nassa sp.*	1	0.04	.	.	.	.
25.	*Aquilofusus eximius* (BEYRICH)	12	0.53	2	1.0	3	0.4
26.	*Aquilofusus semiglaber* (BEYRICH)	300	13.30	7	3.5	66	8.7
27.	*Aquilofusus puggaardi* (BEYRICH)	86	3.81	5	2.5	10	1.3
28.	*Lathyrus rothi* (BEYRICH)	1	0.04	.	.	.	.
29.	*Uromitra cimbrica* (OPPENHEIM)	38	1.77	2	1.0	3	0.4
30.	*Narona rothi* (SEMPER)	32	1.42	4	2.0	9	1.2
31.	*Conus antediluvianus* BRUGUIÈRE	164	7.23	12	6.1	28	3.7
32.	*Gemmula badensis* (R. HÖRNES)	260	11.53	27	13.6	36	4.7
33.	*Gemmula annae* (HÖRN. & AUING.)	91	4.04	7	3.5	10	1.3
34.	*Bathytoma cataphracta* (BROCCHI)	364	16.14	15	7.6	88	11.6
35.	*Acamptogenotia intorta* (BROCCHI)	13	0.58	.	.	.	.
36.	*Spirotropis modiola* (JAN)	18	0.80	2	1.0	2	0.3
37.	*Brachytoma obtusangula* (BROCCHI)	9	0.40	.	.	.	.
38.	*Pleurotomoides luisae* (SEMPER)	10	0.44	2	1.0	.	.
39.	*Retusa elongata* (EICHWALD)	.	.	1	0.5	.	.
40.	*Ringicula buccinea* (BROCCHI)	3	0.13	.	.	.	.
	In all:	2255	99.98	198	99.7	759	100.4

*) Specimens kept in the Mineralogical Museum of Copenhagen.

Table 49. **Måde Brickworks**

			Eastern clay pit										
			Younger portion							New digging zone (1962).			
				South wall			North wall					Sample of clay	
		Northwestern pit	Older section	Western part	Middle part	Eastern part	Middle part of section	Near the con-cret. bed 1	The whole clay pit. With-out knowledge of horizon	Eastern part	Western part	Number	Percentage
1.	*Nucula sp.*	.	.	2	.	1	.	.	4	2	.	9	2.7
2.	*Nuculana pygmaea* (MÜNSTER)	.	.	1	.	1	1	.	19	1	.	30	9.1
3.	*Yoldia glaberrima* (MÜNSTER)	.	.	.	.	.	.	.	3	.	.	?1	0.3
4.	*Bathyarca pectunculoides* (SCACCHI)	.	.	.	.	.	.	.	.	.	.	1	0.3
5.	*Limopsis aurita* (BROCCHI)	.	2	9	8	3	9	8	92	.	.	5	1.5
6.	*Chlamys clavata* (POLI)	.	.	3	1	.	?1	.	4	.	.	.	.
7.	*Amussium cf. woodi* (NYST)	.	.	1	.	.	.	.	2	.	.	1	0.3
8.	*Limatula subauriculata* (MONTAGU)	.	.	.	.	.	.	.	.	.	.	1	0.3
9.	*Astarte vetula* PHILIPPI	.	3	43	20	2	43	.	358	.	2	.	.
10.	*Astarte reimersi* SEMPER	.	18	.	54	115	16	1	414	36	.	57	17.3
11.	*Astarte radiata* NYST & WESTENDORP	.	.	9	3	.	4	2	67	.	1	?1	0.3
12.	*Goodallia esbjergensis nov. sp.*	.	.	.	.	1	1	.	6	.	.	29	8.8
13.	*Cardita orbicularis* (SOWERBY)	.	4	25	21	6	14	3	316	.	.	31	9.4
14.	*Isocardia forchhammeri* BECK	1	2	3	3	3	4	2	13	2	.	1	0.3
15.	*Thyasira cf. flexuosa* (MONTAGU)	.	.	.	.	.	.	.	.	.	.	2	0.6
16.	*Cardium papillosum* (POLI)	.	.	.	.	.	.	.	2	.	.	12	3.6
17.	*Abra cf. prismatica* (MONTAGU)	.	.	.	.	.	.	.	3	.	.	1	0.3
18.	*Varicorbula gibba* (OLIVI)	.	.	.	.	.	.	.	4	.	.	.	.
19.	*Cuspidaria cuspidata* (OLIVI)	.	.	.	.	.	.	.	1	.	.	2	0.6
20.	*Siphonodentalium cf. lobatum* (SOWERBY)	.	1	.	.	.	.	.	1	.	.	4	1.2
21.	*Dentalium badense* PARTSCH	.	1	7	10	.	2	13	78	.	.	.	.
22.	*Solariella jutensis nov. sp.*	.	.	.	.	.	.	.	.	.	.	1	0.3
23.	*Calliostoma sp.*	.	.	.	.	.	.	.	1	.	.	.	.
24.	*Putilla gottscheana* (v. KOENEN)	.	.	.	.	.	.	.	.	.	.	35	10.6
25.	*Archimediella cochlias* (BAYAN)	2	3	.	10	52	.	.	72	.	.	18	5.5
26.	*Archimediella subangulata* (BROCCHI)	.	.	.	.	.	.	.	8	.	.	.	.
27.	*Turritella tricarinata* (BROCCHI)	.	8	68	24	1	31	1	551	3	.	.	.
28.	*Leiostraca glabra* (DA COSTA)	.	.	.	.	.	.	.	.	.	.	5	1.5
29.	*Aporrhais alata* (EICHWALD)	.	.	.	2	.	1	.	5	.	.	.	.
30.	*Xenophora testigera* (BRONN)	.	1	1	.	.	.	.	6	1	.	1	0.3
31.	*Polinices catena* (DA COSTA)	.	.	1	2	2	.	2	41	.	.	11	3.3
32.	*Galeodea echinophora* (LINNÉ)	.	1	1	2	1	2	.	15	1	.	.	.
33.	*Trophonopsis semperi* (v. KOENEN)	.	.	.	.	.	.	.	2	.	.	1	0.3
34.	*Lyrotyphis sejunctus* (SEMPER)	.	.	3	.	.	.	.	23	.	.	.	.
35.	*Sipho distinctus* (BEYRICH)	.	8	5	15	21	24	.	201	5	1	2	0.6
36.	*Nassa bocholtensis* (BEYRICH)	.	.	2	.	1	.	.	8	.	.	1	0.3
37.	*Nassa holsatica* (BEYRICH)	.	.	3	1	.	.	1	59	.	.	.	.
38.	*Nassa syltensis* (BEYRICH)	1	.	.	.	.	.	.	.	.	.	?1	0.3

Table 49 (continued) Måde Brickworks (continued)

			Eastern clay pit										
			Younger portion							New digging zone (1962)			
				South wall			North wall					Sample of clay	
		Northwestern pit	Older section	Western part	Middle part	Eastern part	Middle part of section	Near the con-cret. bed 1	The whole clay pit. With-out knowledge of horizon	Eastern part	Western part	Number	Percentage
39.	*Aquilofusus luneburgensis* (PHILIPPI)	1	2	7	.	.	10	1	.	.	1	.	.
40.	*Aquilofusus semiglaber* (BEYRICH)	.	.	.	.	.	.	.	.	2	.	.	.
	Aquilofusus luneburgensis incl. *semiglaber*	.	.	.	10	14	.	.	128	.	.	.	.
41.	*Aquilofusus puggaardi* (BEYRICH)	.	.	.	.	14	1	.	45	1	.	1	0.3
42.	*Lathyrus rothi* (BEYRICH)	.	.	5	4	.	1	.	50	.	.	.	.
43.	*Scaphella bolli* (KOCH)	.	.	.	1	.	.	.	13	.	.	.	.
44.	*Uromitra wirtzi* HINSCH	.	.	9	.	.	4	.	.	.	.	.	.
45.	*Uromitra cimbrica* (OPPENHEIM) or *Uromitra wirtzi* incl. *cimbrica*	.	.	.	2	7	.	.	46	.	.	.	.
46.	*Narona lyrata* (BROCCHI)	.	.	2	.	.	.	.	.	.	.	.	.
47.	*Narona rothi* (SEMPER)	1	.	.	.	.	.	.	.	1	.	1	0.3
	Narona lyrata incl. *rothi*	.	.	.	1	.	.	.	28	.	.	.	.
48.	*Admete fusiformis* (CANTRAINE)	.	.	2	.	.	.	.	2	.	.	2	0.6
49.	*Conus antediluvianus* BRUGUIÈRE	.	9	13	10	5	6	2	159	3	.	.	.
50.	*Gemmula badensis* (R. HÖRNES)	1	8	53	23	20	29	1	431	3	.	4	1.2
51.	*Gemmula annae* (HÖRNES & AUINGER)	.	1	12	12	10	11	.	182	1	.	.	.
52.	*Bathytoma cataphracta* (BROCCHI)	.	5	16	22	14	14	3	245	1	.	1	0.3
53.	*Acamptogenotia intorta* (BROCCHI)	.	1	.	.	.	.	1	9	.	.	.	.
54.	*Inquisitor borealis* (KAUTSKY)	.	.	.	1	.	.	.	.	.	.	.	.
55.	*Spirotropis modiola* (JAN)	.	.	.	.	8	1	.	24	.	.	.	.
56.	*Microdrillia serratula* (BELLARDI)	.	.	1	.	.	.	.	3	.	.	.	.
57.	*Haedropleura maitreja* (SEMPER)	.	.	.	.	.	.	.	3	.	.	.	.
58.	*Brachytoma obtusangula* (BROCCHI)	.	.	4	2	.	.	.	38	.	.	5	1.5
59.	*Asthenotoma ravni nov. sp.*	.	.	.	.	1	.	.	10	.	.	1	0.3
60.	*Pleurotomoides luisae* (SEMPER)	.	.	9	.	1	1	.	51	.	.	2	0.6
61.	*Acteon semistriatus* (BASTEROT)	.	.	.	.	.	.	.	3	.	.	.	.
62.	*Odostomia conoidea* (BROCCHI)	.	.	.	.	.	.	.	.	.	.	3	0.9
63.	*Turbonilla costellata* (GRATELOUP)	.	.	.	.	.	.	.	1	.	.	3	0.9
64.	*Ringicula buccinea* (BROCCHI)	.	.	1	3	.	.	.	3	.	.	3	0.9
65.	*Retusa elongata* (EICHWALD)	.	.	.	.	.	.	.	4	.	.	10	3.0
66.	*Scaphander lignarius* (LINNÉ)	.	.	.	.	.	.	.	1	.	.	.	.
67.	*Spiratella atlanta* (MØRCH)	.	.	.	.	.	.	.	15	.	.	28	8.5
	Pelecypoda indet.	.	.	.	.	.	.	.	.	.	.	.	.
	Gastropoda indet.	.	.	.	.	.	.	.	.	.	.	2	0.6
	Mollusca indet.	.	.	.	.	.	.	.	.	.	.	.	.
	In all:	7	78	321	267	304	231	41	3873	63	5	330	99.8

Table 50. **Strandgård Brickworks**

		Collections by A. Jessen & V. Nordmann 1906	Collections by A. Jessen 1912 & 1913	Collections in the new pit N of the brickworks by L.B.R. 1947, 49 & 54	Collections in the new pit W of the brickworks by L.B.R. 1954
1.	*Nucula georgiana* SEMPER	3	1	1	.
2.	*Limopsis aurita* (BROCCHI)	.	1	3	.
3.	*Chlamys clavata* (POLI)	1	.	1	.
4.	*Astarte vetula* PHILIPPI	.	6	10	2
5.	*Astarte reimersi* SEMPER	64	54	172	3
6.	*Astarte radiata* NYST & WEST	.	1	3	.
7.	*Cardita orbicularis* (SOWERBY)	.	.	4	.
8.	*Isocardia forchhammeri* BECK	2	1	6	.
9.	*Archimediella cochlias* (BAYAN)	.	.	11	.
10.	*Archimediella subangulata* (BROCCHI)	.	.	1	.
11.	*Turritella tricarinata* (BROCCHI)	.	1	12	.
12.	*Polinices catena* (DA COSTA)	.	.	1	.
13.	*Galeodea echinophora* (*L.*)	1	1	6	1
14.	*Semicassis miolaevigata* (SACCO)	.	.	2	.
15.	*Liomesus ventrosus* (BEYRICH)	1	.	.	.
16.	*Sipho distinctus* (BEYRICH)	6	11	39	2
17.	*Nassa bocholtensis* (BEYRICH)	.	.	1	.
18.	*Aquilofusus luneburgensis* (PHILIPPI)	.	?1	5	.
19.	*Aquilofusus semiglaber* (BEYRICH)	5	.	11	.
20.	*Aquilofusus puggaardi* (BEYRICH)	.	1	9	.
21.	*Aquilofusus sp.*	.	.	1	.
22.	*Scaphella bolli* (KOCH)	.	1	.	.
23.	*Uromitra cimbrica* (OPPENHEIM)	.	.	1	.
24.	*Uromitra wirtzi* HINSCH	.	.	1	.
25.	*Narona rothi* (SEMPER)	1	.	2	.
26.	*Conus antediluvianus* BRUGUIÈRE	1	6	16	.
27.	*Gemmula badensis* (R. HOERNES)	6	8	36	2
28.	*Gemmula annae* (HOERN. & AUING.)	.	1	4	.
29.	*Bathytoma cataphracta* (BROCCHI)	1	7	19	1
30.	*Spirotropis modiola* (JAN)	.	.	1	.
	In all:	92	102	379	11

Region V

Table 51. **Various localities in North Slesvig**

		Gørding. Brickworks pit	Sønderskovgård. D.G.U. File No. 132.34.13.0–27.0 m.	Tobøl. D.G.U. File No. 132.37.16–45 m. (?)	Hjerting D.G.U. File No. 141.238		Brøstrup. D.G.U. File No. 141.255 ca. 20 m.	Rojbøl. D.G.U. File No. 141.194		Tiset. D.G.U. File No. 141.244 15.0–43.5 m.	Arnum. D.G.U. File No. 150.25 b ca. 24.5 m.	Hønning. D.G.U. File No. 150.197 ca. 63–68 m.	Tønder. D.G.U. File No. 166.227 ca. 36–61 m.	Heds. D.G.U. File No. 167.234.b. ca. 80–83 m.
					20.2 m.	27.7 m.		15 m.	20 m.					
1.	*Nucula georgiana* SEMPER	1	.	.	.	.	1	.	.	?1	.	.	.	.
2.	*Nuculana pygmaea* (MÜNSTER)	.	2	.	.	.	4	2	.	2	.	.	.	.
3.	*Yoldia glaberrima* (MÜNSTER)	.	.	.	.	.	.	.	.	1	.	.	.	.
4.	*Chlamys clavata* (POLI)	1	.	.	.	.	.	.	.	.	.	.	.	.
5.	*Astarte reimersi* SEMPER	4	.	1	.	1	?1	.	?1	?1	1	1	1	1
6.	*Goodallia esbjergensis nov. sp.*	.	.	.	1	.	.	.	.	.	.	.	.	.
7.	*Pygocardia rustica* (NYST)	1	.	.	.	.	.	.	.	.	.	.	.	.
8.	*Thracia sp.*	.	.	.	.	.	.	1	.	.	.	.	.	.
9.	*Siphonodentalium cf. lobatum* (SOW.)	.	.	.	.	.	.	.	.	1	.	.	.	.
10.	*Putilla gottscheana* (v. KOENEN)	.	.	.	.	.	1	.	.	.	.	.	.	.
11.	*Galeodea echinophora* (L.)	1	.	.	.	.	.	.	.	.	.	.	.	.
12.	*Lyrotyphis sejunctus* (SEMPER)	.	.	.	.	.	.	.	.	1	.	.	.	.
13.	*Aquilofusus semiglaber* (BEYRICH)	3	.	.	.	.	.	.	.	.	.	.	.	.
14.	*Gemmula badensis* (HÖRNES)	.	.	.	.	.	.	.	.	1	.	.	.	.
15.	*Brachytoma obtusangula* (BROCCHI)	.	.	.	.	.	1	.	.	.	.	.	.	.
16.	*Pleurotomoides luisae* (SEMPER)	.	.	.	.	.	.	.	.	1	.	.	.	.
17.	*Spiratella atlanta* (MØRCH)	.	.	.	.	.	3	.	1	2	.	.	.	.
	In all:	11	2	1	1	1	11	3	2	11	1	1	1	1

Table 52. **Holleskov. 132.46b** 4.9–11.2 m.

		Number of individuals	Percentage
1.	*Nucula georgiana* SEMPER	17	3.1
2.	*Nuculana pygmaea* (MÜNSTER)	83	15.1
3.	*Yoldia glaberrima* (MÜNSTER)	10	1.8
4.	*Chlamys clavata* (POLI)	1	0.2
5.	*Astarte reimersi* SEMPER	58	10.6
6.	*Cardita orbicularis* (SOWERBY)	3	0.5
7.	*Isocardia forchhammeri* BECK	1	0.2
8.	*Thyasira sp.*	2	0.4
9.	*Cardium papillosum* (POLI)	4	0.7
10.	*Abra prismatica* (MONTAGU)	2	0.4
11.	*Thracia sp.*	3	0.5
12.	*Cuspidaria cuspidata* (OLIVI)	1	0.2
13.	*Siphonodentalium cf. lobatum* (SOWERBY)	34	6.2
14.	*Putilla gottscheana* (v. KOENEN)	1	0.2
15.	*Archimediella cochlias* (BAYAN)	14	2.6
16.	*Turritella tricarinata* (BROCCHI)	34	6.2
17.	*Opalia vilandti* (MØRCH)	1	0.2
18.	*Leiostraca glabra* (DA COSTA)	2	0.4
19.	*Natica koeneni* SACCO	1	0.2
20.	*Natica spp.*	83	15.1
21.	*Galeodea echinophora* (L.)	1	0.2
22.	*Murex sp.*	1	0.2
23.	*Lyrotyphis sejunctus* (SEMPER)	3	0.5
24.	*Sipho distinctus* (BEYRICH)	1	0.2
25.	*Nassa bocholtensis* (BEYRICH)	2	0.4
26.	*Nassa syltensis* (BEYRICH)	1	0.2
27.	*Aquilofusus semiglaber* (BEYRICH)	6	1.1
28.	*Uromitra cimbrica* (OPPENHEIM)	4	0.7
29.	*Narona rothi* (SEMPER)	1	0.2
30.	*Admete fusiformis* (CANTRAINE)	2	0.4
31.	*Conus antediluvianus* BRUGUIÈRE	5	0.9
32.	*Gemmula badensis* (R. HÖRNES)	22	4.0
33.	*Gemmula annae* (HÖRNES & AUINGER)	4	0.7
34.	*Bathytoma cataphracta* (BROCCHI)	1	0.2
35.	*Haedropleura maitreja* (SEMPER)	1	0.2
36.	*Brachytoma obtusangula* (BROCCHI)	24	4.4
37.	*Neoguraleus kochi* (v. KOENEN)	3	0.5
38.	*Pleurotomoides luisae* (SEMPER)	6	1.1
39.	*Philbertia reticulata* (RENIERI)	1	0.2
40.	*Acteon semistriatus* (BASTEROT)	1	0.2
41.	*Odostomia conoidea* (BROCCHI)	42	7.7
42.	*Eulimella sp.*	1	0.2
43.	*Turbonilla costellata* (GRATELOUP)	2	0.4
44.	*Retusa elongata* (EICHWALD)	8	1.5
45.	*Spiratella atlanta* (MØRCH)	51	9.3
	In all:	549	100.4

Table 53. **Ravning**

		Material in the Min. Mus.	Material collected by V.N. + A.J. 1906 (D.G.U.)	Own collection 1944	Sample of clay	Total number
1.	*Nucula georgiana* SEMPER	.	7	1	3	11
2.	*Nuculana pygmaea* (MÜNSTER)	.	.	.	19	19
3.	*Yoldia glaberrima* (MÜNSTER)	.	.	.	2	2
4.	*Chlamys clavata* (POLI)	.	.	1	.	1
5.	*Astarte reimersi* SEMPER	3	68	2	3	76
6.	*Isocardia forchhammeri* BECK	1	.	.	.	1
7.	*Cardium papillosum* (POLI)	.	.	.	2	2
8.	*Abra prismatica* (MONTAGU)	.	.	.	2	2
9.	*Thracia sp.*	.	.	.	1	1
10.	*Siphonodentalium cf. lobatum* (SOW.)	.	.	.	4	4
11.	*Putilla gottscheana* (v. KOENEN)	.	.	.	2	2
12.	*Turritella tricarinata* (BROCCHI)	.	.	.	1	1
13.	*Polinices catena* (DA COSTA)	.	1	.	7	8
14.	*Semicassis miolaevigata* (SACCO)	1	.	.	.	1
15.	*Galeodea echinophora* (L.)	1	.	.	.	1
16.	*Lyrotyphis sejunctus* (SEMPER)	.	.	.	1	1
17.	*Sipho distinctus* (BEYRICH)	.	12	.	.	12
18.	*Nassa bocholtensis* (BEYRICH)	.	.	.	1	1
19.	*Aquilofusus semiglaber* (BEYRICH)	1	58	.	.	59
20.	*Narona rothi* (SEMPER)	.	3	.	1	4
21.	*Gemmula badensis* (HÖRNES)	1	5	.	1	7
22.	*Gemmula annae* (HÖRNES & AUINGER)	.	10	.	.	10
23.	*Bathytoma cataphracta* (BROCCHI)	4	18	.	.	22
24.	*Pleurotomoides luisae* (SEMPER)	.	.	.	1	1
25.	*Conus antediluvianus* BRUGUIÈRE	1	5	.	.	6
26.	*Odostomia conoidea* (BROCCHI)	.	.	.	3	3
27.	*Retusa sp.*	.	.	.	1	1
28.	*Spiratella atlanta* (MØRCH)	.	.	.	1	1
	Moll. indet.	.	.	.	10	10
	In all:	13	187	4	66	270

Table 54. **Hjortvad. 141.178**

		7.6–10.2 m.	10.2–15.1 m.	15.1–20.1 m.	20.1–23.1 m.	23.1–28.1 m.	28.1–33.1 m.	33.1–38.1 m.	Total number
1.	*Nucula georgiana* SEMPER	2	2	1	.	.	1	.	6
2.	*Nuculana pygmaea* (MÜNSTER)	4	3	3	4	.	.	.	14
3.	*Yoldia glaberrima* (MÜNSTER)	1	.	.	.	.	.	.	1
4.	*Astarte reimersi* SEMPER	.	1	2	1	.	.	1	5
	Astarte reimersi SEMP. or *vetula* PHILIPPI	.	.	.	.	.	2	.	2
5.	*Goodallia esbjergensis nov. sp.*	.	.	2	.	.	.	.	2
6.	*Cardita orbicularis* (SOWERBY)	.	.	.	1	.	1	.	2
7.	*Cardium papillosum* (POLI)	2	.	1	1	.	.	.	4
8.	*Abra prismatica* (MONTAGU)	1	.	1	1	.	.	.	3
9.	*Thracia sp.*	.	.	.	1	.	.	.	1
10.	*Siphonodentalium cf. lobatum* (SOWERBY)	2	2	.	1	.	1	.	6
11.	*Dentalium sp.*	.	.	.	.	.	1	.	1
12.	*Teinostoma pulchralis* (WOOD)	.	.	.	.	.	1	.	1
13.	*Putilla gottscheana* (v. KOENEN)	1	.	2	1	.	1	.	5
14.	*Turritella tricarinata* (BROCCHI)	.	1	.	1	.	.	.	2
15.	*Polinices protracta* (EICHWALD)	4	2	.	.	.	.	.	6
16.	*Sipho distinctus* (BEYRICH)	.	.	.	1	.	.	.	1
17.	*Admete fusiformis* (CANTRAINE)	.	.	.	1	.	.	.	1
18.	*Gemmula badensis* (HÖRNES)	.	.	1	.	.	.	.	1
19.	*Gemmula annae* (HÖRNES & AUINGER)	1	.	.	.	.	.	.	1
20.	*Brachytoma obtusangula* (BROCCHI)	1	.	1	1	.	.	.	3
21.	*Neoguraleus kochi* (v. KOENEN)	.	.	1	.	.	.	.	1
22.	*Philbertia sp.*	.	.	1	.	.	.	.	1
23.	*Eulimella sp.*	.	.	.	1	.	.	.	1
24.	*Odostomia conoidea* (BROCCHI)	2	.	.	.	.	1	.	3
25.	*Retusa elongata* (EICHWALD)	.	.	1	.	.	.	.	1
26.	*Spiratella atlanta* (MØRCH)	2	.	2	4	1	2	.	11
	Moll. indet.	1	.	.	.	.	.	.	1
	In all:	24	11	19	20	1	11	1	87

Table 55. **Lintrup. 132.140**

		3.25–3.75 m.	3.75–4.8 m.	4.8–9.8 m.	9.8–14.8 m.	14.8–19.8 m.	19.8–24.8 m.	24.8–28.0 m.	Total number
1.	*Nucula sp.*	1	1	.	1	1	.	.	4
2.	*Nuculana pygmaea* (MÜNSTER)	.	.	1	8	3	1	.	13
3.	*Yoldia glaberrima* (MÜNSTER)	4	1	1	1	1	.	.	8
4.	*Limopsis aurita* (BROCCHI)	.	.	.	1	.	.	.	1
5.	*Astarte cf. reimersi* SEMPER	.	.	.	.	.	2	1	3
6.	*Cardium papillosum* (POLI)	5	.	.	.	.	.	.	5
7.	*Spisula subtruncata* (DA COSTA)	1	.	.	.	.	.	.	1
8.	*Siphonodentalium cf. lobatum* (SOWERBY)	1	1	.	3	1	1	.	7
9.	*Archimediella cochlias* (BAYAN)	.	.	.	.	.	1	.	1
10.	*Polinices catena* (DA COSTA)	1	1	.	.	.	.	.	2
11.	*Putilla gottscheana* (v. KOENEN)	.	1	.	1	.	1	.	3
12.	*Nassa bocholtensis* (BEYRICH)	1	.	.	.	.	.	.	1
13.	*Gemmula annae* (HÖRNES & AUINGER)	.	.	.	1	.	.	.	1
14.	*Brachytoma obtusangula* (BROCCHI)	.	.	.	1	.	1	.	2
15.	*Odostomia conoidea* (BROCCHI)	.	.	.	.	.	2	.	2
16.	*Turbonilla costellata* GRATELOUP	.	.	.	1	.	.	.	1
17.	*Spiratella atlanta* (MØRCH)	.	.	.	.	.	.	1	1
	Moll. indet.	2	.	.	.	.	3	.	5
	In all:	16	5	2	18	6	12	2	61

Table 56. **Sønder Hygum**

	Fraction 1 > 2.5 mm. 2.5 mm. > Fraction 2 > 0.5 mm. Fraction 3 < 0.5 mm.	Borehole 141.260 12–40 m.		Borehole 141.261										
				13–19 m.					20 m.					
		Number	Percentage	Fraction 1	Fraction 2	Fraction 3	Total number	Percentage	Fraction 1	Fraction 2	Fraction 3	Total number	141.273.45 m.	Total number
1.	*Nucula georgiana* SEMPER	7	2.500	3	38	18	59	4.514	2	15	7	24	2	92
2.	*Nuculana pygmaea* (MÜNSTER)	39	13.929	.	345	107	452	34.583	.	93	31	124	2	617
3.	*Yoldia glaberrima* (MÜNSTER)	6	2.143	1	25	6	32	2.448	1	3	2	6	1	45
4.	*Limopsis aurita* (BROCCHI)	3	1.071	.	.	.	.	.	.	.	.	.	.	3
5.	*Chlamys clavata* (POLI)	2	0.714	.	1	.	1	0.077	.	.	.	.	.	3
6.	*Astarte reimersi* SEMPER	33	11.786	11	22	6	39	2.984	3	7	.	10	2	84
7.	*Goodallia esbjergensis nov. sp.*	40	14.286	.	.	.	.	.	.	.	.	.	.	40
8.	*Cardita orbicularis* (SOWERBY)	2	0.714	.	.	.	.	.	.	.	.	.	.	2
9.	*Isocardia forchhammeri* BECK	2	0.714	1	1	.	2	0.153	.	.	.	.	.	4
10.	*Thyasira cf. flexuosa* (MONTAGU)	1	0.357	.	2	1	3	0.230	.	1	1	2	.	6
11.	*Phacoides sp.*	.	.	.	5	.	5	0.383	.	.	.	.	.	5
12.	*Cardium papillosum* (POLI)	4	1.429	.	20	5	25	1.913	.	9	2	11	1	41
13.	*Spisula subtruncata* (DA COSTA)	.	.	.	2	.	2	0.153	.	2	2	4	.	6
14.	*Abra prismatica* (MONTAGU)	4	1.429	.	15	4	19	1.454	1	3	.	4	.	27
15.	*Thracia sp.*	.	.	1	3	.	4	0.306	.	.	.	.	.	4
16.	*Cuspidaria cuspidata* (OLIVI)	3	1.071	.	7	.	7	0.536	.	2	.	2	.	12

Table 56 (continued) Hygum. (continued)

		Borehole 141.260 12–40 m.		Borehole 141.261 13–19 m.					Borehole 141.261 20 m.					
		Number	Percentage	Fraction 1	Fraction 2	Fraction 3	Total number	Percentage	Fraction 1	Fraction 2	Fraction 3	Total number	141.273.45 m.	Total number
17.	*Siphonodentalium cf. lobatum* (Sow.)	5	1.786	1	54	35	90	6.886	1	17	9	27	1	123
18.	*Circulus hennei* Glibert	1	0.357	.	.	.	.	.	.	.	.	.	.	1
19.	*Putilla gottscheana* (v. Koenen)	16	5.714	.	19	138	157	12.012	.	3	30	33	1	207
20.	*Cingula proxima laevigata* (v. Koenen)	.	.	.	1	.	1	0.077	.	.	.	.	.	1
21.	*Turritella tricarinata* (Brocchi)	11	3.929	2	8	2	12	0.918	.	2	1	3	3	29
22.	*Triphora fritschi* (v. Koenen)	.	.	.	.	2	2	0.153	.	.	.	.	.	2
23.	*Opalia vilandti* (Mørch)	.	.	.	2	.	2	0.153	.	.	.	.	.	2
24.	*Leiostraca glabra* (Da Costa)	1	0.357	.	.	.	.	.	.	.	.	.	.	1
25.	*Xenophora testigera* (Bronn)	1	0.357	.	.	.	.	.	.	.	.	.	.	1
26.	*Natica spp.*	14	5.000	3	103	24	130	9.946	.	9	3	12	.	156
27.	*Galeodea echinophora* (L.)	.	.	.	3	.	3	0.230	.	.	.	.	.	3
28.	*Murex spinicosta* Bronn	1	0.357	.	.	.	.	.	.	.	.	.	.	1
29.	*Lyrotyphis sejunctus* (Semper)	1	0.357	.	9	.	9	0.689	.	1	.	1	.	11
30.	*Sipho distinctus* (Beyrich)	1	0.357	1	1	.	2	0.153	1	1	.	2	.	5
31.	*Nassa bocholtensis* (Beyrich)	1	0.357	1	3	.	4	0.306	.	1	.	1	.	6
32.	*Nassa syltensis* (Beyrich)	1	0.357	.	4	.	4	0.306	.	.	.	.	.	5
33.	*Aquilofusus semiglaber* (Beyrich)	2	0.714	1	1	.	2	0.153	.	.	.	.	.	4
34.	*Uromitra cimbrica* (Kautsky)	.	.	.	.	.	.	.	.	.	.	.	1	1
35.	*Narona rothi* (Semper)	1	0.357	.	2	.	2	0.153	.	.	.	.	.	3
36.	*Admete fusiformis* (Cantraine)	1	0.357	.	2	1	3	0.230	.	.	.	.	1	5
37.	*Conus antediluvianus* Bruguière	.	.	1	5	.	6	0.459	.	1	.	1	.	7
38.	*Gemmula badensis* (Hörnes)	7	2.500	4	15	1	20	1.530	4	5	.	9	.	36
39.	*Gemmula annae* (Hörn. & Auing.)	3	1.071	2	2	.	4	0.306	.	1	.	1	.	8
40.	*Bathytoma cataphracta* (Brocchi)	.	.	1	1	.	2	0.153	.	.	.	.	.	2
41.	*Inquisitor borealis* (Kautsky)	.	.	.	2	.	2	0.153	.	.	.	.	.	2
42.	*Brachytoma obtusangula* (Brocchi)	2	0.714	2	11	1	14	1.071	.	5	.	5	.	21
43.	*Neoguraleus kochi* (v. Koenen)	.	.	.	12	2	14	1.071	.	1	.	1	.	15
44.	*Pleurotomoides luisae* (Semper)	1	0.357	.	6	1	7	0.536	1	4	.	5	.	13
45.	*Philbertia reticulata* (Renieri)	.	.	.	1	.	1	0.077	.	.	.	.	.	1
46.	*Philbertia sinuosula* Sorgenfrei	.	.	.	1	.	1	0.077	.	.	.	.	.	1
	Philbertia sp. indet.	.	.	.	.	1	1	0.077	.	.	.	.	.	1
47.	*Acteon semistriatus* (Basterot)	1	0.357	.	6	.	6	0.459	.	.	.	.	.	7
48.	*Odostomia conoidea* (Brocchi)	11	3.929	.	52	24	76	5.815	.	17	5	22	.	109
49.	*Turbonilla costellata* (Grateloup)	1	0.357	.	3	1	4	0.306	.	.	.	.	.	5
50.	*Ringicula buccinea* (Brocchi)	6	2.143	.	.	.	.	.	.	.	.	.	.	6
51.	*Retusa elongata* (Eichwald)	3	1.071	.	14	1	15	1.148	.	1	1	2	1	21
52.	*Spiratella atlanta* (Mørch)	38	13.571	.	34	15	49	3.749	.	20	6	26	1	114
	Pelecypoda indet.	1	0.357	1	.	6	7	0.536	.	.	.	.	.	8
	Gastropoda indet.	2	0.714	.	2	3	5	0.383	.	.	.	.	.	7
	In all:	280	99.897	37	865	405	1307	100.005	14	224	100	338	17	1942

Table 57. **Rødding**

		D.G.U. File No. 141.75				D.G.U. File No. 141.76			D.G.U. File No. 141.241 9.6–28.0 m.	D.G.U. File No. 141.242 19 m.	D.G.U. File No. 141.243 20 m.	D.G.U. File No. 141.247 20 m.
		10.80–16.75 m.	16.75–25.60 m.	25.60–33.20 m.	Total number	28.35–37.15 m.	37.15–42.40 m.	Total number				
1.	*Nucula sp.*	.	.	.	.	1	1	2	.	1	1	.
2.	*Nuculana pygmaea* (MÜNSTER)	2	3	.	5	6	.	6	1	2	6	1
3.	*Yoldia glaberrima* (MÜNSTER)	1	.	.	1	1	.	1	.	2	.	1
4.	*Limopsis aurita* (BROCCHI)	.	1	.	1	.	.	.	.	.	.	.
5.	*Astarte reimersi* SEMPER	1	2	.	3	.	1	1	.	.	4	.
6.	*Goodallia esbjergensis nov. sp.*	.	3	.	3	.	.	.	.	.	.	.
7.	*Cardita orbicularis* (SOWERBY)	.	.	.	.	.	1	1	.	.	.	.
8.	*Cardium papillosum* (POLI)	4	.	.	4	.	.	.	.	1	2	.
9.	*Thracia sp.*	.	.	.	.	1	.	1	.	.	.	.
10.	*Siphonodentalium cf. lobatum* (SOWERBY)	.	.	.	.	1	.	1	.	2	1	.
11.	*Dentalium sp.*	.	.	.	.	.	1	1	.	.	.	.
12.	*Putilla gottscheana* (v. KOENEN)	4	.	.	4	.	.	.	.	.	3	.
13.	*Turritella tricarinata* (BROCCHI)	1	.	?1	?2	.	.	.	.	.	1	.
14.	*Natica sp.*	.	1	.	1	1	.	1	.	1	2	.
15.	*Murex spinicosta* BRONN	.	.	.	.	.	.	.	.	.	.	1
16.	*Nassa bocholtensis* (BEYRICH)	.	.	.	.	1	.	1	.	.	.	.
17.	*Nassa syltensis* (BEYRICH)	1	.	.	1	.	.	.	.	.	.	.
	Nassa sp. indet.	.	.	.	.	.	.	.	.	1	.	.
18.	*Aquilofusus semiglaber* (BEYRICH)	.	.	.	.	.	.	.	.	.	1	.
19.	*Narona rothi* (SEMPER)	1	.	.	1	.	.	.	.	.	.	.
20.	*Conus antediluvianus* BRUGUIÈRE	.	.	.	.	1	.	1	.	.	.	.
21.	*Gemmula badensis* (HÖRNES)	.	.	.	.	1	.	1	.	?1	.	.
22.	*Gemmula annae* (HÖRN. & AUING.)	.	.	.	.	.	.	.	.	.	1	.
23.	*Brachytoma obtusangula* (BROCCHI)	.	.	.	.	.	.	.	.	.	1	.
24.	*Odostomia conoidea* (BROCCHI)	.	.	.	.	1	.	1	.	1	.	.
25.	*?Retusa sp.*	1	1	.	2	.	.	.	.	.	.	.
26.	*Spiratella atlanta* (MØRCH)	2	2	.	4	.	2	2	.	.	2	.
	Moll. indet.	2	1	.	3	.	.	.	.	2	.	.
	In all:	20	14	1	35	15	6	21	1	14	25	3

Table 58. **Vester Lindet. 141.246**

		30.9 m.	36.8 m.	43.2 m.	Total number
1.	*Nucula sp.*	1	.	1	2
2.	*Nuculana pygmaea* (MÜNSTER)	11	3	4	18
3.	*Yoldia glaberrima* (MÜNSTER)	.	1	.	1
4.	*Pecten sp.*	.	1	.	1
5.	*Astarte cf. reimersi* SEMPER	.	1	3	4
6.	*Cardium papillosum* (POLI)	3	.	1	4
7.	*Cuspidaria cuspidata* (OLIVI)	1	.	.	1
8.	*Siphonodentalium cf. lobatum* (SOWERBY)	2	1	1	4
9.	*Turritella sp.*	.	1	1	2
10.	*Putilla gottscheana* (v. KOENEN)	.	1	.	1
11.	*Natica sp.*	.	1	.	1
12.	*Gemmula sp.*	.	.	2	2
13.	*Turbonilla costellata* (GRATELOUP)	1	.	.	1
	In all:	19	10	13	42

Table 59. Part 1. **Gram. 141.277** (5.30–15.55 m.)

		5.30–5.70 m.	5.70–6.10 m.	6.10–6.40 m.	6.40–6.90 m.	6.90–7.30 m.	7.30–7.65 m.	7.65–8.05 m.	8.05–8.50 m.	8.50–9.00 m.	9.00–9.50 m.	9.50–9.90 m.	9.90–10.30 m.	10.30–10.80 m.	10.80–11.25 m.	11.25–11.65 m.	11.65–12.10 m.	12.10–12.60 m.	12.60–13.10 m.	13.10–13.50 m.	13.50–14.00 m.	14.00–14.60 m.	14.60–15.10 m.	15.10–15.55 m.
1.	*Nucula sp.*	24	19	15	9	7	9	10	12	10	9	23	8	9	8	15	1	8	10	5	10	8	7	3
2.	*Nuculana pygmaea* (MÜNSTER)	116	100	72	48	39	55	34	42	27	33	119	38	57	56	33	7	16	17	15	14	60	25	27
3.	*Yoldia glaberrima* (MÜNSTER)	19	20	10	3	14	5	15	10	5	2	12	2	5	1	2	1	3	1	2	1	.	1	.
4.	*Bathyarca pectunculoides* (SCACCHI)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5.	*Limopsis aurita* (BROCCHI)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	5
6.	*Volsella phaseolina* (PHILIPPI)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
7.	?*Pinna sp.*	.	.	.	.	1	.	.	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.
8.	*Chlamys clavata* (POLI)	.	.	1	1	.	1	.	.	1	.	1	.	.	1	.	.	?1	.	.	1	.	.	.
9.	*Amussium cf. woodi* (NYST)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
10.	*Limatula subauriculata* (MONTAGU)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11.	*Astarte vetula* PHILIPPI	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
12.	*Astarte reimersi* SEMPER	.	8	11	13	2	22	6	19	16	7	25	17	4	5	17	9	10	7	11	6	9	22	7
13.	*Astarte radiata* NYST & WESTENDORP	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14.	*Goodallia esbjergensis nov. sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	31	54	75
15.	*Cardita orbicularis* (SOWERBY)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	16	3
16.	*Kellyella rotunda* SORGENFREI	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17.	*Isocardia forchhammeri* BECK	1	.	2	.	.	1	.	?1	?1	.	1	1	.	.	.	.	1	.	.	.	1	1	.
18.	*Thyasira cf. flexuosa* (MONTAGU)	1	1	.	.	.	.	1	2	1	1	5	2	1	4	1	1	1	3	1	1	2	.	.
19.	*Thyasira sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
20.	*Phacoides sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
21.	*Erycina sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	?1	1
22.	*Cardium papillosum* (POLI)	2	2	11	4	.	5	7	.	3	2	3	4	2	6	3	1	5	7	6	1	14	3	7
23.	*Spisula subtruncata* (DA COSTA)	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.	.
24.	*Abra cf. prismatica* (MONTAGU)	1	3	2	2	3	6	6	4	4	1	4	2	3	3	2	2	6	1	2	1	2	1	3

		5.30–5.70 m.	5.70–6.10 m.	6.10–6.40 m.	6.40–6.90 m.	6.90–7.30 m.	7.30–7.65 m.	7.65–8.05 m.	8.05–8.50 m.	8.50–9.00 m.	9.00–9.50 m.	9.50–9.90 m.	9.90–10.30 m.	10.30–10.80 m.	10.80–11.25 m.	11.25–11.65 m.	11.65–12.10 m.	12.10–12.60 m.	12.60–13.10 m.	13.10–13.50 m.	13.50–14.00 m.	14.00–14.60 m.	14.60–15.10 m.	15.10–15.55 m.
25.	*Varicorbula gibba* (OLIVI)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	1
26.	*Thracia ventricosa* PHILIPPI	1	1	1	3	2	1	1	1	2	1	1	1	.	1	1	.	3	2	1	.	3	1	.
27.	*Cuspidaria cuspidata* (OLIVI)	5	3	2	.	.	1	.	.	1	?1	?2	.	.	?1	.	.	1	.	2	1	.	?1	1
28.	*Cuspidaria costellata* (DESHAYES)	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
29.	*Siphonodentalium cf. lobatum* (SOWERBY)	35	42	28	11	18	14	16	9	7	7	11	6	5	5	4	4	8	7	7	7	8	6	5
30.	*Dentalium cf. michelotti* HÖRNES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
31.	*Dentalium badense* PARTSCH	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
32.	?*Lacuna sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
33.	*Solariella jutensis nov. sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
34.	*Teinostoma pulchralis* (WOOD)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
35.	*Circulus hennei* GLIBERT	1	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
36.	*Putilla gottscheana* (v. KOENEN)	7	1	3	1	3	5	5	13	20	6	42	13	18	9	14	6	23	12	2	23	20	9	3
37.	*Cingula inusitata* (BEETS)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
38.	*Archimediella cochlias* (BAYAN)	.	.	.	.	.	.	.	.	.	.	.	2	.	4	.	8	11	4	3	.	5	9	5
39.	*Archimediella subangulata* (BROCCHI)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
40.	*Turritella tricarinata* (BROCCHI)	.	6	3	6	6	6	2	4	8	.	.	1	2	3	6	.	.	.	.	.	.	.	.
41.	*Bittium tenuispina* SORGENFREI	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
42.	*Aclis minor* (BROWN)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.
43.	*Opalia vilandti* (MØRCH)	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
44.	*Leiostraca glabra* (DA COSTA)	1	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	2	.	.	1	.
45.	*Xenophora testigera* (BRONN)	.	.	.	1	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	1	1	.	.
46.	*Polinices catena* (DA COSTA)	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
47.	*Polinices protracta* (EICHWALD)	1	.	.	.	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.
48.	*Natica koeneni* SACCO	.	.	.	1	.	1	.	.	.	.	1	1	.	.	.	.	1	3	2	.	.	1	.
	Naticidae indet.	35	48	8	19	23	20	12	13	15	6	16	9	4	6	28	6	7	7	3	2	7	9	15
49.	*Galeodea echinophora* (LINNÉ)	.	.	.	.	1	?1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
50.	*Murex spinicosta* BRONN	3	2	.	1	.	1	1	1	1	1	1	.	.	.	1	1	.	.	.	1	.	.	1

51.	*Trophonopsis semperi* (v. KOENEN)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
52.	*Lyrotyphis sejunctus* (SEMPER)	5	?11	.	.	3	3	.	.	2	1	1	.	.	.	.	.	1	.	.	.	2	.	1
53.	*Sipho distinctus* (BEYRICH)	.	.	2	2	.	.	.	.	.	1	1	.	.	.	.	1	1	.	1	.	1	1	1
54.	*Nassa bocholtensis* (BEYRICH)	1	3	.	1	3	1	1	2	.	.	.	1	.	1	1	.	.	.	.	.	1	.	.
55.	*Nassa holsatica* (BEYRICH)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
56.	*Nassa syltensis* (BEYRICH)	5	3	.	1	2	.	1	.	.	2	1	.	3	1	.	.	1	.	1	1	1	1	2
57.	*Nassa prismatica* (BROCCHI)	.	.	.	.	.	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
58.	*Aquilofusus eximius* (BEYRICH)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
59.	*Aquilofusus semiglaber* (BEYRICH)	1	.	.	1	1	1	1	.	.	1	1	1	.	2	?1	.	.	.	.	.	.	.	.
60.	*Aquilofusus puggaardi* (BEYRICH)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	1	1	.
61.	*Lathyrus rothi* (BEYRICH)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
62.	*Uromitra cimbrica* (OPPENHEIM)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1
63.	*Narona calcarata* (BROCCHI)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
64.	*Narona rothi* (SEMPER)	1	1	.	.	.	.	.	.	.	.	.	1	?1	.	.	.	.	.	?1	.	.	.	.
65.	*Admete fusiformis* (CANTRAINE)	.	2	.	.	1	1	2	1	.	.	2	1	.	.	1	.	1	.	2	.	1	2	4
66.	*Conus antediluvianus* BRUGUIÈRE	2	3	1	2	1	1	.	.	2	1	.	.	1	.	1	.	.	.	1	.	.	1	.
67.	*Gemmula badensis* (R. HÖRNES)	10	4	2	5	6	3	2	4	5	2	4	1	4	2	6	1	8	2	3	.	1	7	4
68.	*Gemmula annae* (HÖRNES & AUINGER)	3	2	3	1	2	.	.	2	.	.	.	.	.	.	1	.	1	1	1	.	.	1	2
69.	*Fusiturris helena* (SEMPER)	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
70.	*Bathytoma cataphracta* (BROCCHI)	1	1	.	1	1	1	.	.	.	.	1	.	1	.	.	.	2	.	1	.	1	2	1
71.	*Acamptogenotia intorta* (BROCCHI)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	?1	.	.	.	.
72.	*Inquisitor borealis* (KAUTSKY)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
73.	*Spirotropis modiola* (JAN)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
74.	*Haedropleura maitreja* (SEMPER)	.	.	.	.	?1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
75.	*Microdrillia serratula* (BROCCHI)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.
76.	*Asthenotoma ravni nov. sp.*	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	1	.	.	.	1	.	.
77.	*Brachytoma obtusangula* (BROCCHI)	10	8	2	4	4	7	3	4	3	2	5	4	2	2	7	1	1	2	3	3	2	9	3
78.	*Neoguraleus kochi* (v. KOENEN)	1	5	.	2	2	1	.	.	.	.	.	.	.	.	.	2	.	1	1	.	1	1	1
79.	*Pleurotomoides luisae* (SEMPER)	5	2	2	3	3	3	.	.	1	1	1	2	2	1	4	1	2	.	1	1	.	2	2
80.	*Philbertia reticulata* (RENIERI)	1	1	1	.	1	1	.	.	.	.	.	1	.	.	.	.	2	.	.	.	.	.	?1
81.	*Philbertia sinuosula* SORGENFREI	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.
82.	*Acteon semistriatus* (BASTEROT)	?1	?1	.	.	.	.	.	.	.	?1	?1	?1	.	.	.	.	.	?1	.	.	?1	1	.
83.	*Chrysallida pygmaea* (GRATELOUP)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
84.	*Chrysallida semireticulata* SORGENFREI	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.

No.	Species	5.30–5.70 m.	5.70–6.10 m.	6.10–6.40 m.	6.40–6.90 m.	6.90–7.30 m.	7.30–7.65 m.	7.65–8.05 m.	8.05–8.50 m.	8.50–9.00 m.	9.00–9.50 m.	9.50–9.90 m.	9.90–10.30 m.	10.30–10.80 m.	10.80–11.25 m.	11.25–11.65 m.	11.65–12.10 m.	12.10–12.60 m.	12.60–13.10 m.	13.10–13.50 m.	13.50–14.00 m.	14.00–14.60 m.	14.60–15.10 m.	15.10–15.55 m.
85.	*Chrysallida* (*nov. sp.* ?)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.
86.	*Kleinella nordmanni* SORGENFREI	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
87.	*Odostomia conoidea* (BROCCHI)	32	53	12	5	12	15	10	10	9	6	8	6	1	1	1	.	8	13	6	5	5	9	4
88.	*Eulimella scillae* (SCACCHI)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
89.	*Eulimella sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	1
90.	*Turbonilla costellata* (GRATELOUP)	.	5	1	.	.	.	.	.	.	1	.	.	.	?1	?1	.	2	4	.	.	3	3	3
91.	*Turbonilla sp.*	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
92.	*Pyramidella plicosa* BRONN	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
93.	*Ringicula buccinea* (BROCCHI)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	17	13	11	.	5	9	3
94.	*Cylichna cylindracea* (PENNANT)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.
95.	*Retusa elongata* (EICHWALD)	2	?1	4	4	4	?1	?1	?1	.	?2	3	.	?1	?1	3	1	5	4	3	3	4	4	2
96.	*Diaphana moerchi nov. sp.*	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	1	.	1	1	.	.	.	.
97.	*Spiratella atlanta* (MØRCH)	6	4	1	17	27	9	32	18	27	11	51	25	59	15	29	6	46	48	27	33	32	36	31
98.	*Spiratella gramensis nov. sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Pelecypoda indet.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	3	1	.
	Gastropoda indet.	12	1	.	.	1	1	.	.	.	.	.	1	1	.	.	.	1	.	2	.	1	.	.
	Mollusca indet.	.	.	2	6	.	.	.	.	.	.	7	2	.	.	2	.	.	.	.	.	.	.	.
	In all:	359	367	203	181	194	206	169	175	174	111	358	156	189	143	187	66	213	175	134	117	247	270	231

Table 59. Part 2. Gram. 141.277 (15.55–25.50)

		15.55–16.00 m.	16.00–16.50 m.	16.50–17.00 m.	17.00–17.50 m.	17.50–18.00 m.	18.00–18.50 m.	18.50–19.00 m.	19.00–19.50 m.	19.50–20.00 m.	20.00–20.50 m.	20.50–21.00 m.	21.00–21.50 m.	21.50–22.00 m.	22.00–22.50 m.	22.50–23.00 m.	23.00–23.50 m.	23.50–24.00 m.	24.00–24.50 m.	24.50–25.00 m.	25.00–25.50 m.
1.	*Nucula sp.*	3	4	1	6	6	1	3	3	2	1	1	1	.	1	.	.	.	.	1	.
2.	*Nuculana pygmaea* (MÜNSTER)	19	8	7	10	12	6	3	7	8	8	5	9	1	3	1	1	.	1	.	.
3.	*Yoldia glaberrima* (MÜNSTER)	.	.	.	2	.	.	.	1	1	.	1	1	.	1	.	.	.	1	.	.
4.	*Bathyarca pectunculoides* (SCACCHI)	.	.	.	.	.	1	.	1	1	.	.	.	.	.	.	.	.	.	.	.
5.	*Limopsis aurita* (BROCCHI)	4	6	10	22	2	.	1	.	.	3	4	1	.	.	.	.	.	.	.	.
6.	*Volsella phaseolina* (PHILIPPI)	.	.	.	1	?1	.	1	.	.	.	.	1	.	.	.	.	.	.	.	.
7.	*?Pinna sp.*	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8.	*Chlamys clavata* (POLI)	.	.	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.
9.	*Amussium cf. woodi* (NYST)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10.	*Limatula subauriculata* (MONTAGU)	.	.	.	.	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
11.	*Astarte vetula* PHILIPPI	.	.	18	23	?27	12	9	1	2	2	6	2	1	?1	?1	.	.	.	.	.
12.	*Astarte reimersi* SEMPER	17	19	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
13.	*Astarte radiata* NYST & WESTENDORP	.	.	.	.	.	2	.	.	.	4	.	.	.	.	.	.	.	.	.	.
14.	*Goodallia esbjergensis nov. sp.*	39	35	11	33	9	1	1	.	.	.	.	3	.	.	.	.	.	.	.	.
15.	*Cardita orbicularis* (SOWERBY)	3	10	13	17	18	9	13	4	3	3	1	.	4	.	.	.	.	.	.	.
16.	*Kellyella rotunda* SORGENFREI	.	.	.	.	.	.	.	1	.	.	.	.	1	.	.	.	.	.	.	.
17.	*Isocardia forchhammeri* BECK	1	1	1	2	1	.	1	1	.	.	.	1	.	?1	.	.	.	.	.	.
18.	*Thyasira cf. flexuosa* (MONTAGU)	.	3	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
19.	*Thyasira sp.*	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
20.	*Phacoides sp.*	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
21.	*Erycina sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
22.	*Cardium papillosum* (POLI)	3	4	2	10	5	2	2	2	1	1	1	1	?1	.	.	.	.	1	.	.
23.	*Spisula subtruncata* (DA COSTA)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
24.	*Abra cf. prismatica* (MONTAGU)	.	4	5	5	2	.	.	.	1	1	1	.	.	.	.	.	.	.	.	.

		15.55–16.00 m.	16.00–16.50 m.	16.50–17.00 m.	17.00–17.50 m.	17.50–18.00 m.	18.00–18.50 m.	18.50–19.00 m.	19.00–19.50 m.	19.50–20.00 m.	20.00–20.50 m.	20.50–21.00 m.	21.00–21.50 m.	21.50–22.00 m.	22.00–22.50 m.	22.50–23.00 m.	23.00–23.50 m.	23.50–24.00 m.	24.00–24.50 m.	24.50–25.00 m.	25.00–25.50 m.
25.	*Varicorbula gibba* (OLIVI)	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
26.	*Thracia ventricosa* PHILIPPI	2	1	1	1	3	1	1	1	1	1	1	.	.	.	.	.	.	.	.	.
27.	*Cuspidaria cuspidata* (OLIVI)	.	2	1	3	1	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.
28.	*Cuspidaria costellata* (DESHAYES)	.	.	.	.	.	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.
29.	*Siphonodentalium cf. lobatum* (SOWERBY)	3	2	2	4	2	2	2	2	1	1	1	1	1	1	1	.	.	1	.	.
30.	*Dentalium cf. michelotti* HÖRNES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
31.	*Dentalium badense* PARTSCH	.	.	2	2	1	.	.	.	.	2	4	.	?1	.	.	.	.	.	.	.
32.	?*Lacuna sp.*	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
33.	*Solariella jutensis nov. sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
34.	*Teinostoma pulchralis* (WOOD)	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
35.	*Circulus hennei* GLIBERT	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
36.	*Putilla gottscheana* (v. KOENEN)	7	6	4	38	7	2	5	2	1	1	1	2	.	.	.	.	.	.	.	.
37.	*Cingula inusitata* (BEETS)	.	.	.	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.
38.	*Archimediella cochlias* (BAYAN)	7	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
39.	*Archimediella subangulata* (BROCCHI)	.	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.
40.	*Turritella tricarinata* (BROCCHI)	.	.	11	12	9	3	5	3	.	.	.	.	.	.	.	.	.	.	.	.
41.	*Bittium tenuispina* SORGENFREI	.	.	.	.	?1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
42.	*Aclis minor* (BROWN)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
43.	*Opalia vilandti* (MØRCH)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
44.	*Leiostraca glabra* (DA COSTA)	.	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
45.	*Xenophora testigera* (BRONN)	.	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
46.	*Polinices catena* (DA COSTA)	.	.	.	.	.	.	2	.	1	2	.	.	.	.	.	.	.	.	.	.
47.	*Polinices protracta* (EICHWALD)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
48.	*Natica koeneni* SACCO	.	.	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Naticidae indet.	11	10	11	9	15	3	.	2	.	.	2	1	.	.	.	.	.	.	.	.
49.	*Galeodea echinophora* (LINNÉ)	.	1	.	1	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
50.	*Murex spinicosta* BRONN	.	.	1	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.

51.	*Trophonopsis semperi* (v. KOENEN)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
52.	*Lyrotyphis sejunctus* (SEMPER)	2	5	2	.	4	1	.	2	.	.	.	.	.	.	.	.	.	.	.	.
53.	*Sipho distinctus* (BEYRICH)	.	.	.	1	?1	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.
54.	*Nassa bocholtensis* (BEYRICH)	.	.	.	1	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.
55.	*Nassa holsatica* (BEYRICH)	.	.	.	.	.	.	.	5	4	4	.	.	.	.	.	.	.	.	.	.
56.	*Nassa syltensis* (BEYRICH)	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
57.	*Nassa prismatica* (BROCCHI)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
58.	*Aquilofusus eximius* (BEYRICH)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
59.	*Aquilofusus semiglaber* (BEYRICH)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
60.	*Aquilofusus puggaardi* (BEYRICH)	?1	.	.	.	.	?1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
61.	*Lathyrus rothi* (BEYRICH)	.	.	.	.	.	2	.	1	.	.	.	.	.	.	.	.	.	.	.	.
62.	*Uromitra cimbrica* (OPPENHEIM)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
63.	*Narona calcarata* (BROCCHI)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
64.	*Narona rothi* (SEMPER)	.	1	.	.	?1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
65.	*Admete fusiformis* (CANTRAINE)	1	1	2	2	1	.	1	1	.	.	.	.	.	.	.	.	.	1	.	.
66.	*Conus antediluvianus* BRUGUIÈRE	1	1	2	.	3	1	.	1	1	.	.	.	.	.	.	.	.	.	.	.
67.	*Gemmula badensis* (R. HÖRNES)	4	7	3	6	7	2	.	1	2	2	2	2	.	?1	.	.	.	.	.	.
68.	*Gemmula annae* (HÖRNES & AUINGER)	1	.	1	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
69.	*Fusiturris helena* (SEMPER)	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
70.	*Bathytoma cataphracta* (BROCCHI)	3	1	.	1	1	.	.	1	1	1	.	.	.	.	.	.	.	.	.	.
71.	*Acamptogenotia intorta* (BROCCHI)	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
72.	*Inquisitor borealis* (KAUTSKY)	.	?1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
73.	*Spirotropis modiola* (JAN)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
74.	*Haedropleura maitreja* (SEMPER)	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
75.	*Microdrillia serratula* (BROCCHI)	1	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
76.	*Asthenotoma ravni nov. sp.*	.	1	1	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
77.	*Brachytoma obtusangula* (BROCCHI)	6	7	4	5	10	4	2	.	.	1	.	.	.	1	.	.	.	1	.	.
78.	*Neoguraleus kochi* (v. KOENEN)	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
79.	*Pleurotomoides luisae* (SEMPER)	2	2	5	1	6	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
80.	*Philbertia reticulata* (RENIERI)	1	1	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
81.	*Philbertia sinuosula* SORGENFREI	.	.	.	.	1	.	.	.	1	.	.	1	.	.	.	.	.	.	.	.
82.	*Acteon semistriatus* (BASTEROT)	1	1	.	.	?1	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.
83.	*Chrysallida pygmaea* (GRATELOUP)	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
84.	*Chrysallida semireticulata* SORGENFREI	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 59. Part 2 (continued) Gram. 141.277 (15.55–25.50 m.) (continued)

		15.55–16.00 m.	16.00–16.50 m.	16.50–17.00 m.	17.00–17.50 m.	17.50–18.00 m.	18.00–18.50 m.	18.50–19.00 m.	19.00–19.50 m.	19.50–20.00 m.	20.00–20.50 m.	20.50–21.00 m.	21.00–21.50 m.	21.50–22.00 m.	22.00–22.50 m.	22.50–23.00 m.	23.00–23.50 m.	23.50–24.00 m.	24.00–24.50 m.	24.50–25.00 m.	25.00–25.50 m.
85.	*Chrysallida* (*nov. sp.*?)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
86.	*Kleinella nordmanni* SORGENFREI	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
87.	*Odostomia conoidea* (BROCCHI)	2	5	.	2	.	.	.	1	1	.	1	1	.	.	.	.	.	.	1	.
88.	*Eulimella scillae* (SCACCHI)	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
89.	*Eulimella sp.*	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.
90.	*Turbonilla costellata* (GRATELOUP)	3	.	1	3	.	3	1	.	.	.	1	.	.	.	.	.	.	.	.	.
91.	*Turbonilla sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
92.	*Pyramidella plicosa* BRONN	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
93.	*Ringicula buccinea* (BROCCHI)	4	7	2	2	.	.	1	.	.	1	2	.	.	.	.	.	.	.	.	.
94.	*Cylichna cylindracea* (PENNANT)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
95.	*Retusa elongata* (EICHWALD)	3	1	2	4	3	.	1	.	?1	.	.	.	.	.	.	.	.	.	.	.
96.	*Diaphana moerchi nov. sp.*	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
97.	*Spiratella atlanta* (MØRCH)	61	68	47	74	53	7	15	5	1	18	18	8	7	.	.	.	.	.	.	.
98.	*Spiratella gramensis nov. sp.*	.	.	.	.	.	3	6	.	12	8	.	45	2	.	.	.	.	.	.	.
	Pelecypoda indet.	.	.	.	3	.	.	.	2	1	1	.	.	.	.	.	.	.	.	.	.
	Gastropoda indet.	1	.	.	2	.	.	.	1	3	.	2	1	.	.	.	.	.	1	.	.
	Mollusca indet.	.	.	.	.	2	4	2	.	.	.	.	.	4	.	.	.	.	.	.	.
	In all:	224	240	175	317	224	79	87	58	55	69	59	81	25	10	3	1	0	7	2	1

Table 60. **Spandetgård**

		Collections from dug clay	Collections in westernmost clay pit	Collections in the eastern clay pit 1957–1962		Collections in the eastern clay pit 1963		Sample of clay from the eastern clay pit				
				Number	Percentage	Number	Percentage	Fraction 1	Fraction 2	Fraction 3	Number	Percentage
1.	*Nuculana georgiana* SEMPER	2	1	17	1.397	9	1.27	.	18	15	33	3.140
2.	*Nuculana pygmaea* (MÜNSTER)	.	.	5	0.411	1	0.14	.	263	97	360	34.253
3.	*Yoldia glaberrima* (MÜNSTER)	.	.	.	.	.	.	1	26	12	39	3.711
4.	*Limopsis aurita* (BROCCHI)	.	.	6	0.493	5	0.71	.	.	.	.	.
5.	*Chlamys clavata* (POLI)	1	.	2	0.164	.	.	.	1	.	1	0.095
6.	*Astarte reimersi* SEMPER	15	7	160	13.147	122	17.21	.	.	.	.	.
7.	*Goodallia esbjergensis nov. sp.*	.	.	1	0.082	.	.	.	.	.	.	.
8.	*Cardita orbicularis* (SOWERBY)	.	.	11	0.904	4	0.56	.	.	.	.	.
9.	*Isocardia forchhammeri* BECK	2	1	10	0.822	10	1.41	.	1	1	2	0.190
10.	*Thyasira cf. flexuosa* (MONTAGU)	.	.	.	.	.	.	.	2	1	3	0.285
11.	*Cardium papillosum* (POLI)	.	1	.	.	.	.	.	5	3	8	0.761
12.	*Abra prismatica* (MONTAGU)	.	.	.	.	.	.	.	10	11	21	1.998
13.	*Thracia sp.*	.	.	.	.	.	.	1	1	.	2	0.190
14.	*Cuspidaria cuspidata* (OLIVI)	.	.	.	.	.	.	.	1	1	2	0.190
15.	*Siphonodentalium cf. lobatum* (SOW.)	.	.	21	1.726	.	.	1	34	39	74	7.041
16.	*Dentalium entale* (L.)	.	.	1	0.082	.	.	.	.	.	.	.
17.	*Putilla gottscheana* (v. KOENEN)	.	.	.	.	.	.	.	15	178	193	18.363
18.	*Circulus hennei* GLIBERT	.	.	1	0.082	1	0.14	.	.	.	.	.
19.	*Turritella tricarinata* (BROCCHI)	3	1	150	12.325	67	9.45	.	4	.	4	0.381
20.	*Opalia vilandti* (MØRCH)	.	.	.	.	.	.	.	1	4	5	0.476
21.	*Scala frondicula* (WOOD)	.	.	1	0.082	.	.	.	.	1	1	0.095
22.	*Xenophora testigera* (BRONN)	.	.	1	0.082	1	0.14	.	1	.	1	0.095
23.	*Natica koeneni* SACCO	.	.	1	0.082	1	0.14	.	.	.	.	.
24.	*Polinices protracta* (EICHWALD)	.	.	2	0.164	1	0.14	1	.	.	1	0.095
25.	*Polinices catena* (DA COSTA)	.	.	.	.	2	0.28	.	.	.	.	.
–	*Polinices sp. indet.*	.	2	82	6.738	16	2.26	.	79	16	95	9.039
26.	*Semicassis miolaevigata* (SACCO)	.	.	5	0.411	7	0.99	.	.	.	.	.
27.	*Galeodea echinophora* (L.)	1	.	8	0.657	7	0.99	.	1	.	1	0.095
28.	*Lyrotyphis sejunctus* (SEMPER)	.	.	5	0.411	2	0.28	1	3	.	4	0.381
29.	*Sipho distinctus* (BEYRICH)	.	2	38	3.123	35	4.94	.	.	.	.	.
30.	*Nassa bocholtensis* (BEYRICH)	.	.	11	0.904	12	1.69	1	1	.	2	0.190
31.	*Nassa syltensis* (BEYRICH)	.	.	3	0.247	1	0.14	.	2	.	2	0.190
32.	*Nassa prismatica* (BROCCHI)	.	.	.	.	1	0.14	.	.	.	.	.
33.	*Aquilofusus semiglaber* (BEYRICH)	3	2	50	4.108	59	8.32	.	1	.	1	0.095
34.	*Narona rothi* (SEMPER)	.	.	15	1.230	5	0.71	.	1	.	1	0.095
35.	*Admete fusiformis* (CANTRAINE)	.	.	1	0.082	.	.	.	1	1	2	0.190
36.	*Conus antediluvianus* BRUGUIÈRE	3	1	94	7.724	66	9.31	1	1	.	2	0.190
37.	*Gemmula badensis* (HÖRNES)	7	1	208	17.091	103	14.53	6	5	.	11	1.048
38.	*Gemmula annae* (HÖRNES & AUINGER)	4	1	115	9.449	69	9.73	2	4	.	6	0.571
39.	*Fusiturris helena* (SEMPER)	.	.	.	.	.	.	.	1	.	1	0.095
40.	*Bathytoma cataphracta* (BROCCHI)	7	1	68	5.588	58	8.18	1	4	.	5	0.476
41.	*Acamptogenotia intorta* (BEYRICH)	.	.	4	0.329	2	0.28	.	.	.	.	.
42.	*Inquisitor borealis* (KAUTSKY)	.	.	1	0.082	1	0.14	.	.	.	.	.

Table 60 (continued) Spandetgård (continued)

		Collections from dug clay	Collections in westernmost clay pit	Collections in the eastern clay pit 1957–1962		Collections in the eastern clay pit 1963		Sample of clay from the eastern clay pit				
				Number	Percentage	Number	Percentage	Fraction 1	Fraction 2	Fraction 3	Number	Percentage
43.	*Spirotropis modiola* (JAN)	.	.	.	.	1	0.14	.	.	.	.	.
44.	*Asthenotoma sp.*	.	.	1	0.082	.	.	.	.	.	.	.
45.	*Brachytoma obtusangula* (BROCCHI)	2	.	72	5.916	24	3.39	2	11	1	14	1.332
46.	*Neoguraleus kochi* (v. KOENEN)	.	.	5	0.411	2	0.28	.	10	1	11	1.048
47.	*Pleurotomoides luisae* (SEMPER)	3	.	18	1.479	13	1.83	2	5	.	7	0.666
48.	*Philbertia reticulata* (RENIERI)	.	.	.	.	1	0.14	.	1	.	1	0.095
49.	*Philbertia sinuosula* SORGENFREI	.	.	1	0.082	.	.	.	.	.	.	.
–	*Philbertia sp. indet.*	.	.	.	.	.	.	.	.	1	1	0.095
50.	?*Terebra sp.*	.	.	.	.	.	.	.	1	.	1	0.095
51.	*Chrysallida semireticulata* SORGENFR.	.	.	.	.	.	.	.	.	1	1	0.095
52.	*Odostomia conoidea* (BROCCHI)	1	.	18	1.479	.	.	.	46	17	63	5.994
53.	*Turbonilla costellata* (GRATELOUP)	.	.	2	0.164	.	.	.	3	.	3	0.285
54.	*Cylichna cylindracea* (PENNANT)	.	.	2	0.164	.	.	.	6	.	6	0.571
55.	*Retusa elongata* (EICHWALD)	.	.	.	.	.	.	.	1	.	1	0.095
56.	*Spiratella atlanta* (MØRCH)	.	.	.	.	.	.	.	32	26	58	5.519
–	Mollusca indet.	.	.	.	.	.	.	.	1	.	1	0.095
	In all:	54	21	1217	99.996	709	100.00	20	604	427	1051	99.999

Table 61. **Spandet. 150.184**

		22.75–27.00 m.	27.0–33.0 m.	33.0–37.1 m.	Total number
1.	*Nucula sp.*	.	1	.	1
2.	*Yoldia glaberrima* (MÜNSTER)	.	.	1	1
3.	*Limopsis aurita* (BROCCHI)	.	2	.	2
4.	*Astarte reimersi* SEMPER	1	2	1	4
5.	*Goodallia esbjergensis nov. sp.*	.	1	.	1
6.	*Cardita orbicularis* (SOWERBY)	.	1	1	2
7.	*Abra prismatica* (MONTAGU)	.	1	.	1
8.	*Thracia sp.*	.	1	.	1
9.	*Putilla gottscheana* (v. KOENEN)	.	2	.	2
10.	*Turritella sp.*	1	.	.	1
11.	*Aquilofusus sp.*	.	1	.	1
12.	*Gemmula annae* (HÖRN. & AUING.)	.	.	1	1
	Gemmula sp. indet.	1	.	.	1
13.	*Brachytoma obtusangula* (BROCCHI)	.	.	1	1
14.	*Turbonilla costellata* (GRATELOUP)	.	.	1	1
15.	*Ringicula sp.*	.	1	.	1
16.	*Spiratella atlanta* (MØRCH)	.	4	9	13
	In all:	3	17	15	35

Table 62. **Tønder. 166.398**

		24 m.	37 m.	43.5 m.	45 m.	50 m.	58.85–59.00 m.	72 m.	74 m.
1.	*Nucula sp.*	.	1	2	.	3	1	.	1
2.	*Nuculana pygmaea* (Münster)	1	2	3	2	3	7	.	.
3.	*Yoldia glaberrima* (Münster)	1	1	1	1	.	.	.	.
4.	*Limopsis aurita* (Brocchi)	.	.	.	.	.	2	1	3
5.	*Astarte reimersi* Semper	.	.	.	1	.	13	.	.
6.	*Cardita orbicularis* (Sowerby)	.	.	.	.	.	2	.	.
7.	*Kellyella rotunda* Sorgenfrei	.	.	.	.	.	2	.	.
8.	*Cardium papillosum* (Poli)	.	.	.	.	2	3	.	.
9.	*Abra cf. prismatica* (Montagu)	.	.	.	.	.	4	1	.
10.	*Thracia cf. ventricosa* Philippi	.	.	.	.	.	1	.	.
11.	*Siphonodentalium cf. lobatum* (Sowerby)	1	2	1	.	1	2	.	.
12.	*?Lacuna sp.*	.	.	.	.	.	1	.	.
13.	*Putilla gottscheana* (v. Koenen)	.	.	.	.	.	6	.	2
14.	*Cingula sp.*	.	.	.	.	.	.	.	1
15.	*Turritella tricarinata* (Brocchi)	?1	.	.	1	.	6	.	.
16.	*Xenophora testigera* (Bronn)	.	.	.	.	.	2	.	1
17.	*Polinices catena* (Da Costa)	.	.	.	.	.	3	.	.
–	Naticidae indet.	.	.	1	2	.	.	1	.
18.	*Lyrotyphis sejunctus* (Semper)	.	1	.	.	.	1	.	.
19.	*Sipho distinctus* (Beyrich)	.	.	.	1	.	1	.	.
20.	*Nassa bocholtensis* (Beyrich)	.	.	.	.	.	.	.	1
21.	*Lathyrus rothi* (Beyrich)	.	.	.	.	.	1	.	.
22.	*Admete fusiformis* (Cantraine)	.	.	.	.	.	1	.	.
23.	*Conus antediluvianus* Bruguière	.	.	.	.	.	1	.	.
24.	*Gemmula badensis* (R. Hörnes)	.	.	1	.	.	3	.	1
25.	*Gemmula annae* (Hoern. & Auing.)	.	.	.	.	.	1	.	.
26.	*?Bathytoma cataphracta* (Brocc.)	.	.	1	.	.	.	.	.
27.	*Microdrillia serratula* (Bellardi)	.	.	.	.	.	1	.	.
28.	*Brachytoma obtusangula* (Brocchi)	1	.	2	.	1	3	.	1
29.	*Pleurotomoides luisae* (Semper)	.	.	1	.	.	4	.	.
30.	*Acteon semistriatus* Basterot)	.	.	.	.	1	.	.	.
31.	*Odostomia conoidea* (Brocchi)	1	.	1	.	.	.	.	.
32.	*Turbonilla costellata* (Grateloup)	.	.	.	.	.	1	.	.
33.	*Scaphander sp.*	.	.	.	.	.	1	.	.
34.	*Spiratella cf. valvatina* (Reuss)	.	.	.	.	.	.	2	1
35.	*Spiratella atlanta* (Mørch)	.	.	.	1	5	28	.	.
	Pelecypoda indet.	.	.	.	.	.	1	.	.
	In all:	6	7	14	9	16	103	5	12

Table 63. **Brodersmark. 166.351 b**

		22.6–24 m.	24–25 m.	25–26 m.	26–27 m.	27–28 m.	28–29 m.	29–30 m.	30–31 m.	31–32 m.	Total number
1.	*Nucula sp.*	4	3	7	10	2	4	5	3	4	42
2.	*Nuculana pygmaea* (MÜNSTER)	32	37	25	26	16	21	30	21	15	223
3.	*Yoldia glaberrima* (MÜNSTER)	6	5	8	1	2	4	3	.	2	31
4.	*Chlamys clavata* (POLI)	1	.	1	.	.	.	.	.	1	3
5.	*Astarte reimersi* SEMPER	35	15	12	27	16	12	38	35	21	211
6.	*Cardita orbicularis* (SOWERBY)	.	.	2	.	2	1	.	1	.	6
7.	*Isocardia forchhammeri* BECK	.	.	.	.	.	1	.	.	.	1
8.	*Thyasira cf. flexuosa* (MONTAGU)	.	.	1	.	.	.	1	.	1	3
9.	*Erycina sp.*	.	.	.	.	.	.	1	.	.	1
10.	*Cardium papillosum* (POLI)	1	.	2	1	.	.	.	.	1	5
11.	*Abra cf. prismatica* (MONTAGU)	4	2	.	.	1	.	.	.	1	8
12.	*Thracia cf. ventricosa* PHILIPPI	2	.	1	.	1	.	.	.	.	4
–	Pelecypoda indet.	.	1	.	1	.	1	1	.	1	5
13.	*Siphonodentalium cf. lobatum* (SOW.)	5	1	.	5	3	2	7	4	3	30
14.	*Dentalium sp.*	.	.	.	.	.	.	.	.	1	1
15.	*Solariella jutensis nov. sp.*	.	.	.	.	.	.	1	.	.	1
16.	*Circulus hennei* GLIBERT	.	.	.	.	1	.	.	.	.	1
17.	*Putilla gottscheana* (v. KOENEN)	.	.	.	.	.	.	.	.	1	1
18.	*Turritella tricarinata* (BROCCHI)	37	11	35	26	30	17	29	34	28	247
19.	*Bittium tenuispina* SORGENFREI	1	.	.	.	.	.	.	.	.	1
20.	*Opalia vilandti* MØRCH	2	.	1	1	.	.	1	3	1	9
21.	*Scala cf. frondicula* (WOOD)	.	.	.	.	.	.	.	.	1	1
22.	Naticidae indet.	56	52	38	21	40	30	29	16	9	291
23.	*Galeodea echinophora* (L.)	1	.	.	.	.	.	.	1	.	2
24.	*Murex spinicosta* BRONN	1	.	.	1	.	.	1	.	.	3
25.	*Trophonopsis semperi* (v. KOENEN)	.	.	.	.	.	.	.	.	1	1
26.	*Lyrotyphis sejunctus* (SEMPER)	7	1	4	.	1	1	.	3	1	18
27.	*Sipho distinctus* (BEYRICH)	.	.	.	2	1	.	.	.	.	3
28.	*Nassa bocholtensis* (BEYRICH)	2	1	2	5	.	2	3	.	1	16
29.	*Nassa syltensis* (BEYRICH)	.	1	2	1	.	1	.	.	.	5
30.	*Aquilofusus semiglaber* (BEYRICH)	1	.	.	1	.	.	1	.	1	4
31.	*Narona rothi* (SEMPER)	1	.	.	.	.	1	.	.	.	2
32.	*Admete fusiformis* (CANTRAINE)	1	.	.	.	.	.	.	.	1	2
33.	*Conus antediluvianus* BRUGUIÈRE	3	.	2	.	.	1	1	.	.	7
34.	*Gemmula badensis* (R. HOERNES)	20	7	12	6	5	5	11	10	5	81
35.	*Gemmula annae* (HOERN. & AUING)	1	1	1	5	2	4	1	1	2	18
36.	*Bathytoma cataphracta* (BROCCHI)	.	.	.	1	1	.	.	1	.	3
37.	*Brachytoma obtusangula* (BROCCHI)	10	12	9	12	12	12	8	6	6	87
38.	*Neoguraleus kochi* (v. KOENEN)	2	1	2	1	1	1	1	.	.	9
39.	*Pleurotomoides luisae* (SEMPER)	6	4	5	5	5	3	2	2	1	33
40.	*Philbertia reticulata* (RENIERI)	6	1	1	.	.	1	.	1	.	10
41.	*Odostomia conoidea* (BROCCHI)	27	13	29	26	11	25	25	18	15	189
42.	*Eulimella sp.*	.	.	.	.	.	2	.	.	.	2
43.	*Pyramidella plicosa* BRONN	.	.	4	.	.	.	.	.	.	4
44.	*Turbonilla costellata* (GRATELOUP)	1	.	.	1	.	2	.	.	.	4
45.	*Retusa elongata* (EICHWALD)	.	.	1	.	1	.	2	.	.	4
46.	*Spiratella atlanta* (MØRCH)	27	9	35	49	14	17	47	84	48	330
–	Gastropoda indet.	.	.	.	.	.	1	.	.	1	2
	In all:	303	178	242	235	168	172	249	244	174	1965

Table 64. **Sæd Custom-house. 167.4. 70 m.**

		Sæd Clay	Gram Clay
1.	*Nucula sp.*	5	.
2.	*Nuculana pygmaea* (MÜNSTER)	5	3
3.	*Yoldia glaberrima* (MÜNSTER)	5	1
4.	*Astarte reimersi* SEMPER	.	2
5.	*Kellyella rotunda* SORGENFREI	1	.
6.	*Isocardia forchhammeri* BECK	.	1
7.	*Thyasira cf. flexuosa* (MONTAGU)	1	1
8.	*Cardium papillosum* (POLI)	16	.
9.	*Abra cf. prismatica* (MONTAGU)	.	1
10.	*Siphonodentalium cf. lobatum* (SOWERBY)	12	1
11.	*Turritella tricarinata* (BROCCHI)	.	1
12.	Naticidae indet.	2	.
13.	*Nassa syltensis* (BEYRICH)	6	.
14.	*Nassa slieswicia nov. sp.*	11	.
15.	*Gemmula badensis* (R. HÖRNES)	2	.
16.	*Fusiturris helena* (SEMPER)	2	.
17.	*Bathytoma cataphracta* (BROCCHI)	.	1
18.	*Brachytoma obtusangula* (BROCCHI)	.	1
19.	*Neoguraleus sæthensis nov. sp.*	2	.
20.	*Chrysallida semireticulata* SORGENFREI	5	.
21.	*Odostomia conoidea* (BROCCHI)	3	1
22.	*Retusa sp.*	4	.
23.	*Spiratella atlanta* (MØRCH)	2	.
–	*Spiratella sp.*	3	.
	Pelecypoda indet.	8	1
	In all:	95	15

Table 65. **Sæd Custom-house. 167.445**

		90.30–91.00 m.	91.00–91.50 m.	91.50–91.75 m.	91.75–92.00 m.	92.00–92.25 m.	92.25–92.70 m.	92.70–93.00 m.	93.00–93.70 m.	93.70–94.10 m.	94.10–94.75 m.	94.75–95.50 m.	95.50–95.90 m.	95.90–96.20 m.	96.20–96.75 m.	96.75–97.40 m.	97.40–97.90 m.	94.00–97.70 m. (Special sample)	97.90–98.60 m.	98.60–99.05 m.	99.05–99.55 m.	99.55–100.10 m.
1.	*Nucula sp.*	.	3	1	1	.	3	4	2	1	5	3	1	3	5	3	3	3	1	2	3	5
2.	*Nuculana pygmaea* (MÜNSTER)	2	10	3	2	7	22	11	11	6	8	6	5	10	21	8	11	13	12	7	8	5
3.	*Yoldia glaberrima* (MÜNSTER)	2	22	10	5	27	26	6	5	2	4	1	2	2	1	5	3	2	4	1	2	1
4.	*Chlamys clavata* (POLI)	.	.	.	.	.	.	.	.	1	.	.	.	.	1	.	1	.	1	1	1	.
5.	*Chlamys tigerina* (MÜLLER)	.	1	1	3	4	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6.	*Astarte cf. rollei* SEMPER	2	12	2	2	10	17	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.
7.	*Astarte reimersi* SEMPER	.	.	.	.	.	.	.	14	10	1	.	.	5	6	.	5	13	11	5	11	5
8.	*Goodallia esbjergensis pseudo-ovata nov. sp. et subsp.*	30	148	58	55	126	120	10	1	2	1	.	.	.	.	.	.	.	.	.	.	.
9.	*Isocardia forchhammeri* BECK	.	1	.	.	.	.	.	1	1	1	.	1	.	.	.	1	1	1	.	.	1
10.	*Thyasira cf. flexuosa* (MONTAGU)	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1
11.	*Codokia jutensis* SORGENFREI	.	.	.	.	.	.	?1	.	.	1	.	.	.	.	.	.	.	.	.	.	.
12.	*Cardium papillosum* (POLI)	4	15	15	7	11	14	3	2	1	1	.	1	1	2	.	.	1	.	.	3	.
13.	*Spisula subtruncata* (DA COSTA)	.	1	.	.	1	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14.	*Abra cf. prismatica* (MONTAGU)	.	3	2	1	4	8	1	1	.	.	.	.	.	.	1	.	1	.	.	3	.
15.	*Thracia cf. ventricosa* PHILIPPI	.	1	.	1	1	1	1	1	1	.	1	.	.	1	.	1	1	1	1	.	.
16.	*Cuspidaria cuspidata* (OLIVI)	1	3	2	2	4	7	.	.	1	.	1	.	.	1	.	.	1	.	1	1	.
17.	*Siphonodentalium cf. lobatum* (SOWERBY)	1	4	8	12	8	6	6	15	15	20	13	8	7	4	10	9	9	6	4	3	4
18.	*Putilla gottscheana* (v. KOENEN)	.	.	.	.	.	.	.	4	.	.	1	1	1	2	2	1	1	.	1	2	.
19.	*Circulus hennei* GLIBERT	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.
20.	*Turritella tricarinata* (BROCCHI)	.	3	.	1	.	3	4	7	3	.	.	1	3	4	6	4	4	7	2	4	5
21.	*Triphora fritschi* (v. KOENEN)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
22.	*Opalia vilandti* (MØRCH)	.	.	.	.	.	.	.	1	.	.	1	.	.	.	.	.	.	1	.	1	.
23.	*Leiostraca glabra* (DA COSTA)	.	.	1	1	4	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
24.	*Xenophora testigera* (BRONN)	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.	1	.	.	.
25.	*Aporrhais alata* (EICHWALD)	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
26.	*Polinices protracta* (EICHWALD)	.	.	.	2	.	.	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.

27.	*Natica koeneni* SACCO	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
–	Naticidae indet.	1	2	4	.	8	14	13	8	15	30	14	9	11	5	3	4	12	6	5	.	12
28.	*Galeodea echinophora* (L.)	.	.	.	.	.	.	1	.	.	1	.	.	?1	.	1	.	.	1	1	.	.
29.	*Murex spinicosta* BRONN	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	1	.	.	.	.	.
30.	*Lyrotyphis sejunctus* (SEMPER)	.	.	.	.	.	.	.	2	1	1	3	.	1	1	2	1	3	1	3	1	.
31.	*Pyrene sp.*	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
32.	*Sipho distinctus* (BEYRICH)	.	.	.	.	.	.	.	1	1	1	1	.	1	.	.	.	1	.	.	.	.
33.	*Nassa bocholtensis* (BEYRICH)	.	.	.	.	?2	?1	.	1	.	.	.	.	.	1	1	1	1	2	1	.	.
34.	*Nassa syltensis* (BEYRICH)	.	.	2	5	3	6	3	1	.	.	2	.	.	.	.	.	1	.	.	1	1
35.	*Nassa prismatica* (BROCCHI)	.	.	.	.	.	.	.	.	1	5	.	.	1	.	.	.	.	.	.	.	.
36.	*Nassa slieswicia nov. sp.*	.	.	.	1	6	20	4	?1	.	.	.	.	.	.	.	.	.	.	.	.	.
–	Nassidae indet.	.	8	.	.	4	12	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
37.	*Aquilofusus semiglaber* (BEYRICH)	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	2	.
38.	?*Uromitra sp.*	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
39.	*Narona rothi* SEMPER	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1	.	.	.	.
40.	*Admete fusiformis* (CANTRAINE)	.	.	.	?1	?1	.	1	.	2	1	.	.	.	.	.	1	1	.	.	1	1
41.	*Conus antediluvianus* BRUGUIÈRE	.	.	.	?1	1	.	2	.	1	1	.	.	1	1	3	1	1	.	1	.	1
42.	*Gemmula badensis* (R. HOERNES)	.	.	.	.	?1	2	2	1	2	12	9	2	2	2	2	2	4	2	1	3	3
43.	*Gemmula annae* (HOERN. & AUING.)	.	.	.	.	1	?1	.	1	1	3	2	.	1	1	2	1	1	.	.	.	1
44.	*Fusiturris helena* (SEMPER)	.	.	.	.	.	1	?1	.	.	.	.	.	1	.	.	.	.	.	.	1	.
45.	*Bathytoma cataphracta* (BROCCHI)	.	.	.	.	.	.	.	.	1	1	.	.	.	.	1	.	.	.	.	1	.
46.	*Spirotropis modiola* (JAN)	.	.	.	.	.	1	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.
47.	*Asthenotoma ravni nov. sp.*	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
48.	*Brachytoma obtusangula* (BROCCHI)	.	.	.	.	.	1	1	2	3	12	6	3	2	1	4	2	2	3	2	1	7
49.	*Neoguraleus kochi* (v. KOENEN)	.	.	.	.	.	.	1	1	.	6	1	1	3	.	.	1	.	.	.	.	2
50.	*Neoguraleus sæthensis nov. sp.*	.	.	1	1	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
51.	*Pleurotomoides luisae* (SEMPER)	.	.	.	.	.	.	2	.	.	2	2	.	1	1	2	.	4	2	.	2	1
52.	*Pleurotomoides sp.*	.	.	.	.	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
53.	*Philbertia reticulata* (RENIERI)	.	.	.	.	.	.	.	.	1	2	.	.	.	.	.	.	1	.	.	.	1
54.	*Philbertia sinuosula* SORGENFREI	.	.	.	.	.	?1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
–	Turridae sp.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
55.	*Acteon semistriatus* (BASTEROT)	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
56.	*Chrysallida semireticulata* SORGENFREI	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
–	?*Chrysallida sp.*	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

		90.30–91.00 m.	91.00–91.50 m.	91.50–91.75 m.	91.75–92.00 m.	92.00–92.25 m.	92.25–92.70 m.	92.70–93.00 m.	93.00–93.70 m.	93.70–94.10 m.	94.10–94.75 m.	94.75–95.50 m.	95.50–95.90 m.	95.90–96.20 m.	96.20–96.75 m.	96.75–97.40 m.	97.40–97.90 m.	94.00–97.70 m. (Special sample)	97.90–98.60 m.	98.60–99.05 m.	99.05–99.55 m.	99.55–100.10 m.
57.	*Odostomia conoidea* (BROCCHI)	.	.	.	.	.	4	9	16	15	37	15	2	3	11	7	6	12	5	7	.	.
58.	*Eulimella scillae* (SCACCHI)	.	.	.	.	.	?1	?1	.	.	.	.	.	1	.	.	.	.	.	.	.	.
59.	*Turbonilla costellata* (GRATELOUP)	.	.	.	.	.	.	.	7	2	.	1	.	.	1	.	.	2	.	.	.	.
60.	*Pyramidella plicosa* BRONN	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.
61.	*Ringicula buccinea* (BROCCHI)	.	.	.	.	.	?3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
62.	*Cylichna cylindracea* (PENNANT)	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
63.	*Retusa elongata* (EICHWALD)	.	1	.	.	1	2	.	1	.	.	.	.	.	.	.	.	.	1	1	.	2
64.	?*Scaphander sp.*	.	.	.	.	.	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
65.	*Spiratella atlanta* (MØRCH)	3	1	.	1	.	3	32	4	6	7	3	1	6	5	29	13	14	11	32	2	4
	Pelecypoda indet.	.	.	1	.	1	2	.	.	.	1	.	.	.	.	1	1	.	.	1	.	.
	Gastropoda indet.	.	4	2	2	12	7	.	.	3	.	.	.	2	.	1	1	1	.	.	.	1
	In all:	47	243	113	107	256	323	132	113	104	167	86	41	71	79	94	78	113	81	80	57	67

Table 66. **Rends. 167.236. Core interval: 140'–160'**

		In relation to top of core								
		0.0–0.5 m.	0.5–1.0 m.	1.0–1.5 m.	1.5–2.0 m.	2.0–2.5 m.	2.5–3.0 m.	3.00–3.25 m.	Total number	Percentage
1.	*Nucula sp.*	9	11	14	2	5	.	1	42	5.198
2.	*Nuculana pygmaea* (MÜNSTER)	56	83	59	3	19	.	.	220	27.228
3.	*Yoldia glaberrima* (MÜNSTER)	5	6	5	5	8	2	1	32	3.960
4.	*Pecten sp.*	.	.	.	.	1	.	.	1	0.124
5.	*Astarte reimersi* SEMPER	7	16	8	7	6	11	8	63	7.797
6.	*Kellyella rotunda* SORGENFREI	.	1	.	.	.	.	.	1	0.124
7.	*Isocardia forchhammeri* BECK	.	1	1	.	1	.	.	3	0.371
8.	*Thyasira cf. flexuosa* (MONTAGU)	1	1	2	.	.	.	.	4	0.495
9.	*Lucina sp.*	.	.	1	.	1	.	.	2	0.248
10.	*Cardium papillosum* (POLI)	5	11	10	2	1	.	.	29	3.589
11.	*Spisula subtruncata* (DA COSTA)	.	.	4	.	.	.	.	4	0.495
12.	*Abra prismatica* (MONTAGU)	2	3	4	3	1	.	.	13	1.608
13.	*Thracia sp.*	.	.	1	1	1	.	.	3	0.371
14.	*Cuspidaria cuspidata* (OLIVI)	.	1	.	.	.	.	.	1	0.124
15.	*Siphonodentalium cf. lobatum* (SOWERBY)	16	14	20	4	10	1	2	67	8.292
16.	*Putilla gottscheana* (v. KOENEN)	17	8	14	.	1	.	.	40	4.950
17.	*Cingula sp.*	.	.	1	.	.	.	.	1	0.124
18.	*Turritella tricarinata* (BROCCHI)	.	6	6	4	1	.	3	20	2.475
19.	*Leiostraca glabra* (DA COSTA)	.	.	1	.	.	.	.	1	0.124
20.	*Xenophora testigera* (BRONN)	.	.	.	1	.	.	.	1	0.124
21.	*Polinices catena* (DA COSTA) & div. spp.	13	16	14	7	8	5	1	64	7.921
22.	*Natica koeneni* SACCO	.	.	.	.	1	.	.	1	0.124
23.	*Galeodea echinophora* (L.)	.	.	.	.	1	.	1	2	0.248
24.	*Lyrotyphis sejunctus* (SEMPER)	2	4	3	5	.	.	.	14	1.733
25.	*Sipho distinctus* (BEYRICH)	.	1	.	.	.	.	.	1	0.124
26.	*Nassa bocholtensis* (BEYRICH)	.	1	.	1	.	.	1	3	0.371
27.	*Nassa syltensis* (BEYRICH)	1	5	2	1	.	.	.	9	1.114
28.	*Nassa prismatica* (BROCCHI)	.	.	3	.	.	.	.	3	0.371
29.	*Aquilofusus semiglaber* (BEYRICH)	1	.	.	.	.	.	.	1	0.124
30.	*Narona rothi* (SEMPER)	.	.	1	1	.	.	.	2	0.248
31.	*Admete fusiformis* (CANTRAINE)	.	1	2	.	.	.	.	3	0.371
32.	*Conus antediluvianus* BRUGUIÈRE	1	1	.	1	.	.	.	3	0.371
33.	*Gemmula badensis* (HÖRNES)	3	4	2	3	2	.	2	16	1.980
34.	*Gemmula annae* (HÖRNES & AUINGER)	.	.	2	1	.	1	1	5	0.619
35.	*Fusiturris helena* (SEMPER)	1	1	.	.	.	.	.	2	0.248
36.	*Bathytoma cataphracta* (BROCCHI)	.	1	2	.	.	1	.	4	0.495
37.	*Brachytoma obtusangula* (BROCCHI)	2	1	4	3	5	1	2	18	2.228
38.	*Neoguraleus kochi* (v. KOENEN)	3	3	3	1	.	1	.	11	1.361
39.	*Pleurotomoides luisae* (SEMPER)	.	1	1	3	1	1	1	8	0.990
40.	*Philbertia reticulata* (RENIERI)	.	1	.	1	.	.	.	2	0.248
41.	*Acteon semistriatus* (BASTEROT)	.	1	.	.	.	.	.	1	0.124
42.	*Chrysallida semireticulata* SORGENFREI	.	.	1	.	.	.	.	1	0.124
43.	*Odostomia conoidea* (BROCCHI)	3	5	8	7	9	3	.	35	4.332
44.	*Turbonilla costellata* (GRATELOUP)	.	.	.	2	.	.	.	2	0.248
45.	*Pyramidella plicosa* BRONN	.	.	6	4	.	.	.	10	1.238
46.	*Retusa cf. elongata* (EICHWALD)	.	2	2	.	2	.	.	6	0.743
47.	*Spiratella atlanta* (MØRCH)	.	3	13	8	3	.	.	27	3.342
–	Gastropoda indet.	1	1	2	.	2	.	.	6	0.743
	In all:	149	215	222	81	90	27	24	808	100.004

Faunistic Relations of the Gram Formation

I. Neogene Deposits of the North Sea Basin

The whole known molluscan fauna from the whole Gram Formation in Denmark is listed in Table 67, where the appearance of the various species in other Neogene formations in the North Sea Basin is indicated by countries.

Unfortunately there are only modern, complete lists of the molluscan faunas in the Miocene and Plio-Pleistocene of Belgium (GLIBERT 1958), while in the case of the other countries we are referred to earlier papers or to recent special works which only deal with certain species or groups of species. The statements therefore are of different value and can only give a heterogeneous picture of the actual facts as long as there are no new, homogeneous lists of fossils from all formations available.

I shall not here offer detailed comments on each single column, which must speak for itself. The faunistic relation of the Gram Clay to the faunas of the other formations is also well-known from previous works. Reference may be made e.g. to the section pp. 112–137 in RASMUSSEN 1956 and to the papers mentioned below, arranged by countries, from which information has been provided for the preparation of the table:

Denmark.	Klintinghoved Clay:	SORGENFREI 1940.
	The Arnum Formation:	SORGENFREI 1958.
	The Hodde Formation:	the present paper pp. 217–219.
	Quaternary:	NORDMANN 1910 and 1928.
	Recent:	SORGENFREI 1958.
North Germany.	Vierland Stufe:	GRIPP 1914, 1915, and ANDERSON 1959.
	Hemmoor Stufe:	KAUTSKY 1925, DITTMER 1959.
	Reinbek Stufe:	ANDERSON 1958, HINSCH 1962.
	Glimmerton:	RASMUSSEN 1956
Holland.	Miocene:	MOLENGRAAF & WATERSCHOOT v. d. GRACHT 1913.
		ISPEERT 1942, HEERING 1950 b.
		VOORTHUYSEN 1944, SPAINK 1959.
	Plio-Pleistocene:	HEERING 1950a, BEETS (1946).
Belgium.	The whole of the Neogene:	GLIBERT 1958.
England.	Plio-Pleistocene:	WOOD 1848–82, HARMER 1914–25.

Table 67. **List of the Molluscan Fauna of the Gram Formation**

		Denmark					North-Germany				Belgium					Holland		England
		Miocene					Miocene				Miocene			Plio-Pleistocene				
+ = Occurrence according to literature 0 = Allied species according to literature ? = Occurrence dubious		Klintinghoved Clay	Arnum Formation	Hodde Formation	Quaternary	Recent	Vierländer Stufe	Hemmoor Stufe	Reinbek Stufe	Glimmerton	Houthaléen	Anversien	Diestien	Scaldisien	Merxemien	Miocene	Plio-Pleistocene	Plio-Pleistocene
1.	*Nucula georgiana* SEMPER	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
2.	*Nuculana pygmaea* (MÜNSTER)	+	+	+	.	.	+	+	+	+	+	+	+	+	.	+	.	+
3.	*Yoldia glaberrima* (MÜNSTER)	+	+	+	.	.	+	+	+	+	+	+	.	.	.	+	.	.
4.	*Bathyarca pectunculoides* (SCACCHI)	.	+	.	.	+	.	+	.	+	.	+	+	+	.	.	.	+
5.	*Limopsis aurita* (BROCCHI)	+	+	+	.	+	+	+	+	+	.	+	+	.	.	+	?	+
6.	*Limopsis anomala* (EICHWALD)	.	+	.	.	.	.	.	+	.	.	+	+	+	.	+	?	.
7.	*Volsella phaseolina* (PHILIPPI)	.	.	+	.	+	+	+	.	.	.	+	+	+	.	.	.	+
8.	?*Pinna sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
9.	*Chlamys clavata* (POLI)	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.
10.	*Chlamys tigerina* (MÜLLER)	.	+	.	.	+	+	+	.	+	+	+	+	+	.	+	+	+
11.	*Amussium cf. woodi* (NYST)	.	.	.	.	.	+	+	.	?	.	.	+	.	.	.	.	.
12.	*Limatula subauriculata* (MONTAGU)	.	.	.	.	+	+	+	.	.	.	+	+	+	.	+	+	+
13.	*Astarte vetula* PHILIPPI	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
14.	*Astarte reimersi* SEMPER	.	.	.	.	.	.	.	.	+	.	.	0	.	.	.	0	.
15.	*Astarte cf. rollei* SEMPER	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
16.	*Astarte radiata* NYST & WESTENDORP	.	.	.	.	.	.	+	+	+	+	+	.	.	.	+	.	.
17.	*Goodallia esbjergensis nov. sp.*	0	0	0	.	0	0	0	.	.	0	0	0	0	0	.	0	0
18.	*Goodallia esbjergensis pseudo-ovata nov. subsp.*	0	0	0	.	0	0	0	.	.	0	0	0	0	0	.	0	0
19.	*Cardita orbicularis* (SOWERBY)	.	+	.	.	.	+	+	?	+	+	+	+	+	+	+	+	+
20.	*Kellyella rotunda* SORGENFREI	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
21.	*Isocardia forchhammeri* BECK	.	.	.	.	.	0	0	+	+	.	.	0	0	.	0	0	0
22.	*Pygocardia rustica* (SOWERBY)	.	.	.	.	.	.	.	.	+	.	+	+	+	0	0	+	+
23.	*Thyasira flexuosa* (MONTAGU)	.	+	.	+	+	+	+	.	+	.	+	+	+	.	.	.	.
24.	*Thyasira sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
25.	*Phacoides sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
26.	*Codokia jutensis* SORGENFREI	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
27.	*Erycina sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
28.	*Montacuta sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
29.	?*Laevicardium sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
30.	*Cardium papillosum* (POLI)	.	0	0	+	.	0	+	0	+	+	+	.	.	.	+	+	.
31.	*Spisula subtruncata* (DA COSTA)	.	+	+	+	0	+	+	+	+	+	+	.	.	.	+	+	+
32.	*Abra prismatica* (MONTAGU)	+	+	?	+	+	.	.	+	+	0	0	0	+	+	+	+	+
33.	*Varicorbula gibba* (OLIVI)	.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	.
34.	*Teredo sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
35.	*Thracia ventricosa* PHILIPPI	+	?	?	.	.	+	+	.	+	.	+	.	+	.	.	?	+
36.	*Cuspidaria cuspidata* (OLIVI)	.	0	+	.	+	+	+	.	.	.	.	.	.	.	+	.	+
37.	*Cuspidaria costellata* (DESHAYES)	+	0	.	.	.	+	+	.	.	.	+	.	.	.	+	.	.
38.	*Dentalium badense* PARTSCH	+	0	.	.	.	+	.	+	+						+	.	.
39.	*Dentalium cf. michelotti* HÖRNES	.	+	.	.	.	.	+	.	.						.	.	.

Table 67 (continued) List of the Molluscan Fauna (continued)

		Denmark					North-Germany				Belgium					Holland		England
		Miocene					Miocene				Miocene			Plio-Pleistocene				
		Klintinghoved Clay	Arnum Formation	Hodde Formation	Quaternary	Recent	Vierländer Stufe	Hemmoor Stufe	Reinbek Stufe	Glimmerton	Houthaléen	Anversien	Diestien	Scaldisien	Merxemien	Miocene	Plio-Pleistocene	Plio-Pleistocene
40.	*Dentalium entale* LINNÉ	.	.	+	.	+	.	+	.	?						+	+	+
41.	*Siphonodentalium cf. lobatum* (SOW.)	.	.	.	.	0	.	.	.	?						.	.	.
42.	*Solariella jutensis nov. sp.*	.	.	.	.	.	0	0	.	.	.	0	.	.	.	0	.	.
43.	*Calliostoma sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
44.	*Teinostoma pulchralis* (WOOD)	.	.	.	.	.	.	.	.	?	.	.	.	.	.	+	.	+
45.	*Circulus hennei* GLIBERT	.	.	.	.	.	.	+	.	+	.	+	+	.	.	+	.	.
46.	*Putilla gottscheana* (v. KOENEN)	.	+	+	.	.	.	.	.	+	.	.	.	.	.	+	.	.
47.	*Cingula proxima laevigata* (v. KOENEN)	.	.	.	.	.	.	+	+	.	.	+	.	.	.	+	.	.
48.	*Cingula inusitata* (BEETS)	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	.
49.	*Archimediella cochlias* (BAYAN)	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.
50.	*Archimediella subangulata* (BROCCHI)	.	+	.	.	.	.	+	+	+	.	+	+	.	.	+	.	+
51.	*Turritella tricarinata* (BROCCHI)	.	+	.	.	0	.	.	.	+	.	.	.	.	+	+	+	+
52.	*Bittium tenuispina* SORGENFREI	.	+	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.
53.	*Triphora fritschi* (v. KOENEN)	.	.	+	.	0	+	+	+	.	.	.	.	.	.	+	.	.
54.	*Opalia vilandti* (MØRCH)	.	.	.	.	.	.	.	.	+	.	0	.	.	.	+	.	.
55.	*Scala frondicula* (WOOD)	.	+	.	.	.	+	+	.	+	.	+	+	+	?	+	+	+
56.	*Aclis minor* (BROWN)	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
57.	*Leiostraca glabra* (DA COSTA)	.	+	.	.	.	+	+	.	+	.	.	.	+	+	+	+	.
58.	*Xenophora testigera* (BRONN)	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
59.	*Aporrhais alata* (EICHWALD)	.	+	+	.	.	.	+	+	+	+	+	.	.	.	+	.	.
60.	*Polinices catena* (DA COSTA)	+	+	+	.	+	.	+	+	+	.	+	+	+	+	+	+	+
61.	*Polinices protracta* (EICHWALD)	.	.	+	.	.	.	+	+	+	.	+	.	.	.	+	0	.
62.	*Natica koeneni* SACCO	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.
63.	*Galeodea echinophora* (LINNÉ)	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.
64.	*Semicassis miolaevigatum* (SACCO)	.	.	.	.	.	.	+	.	+	+	+	.	.	.	+	?	?
65.	*Ficus conditus* (BRONGNIART)	.	+	.	.	.	+	+	+	+	+	+	?	+	.	+	.	+
66.	*Murex spinicosta* BRONN	.	.	.	.	.	.	+	+	+	.	.	.	.	.	+	.	.
67.	*Trophonopsis semperi* (v. KOENEN)	.	.	.	.	.	?	.	+	+	.	+	.	.	.	+	.	.
68.	*Lyrotyphis sejunctus* (SEMPER)	.	+	+	.	.	+	+	+	+	.	+	+	.	.	+	.	.
69.	*Liomesus ventrosus* (BEYRICH)	.	.	.	.	.	.	.	.	+	.	.	.	0	0	.	0	0
70.	*Sipho distinctus* (BEYRICH)	.	.	.	.	.	.	.	.	+	.	0	.	0	0	.	0	0
71.	*Nassa bocholtensis* (BEYRICH)	.	+	+	.	.	+	.	+	+	.	+	.	.	.	+	.	.
72.	*Nassa holsatica* (BEYRICH)	.	?	.	.	.	?	+	.	+	.	.	.	.	.	+	.	.
73.	*Nassa syltensis* (BEYRICH)	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.
74.	*Nassa prismatica* (BROCCHI)	.	.	.	.	.	?	+	.	+	.	.	.	.	.	+	.	+
75.	*Nassa slieswicia nov. sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
76.	*Lathyrus rothi* (BEYRICH)	+	+	.	.	.	+	+	+	+	.	+	.	.	.	+	.	.
77.	*Aquilofusus luneburgensis luneburgensis* (PHILIPPI)	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.

Table 67 (continued) List of the Molluscan Fauna (continued)

		Denmark					North-Germany				Belgium					Holland		England
		Miocene					Miocene				Miocene			Plio-Pleistocene				
		Klintinghoved Clay	Arnum Formation	Hodde Formation	Quaternary	Recent	Vierländer Stufe	Hemmoor Stufe	Reinbek Stufe	Glimmerton	Houthaléen	Anversien	Diestien	Scaldisien	Merxemien	Miocene	Plio-Pleistocene	Plio-Pleistocene
78.	*Aquilofusus luneburgensis meyni* (v. KOENEN)	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
79.	*Aquilofusus luneburgensis eximius* (BEYRICH)	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
80.	*Aquilofusus semiglaber* (BEYRICH)	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
81.	*Aquilofusus sp.*	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
82.	*Aquilofusus puggaardi* (BEYRICH)	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.
83.	*Uromitra cimbrica cimbrica* (OPPENHEIM)	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.
84.	*Uromitra cimbrica wirtzi* HINSCH	.	.	?	.	.	.	+	.	+	.	+	.	.	.	.	.	.
85.	*Scaphella bolli* (KOCH)	.	.	.	.	.	+	+	+	+	.	+	.	.	.	+	.	.
86.	*Narona lyrata* (BROCCHI)	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.
87.	*Narona rothi* (SEMPER)	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
88.	*Narona calcarata* (BROCCHI)	.	+	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.
89.	*Admete fusiformis* (CANTRAINE)	.	+	+	.	.	0	+	+	+	.	+	.	.	.	+	.	0
90.	*Conus antediluvianus* BRUGUIÈRE	.	.	.	.	.	?	.	+	+	.	.	.	.	.	.	.	.
91.	*Gemmula badensis* (R. HOERNES)	.	+	.	.	.	0	.	.	+	.	.	.	.	.	+	.	.
92.	*Gemmula annae* (HOERN. & AUING)	.	.	.	.	.	0	.	.	+	.	.	.	.	.	+	.	.
93.	*Fusiturris helena* (SEMPER)	.	.	.	.	.	.	.	?	+	.	.	.	.	.	+	.	.
94.	*Bathytoma cataphracta mioturbida* KAUTSKY	+	+	.	.	.	0	+	+	+	+	+	.	.	.	+	.	.
95.	*Bathytoma cataphracta var.*	+	+	+	.	.	0	.	.	+	.	.	.	.	.	+	.	.
96.	*Spirotropis modiola* (JAN)	.	.	.	.	.	.	.	.	+	.	.	+	+	.	+	?	+
97.	*Acamptogenotia intorta* (BROCCHI)	.	0	.	.	.	.	0	0	+	.	+	.	+	.	+	.	+
98.	*Inquisitor borealis* (KAUTSKY)	.	+	+	.	.	0	+	+	+	.	+	.	.	.	+	.	.
99.	*Microdrillia serratula* (BELLARDI)	.	.	+	.	.	0	0	.	+	.	.	.	.	.	.	.	.
100.	*Asthenotoma ravni nov. sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	0	.
101.	*Brachytoma obtusangula* (BROCCHI)	.	+	+	.	.	+	.	+	+	.	+	.	.	.	+	.	.
102.	*Neoguraleus kochi* (v. KOENEN)	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.
103.	*Neoguraleus sæthensis nov. sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
104.	*Haedropleura maitreja* (v. KOENEN)	.	.	+	.	.	.	+	+	+	.	.	.	.	.	+	.	.
105.	*Pleurotomoides luisae* (SEMPER)	.	?	+	.	.	+	+	.	+	.	.	.	.	.	+	.	.
106.	*Pleurotomoides sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
107.	*Philbertia reticulata* (RENIERI)	.	.	.	.	.	.	+	.	+	.	.	.	0	.	+	.	+
108.	*Philbertia sinuosula* SORGENFREI	.	+	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.
109.	*Acteon semistriatus* (BASTEROT)	.	+	.	.	.	.	+	.	+	.	+	.	.	.	+	.	.
110.	*Chrysallida pygmaea* (GRATELOUP)	.	+	+	.	.	.	+	+	+	.	+	+	.	.	+	.	.
111.	*Chrysallida semireticulata* SORGENFREI	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 67 (continued) List of the Molluscan Fauna (continued)

		Denmark					North-Germany				Belgium					Holland		England
		Miocene					Miocene				Miocene			Plio-Pleistocene				
		Klintinghoved Clay	Arnum Formation	Hodde Formation	Quaternary	Recent	Vierländer Stufe	Hemmoor Stufe	Reinbek Stufe	Glimmerton	Houthaléen	Anversien	Diestien	Scaldisien	Merxemien	Miocene	Plio-Pleistocene	Plio-Pleistocene
112.	*Kleinella nordmanni* SORGENFREI	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	. .
113.	*Odostomia conoidea* (BROCCHI)	.	+	+	.	.	+	+	+	+	+	+	.	+	.	+	+	+
114.	*Eulimella scillae* (SCACCHI)	.	+	.	+	+	+	.	.	+	.	.	.	.	.		+	.
115.	*Eulimella acicula* (PHILIPPI)	.	+	.	.	.	.	.	.	.						+		+
116.	*Turbonilla costellata* (GRATELOUP)	.	+	+	.	.	+	.	.	+	.	.	.	.	.	+		.
117.	*Turbonilla sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
118.	*Turbonilla sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
119.	*Pyramidella plicosa* BRONN	.	+	.	.	.	+	+	+	+		+	.	.	.	+	+	.
120.	*Ringicula buccinea* (BROCCHI)	.	+	+	.	.	+	+	+	+	+	+	+	+	.	+	.	+
121.	*Cylichna cylindracea* (PENNANT)	+	?	.	+	+	+	+	.	+	+	+	+	+	+	+	+	+
122.	*Diaphana moerchi nov. sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
123.	*Retusa elongata* (EICHWALD)	.	+	+	.	.	+	+	.	+	.	+	+	.	.	+		.
124.	*Scaphander lignarius* (LINNÈ)	+	+	.	.	+	+	.	.	+	.	.	.	+	.	+	?	+
125.	*Spiratella gramensis nov. sp.*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
126.	*Spiratella atlanta* (MØRCH)	.	+	+	.	.	.	+	.	+	.	.	.	.	.	+		.

It will, however, be of interest to examine more closely the relations to contemporaneous (or presumably contemporaneous) marine deposits in the North Sea Basin from which molluscan faunas are known.

Our knowledge of the Glimmerton of North Germany is fairly thorough and of an early date. Conditions in the western part of the North Sea Basin are still imperfectly elucidated.

II. The Upper Miocene Deposits of the North Sea Basin

A. Northern Germany

Since 1956 a few supplementary pieces of information about the distribution and biostratigraphy of Glimmerton in Northern Germany have been obtained, but little has been published about the composition of species within the fauna of molluscs.[1]

In 1959 H.-J. ANDERSON started a new working-up of the gastropoda in the Upper Tertiary of Northwest Germany and hence of the Upper Miocene formations as well. Unfortunately this work has stopped for the time being without having got farther than describing the Triphoridae (including a revision of the Naticidae) in W. WENZ's systematic arrangement (WENZ 1938–44). Thus on the whole reference may be made only to the old lists of fossils and – in the case of the gastropoda, scaphopoda, and pteropoda – v. KOENEN's monographs of 1872 and 1882. The dominant sediment is the Mica Clay, which occurs in the north in direct continuation of the Danish region of Gram Clay and actually belongs to the same formation: the Gram Formation. It has not been completely elucidated how far south it reaches, but according to the literature (GRIPP 1964 and KÖWING 1956) it does not seem to occur very much farther SW than in the Hamburg region, the glacial floe at Fresenmoor (see the map fig. 10, p. 118, in RASMUSSEN 1956) being the only locality south of the Elbe west of Hamburg. The Mica Clay has been recorded from so far east as Gühlitz (in Mecklenburg), which, together with Lüneburg (Niedersachsen), situated much farther west, is the southernmost of the known and published localities. The clay thus is mainly known from the region around and north of the river Elbe, for which reason J. O. SEMPER as early as 1856 called the formation "Nordalbingischer Glimmerton" (cf. GRIPP's resumption of this term as "der nordelbingische Glimmerton" in 1964, p. 122). It should be emphasized that the reference is to Glimmerton *sensu stricto* and not to the earlier beds of clay containing mica occurring farther west in Niedersachsen (cf. KÖWING 1956), which are also a kind of Mica Clay, but are not known by that name in German literature. The Upper Miocene Mica Clay (= Glimmerton *sensu stricto*) in appearance and character corresponds completely to the Danish Gram Clay.

(1) Schleswig-Holstein.

The newest map of the distribution of the Miocene in Schleswig-Holstein, prepared by JOHANNSEN & PRANGE (1961), adduced a total of 112 localities with Upper Miocene Mica Clay, the great majority of which are boreholes. Of these only an insignificant number have been palaeontologically worked up.

[1] While this chapter was in the press I received from W. HINSCH a recently published article "Neuere Obermiozän-Aufschlüsse in NW-Deutschland" (Senck. leth. 46a. WEILER-Festschrift pp. 145–160. Frankfurt am Main 18.11.1965), in which new Upper Miocene localities in Northern Germany and their molluscan faunas are mentioned, and in which there is a palaeogeographical map illustrating the situations of the recently established localities as well as the distribution of the Sylter, Grammer, and Langenfelder Stufen. The last-mentioned stage has been shown to occur in the boreholes Hamburg-Othmarschen 48, Barsfleth 1, Wöhrden 1, Bockstedt 20, Braudel 1, and Westdorf 2A. At Hamburg-Eimsbüttel (building pit for underground railway) near the old exposures at Langenfelde a molluscan fauna has been collected the quantitative composition of which is stated. The Grammer Stufe with *Astarte reimersi* has been found in the following boreholes and at the following depths: Nordsee B2 (80 m. and 88 m.), Westdorf 2A (404 m.), Jemgum 2 (235 m.), Bunde 2 (160 m.), Holthusen 1 (170–235 m.), Wahn 101 (100 m.), Neusustrum 1 (182–192 m.), Fehndorf 2T (100–110 m.,), and Adorf (see ELLERMANN 1963). The Sylter Stufe was found in Westdorf 2, Jemgum 2, and Nordsee B1 and B2. Marine Pliocene as well was found in the three last-mentioned boreholes.

The map does not include all the many boreholes in the Hamburg area in which the clay has been found, nor do the boreholes mentioned by HINSCH (1955): Hohenwörden 22, Oldenswort 3, and Bramstedt 4, seem to have been indicated. This also applies to some of the boreholes mentioned by DITTMER (1959): Ohrstedt, Feddersburg, and Lehrsbüttel. On the map fig. 1 in DITTMER's paper there are furthermore a few boreholes with "Obermiozän" indicated which are not placed on JOHANNSEN & PRANGE's map, either.

From the boreholes mentioned by HINSCH the remnants of a molluscan fauna are known. In Hohenwörden 22 the following species were found (loc. cit. p. 350): *Nucula georgiana, Chlamys sp. Astarte reimersi, Cardita orbicularis, Dentalium cf. badense, Turritella tricarinata, T. archimedis, Sipho distinctus, Turris badensis, T. annae*, and *T. duchastelii*, and in Bramstedt 4 the following species (loc. cit. p. 354): *Astarte cf. vetula, Isocardia cf. humana, Dentalium cf. badense*, and *Xenophora deshayesii*, while from Oldenswort 3 (loc. cit. p. 351) only *Astarte vetula* is mentioned.

DITTMER (1959, pp. 4–5) mentions the finding of *Aquilofusus luneburgensis* in the borehole at Ohrstedt and of *Astarte vetula* at Lehrsbüttel.

A valuable list of the molluscan fauna in the Upper Miocene Mica Sand in the borehole at Ütersen (on which see WOLFF 1913, 1914, pp. 502–506, S. THIELE 1941, pp. 107–108, and DITTMER 1959, p. 5) has been published by DITTMER (loc. cit. p. 20), and GRIPP (1964, p. 361) has published lists of the molluscs and information about the sequence of strata in a borehole at Flensburg (P. P. SCHMIDT, timber merchants, Flensburg-Neustadt), where the Upper Miocene Mica Clay was overlying the Reinbek Stufe. Unfortunately the fossils from these beds seem to have got out of the borehole in a mixed-up state. From the Mica Clay GRIPP mentions: *Nucula georgiana, Turritella tricarinata, Phalium miolaevigatum, Aquilofusus meyni, Turris boreoturricula, T. badensis, T. semimarginata*, and *Conus antediluvianus*. ANDERSON (1959 and 1960) states as a locality in connexion with a few of the gastropoda described by him, Flensburg-Mürwik, which is identical with a borehole the log of which has been mentioned in detail in S. THIELE (1941, p. 39).

Some boreholes in the Flensburg region have been mentioned by JOHANNSEN (1960), who states the intervals in which Upper Miocene Clay has been found, but says nothing about fossils.

(2) Mecklenburg.

A number of localities in Mecklenburg belong to the Nordalbingian Mica Clay as regards fauna as well as geography and facies. The localities at Gühlitz, Kummer, Hohenwoos, and Bockup are well-known from the literature (SCHULTE 1905, GRIPP 1964, METZMACHER 1903, 1917). Besides, Upper Miocene Mica Clay has been recorded from a few boreholes, e.g. the borehole at Brömsenberg on the salt dome at Lübtheen (SCHUH 1930, p. 75), where a number of Upper Miocene species (determined by K. GRIPP) were found, such as *Nucula georgiana*, *Astarte anus*, *A. radiata*, *Fusus eximius*, etc., from a depth of about 300 to about 530 m. The species from the Glimmerton pictured by GEINITZ 1883, Plates IV–V, from a borehole at Kamdohl, also on the Lütheen salt dome (loc. cit. pp. 116–128), have not, perhaps, been determined correctly (see GEINITZ 1922, II, pp. 14–16).

Because of the method of drilling (flush drilling) it has not, unfortunately, been possible to keep the faunas from the various Miocene beds in these boreholes separate. For that matter, a varied picture of the Miocene deposits in Mecklenburg is obtained from GEINITZ's descriptions (1922, II, pp. 121–167), from which the faunistic and stratigraphical conditions cannot be derived.

The locality at Hohenwoos has recently been investigated by W. v. BÜLOW (1960), who has published a list of 70 species of molluscs with information about the number of individuals. Unfortunately it was not possible to make collections by horizons, which is the more regrettable as the list of fossils contains species which are known from Glimmerton, only, together with other species, which characterize the Reinbek Stufe. Thus it is still an unsolved problem whether the "Gühlitz-Mecklenburger Stufe" set up by STAESCHE (1930) is valid or not. THIELE (1941, p. 108) considered it to have been set up on the basis of mixed-up material from Upper Miocene and Middle Miocene beds, respectively, which RASMUSSEN (1956, p. 127), too, found most probable. It lay very near at hand to suppose that the fossils from several fauna zones might have been mixed up, as the clay in the profiles according to the descriptions seemed to be completely homogeneous. As, furthermore, the Miocene beds are glacially disturbed, it will hardly be possible to avoid mixing up the fossils of several horizons. I am, however, of opinion that at the taking and washing of large samples of clay at several levels in the clay pit, we may succeed in arriving at an understanding of the composition of the molluscan assemblages and learning whether it changes vertically or horizontally in the section. An analysis of the faunas in samples taken below each other at e.g. each 0.5 m. in a number of sections of the whole digging wall in the clay pit, can furthermore yield fairly exact information about the thickness of the fauna zones and their spatial situation. The large number of individuals stated by v. BÜLOW in the case of many of the species make it probable that the clay is just as fossiliferous as the Gram Clay in Denmark, for which reason such a closer examination can be expected to be effective and of importance to the stratigraphy based on molluscs in the Miocene of the North Sea Basin.

The deposit at Gühlitz seems to differ from the normal deposits with Glimmerton by the Mica Clay there, being more silty (see footnote on p. 281 in GRIPP & MAGNE 1956 and Note 51, p. 364, in GRIPP 1964). Because of these deviating conditions of facies GRIPP (1964) considers that the deviating composition of the molluscan fauna can hardly be due to the previously collected material being mixed from several horizons, but to the "earlier" species there having survived in this silty facies. This applies, e.g., to the large number of shells of *Trigonostoma aperta* (BEYRICH). An especially interesting species, *Aquilofusus lategradatus* KAUTSKY, which was first recorded from the Mica Clay at Gühlitz, is considered a descendant of *A. festivus*, which is a guide fossil for the Reinbek Stufe. *A. lategradus* has proved to be identical with the shells from Kummer and Hohenwoos previously denoted as *A. festivus* (see ANDERSON, DITTMER & GRIPP 1959, W. v. BÜLOW 1960, p. 186, and GRIPP 1964, Note 52, pp. 364–365).

This new information does not, however, explain the occurrence of *Limopsis cf. lamellata, Cardita chamaeformis, Dentalium cf. dollfusi, Turris zimmermanni, Turris duchasteli, Asthenotoma pannoides, Surcula steinworthi cf. valvatina* at Hohenwoos and, in part, at Gühlitz, too. Their occurrence in the Hodde Clay and absence in the Gram Clay in Denmark ought to indicate a closer study of biostratigraphical conditions in the Younger Miocene deposits in Mecklenburg.

(3) *Niedersachsen.*

South and west of the Elbe the Upper Miocene Mica Clay seems gradually to be replaced by Glauconite Sand or pale Mica Sand. Fossiliferous localities, however, are known from few and widely dispersed places.

The locality at Nordlohne in South Oldenburg (GRIPP 1940a and b) has been known since 1918 (WEINGÄRTNER). In recent years two new finding-places have been added, viz. Neurüstrum I near Aschendorf in Emsland (about 25 km. ESE of Winschooten in Holland) and Wielen Z 1 in West Emsland close to the Dutch frontier. The former locality has been referred to by HINSCH (in GRIPP 1961, p. 51) without special mention of the fossils apart from the statement that "die Makrofauna bezeugt, dass Schichten vom Alter der Deurnien vorliegen."

The borehole Wielen Z 1, as regards the Tertiary, has been worked up by C. ELLERMANN (1963, p. 124), who in the ditch samples from a depth of 72–88 m. found a small molluscan fauna, which has been determined by W. HINSCH and includes *Astarte (Carinastarte) trigonata reimersi* SEMPER, *Odostomia conoidea* (BROCCHI), and *Turritella tricarinata* (BROCCHI), besides *Astarte sp., Cardium sp., Pyramidella sp., Turritella sp.*, and *Turbonilla sp.* The much richer foraminiferal fauna according to ELLERMANN is characteristic of the Miocene.

The Miocene beds in West Emsland consist of a glauconite horizon, in places overlain by argillaceous Mica Sand. The glauconite horizon transgresses over beds of Oligocene or Eocene age and is considered Middle Miocene because of the microfauna, while the argillaceous Mica Sand because of its contents of fossils is considered to be Upper Miocene and an equivalent of Glimmerton.

B. Holland

The Upper Miocene deposits continue into Holland. The sediments exclusively consist of sandy beds. Neither these nor their faunas have been described in detail. The stratigraphical conditions within the Miocene of Holland on the whole are complicated and incompletely known, as the available, very large faunas of molluscs mainly originate from uncertain levels in flush drillings.

In the case of the Upper Miocene strata the comparison with the molluscan faunas and the biostratigraphy in Denmark and Germany is complicated because of the difference in environment. The Mica Clay facies with its special, reducing environment has not been recorded from Holland, but findings have been made of certain species of molluscs characteristic of the fauna of the Gram Formation.

The first sure demonstration of Upper Miocene fossils in Holland is due to K. GRIPP (1940a, p. 28), who in material from a depth of 50–58 m. from a borehole at Oploo amongst others (see also GRIPP 1940b) found *Pecten septemradiatus*, *Astarte magdalenae* GRIPP (according to HINSCH 1952, p. 156 = *A. fusca* (POLI)), *Cardita laevicosta weingärtneriana* GRIPP, and *Aquilofusus puggaardi* BEYRICH. SPAINK (1959, p. 19) from 50–64 m. in the same borehole also mentions *Astarte reimersi* SEMPER and *A. pseudopygmaea*.

In a borehole at Belfeld the beds from 27 to 40 m. are regarded as Upper Miocene. There a fairly rich molluscan fauna has been found which has in part been examined. ISPEERT (1942) mentions *Glycymeris bimaculata* (POLI), HEERING (1950a) adduces *Pteria dertocrassa* (SACCO), *Pecten haveri* MICHELOTTI, *P. scabrellus* LAMARCK, *P. spinosovatus* (SACCO), *P. opercularis* (LINNÉ), *P. tigerinus* MÜLLER, *Lima strigilata* BROCCHI, *Astarte omalii* DE LA JONKAIRE, *Phacoides borealis* (LINNÉ), *Laevicardium cyprium* (BROCCHI), *Tellina fallax* BEYRICH, and *Aloidis gibba* (OLIVI), while the fauna of gastropoda has only in part been published by VOORTHUYSEN (1944), who mentions the following species: *Erato laevis* (DONOVAN), *Semicassis miolaevigata* (SACCO), *S. rondeleti* (BASTEROT), *Ficus conditus* (BRONGNIART), *Murex spinicosta* BRONN, *Typhis fistulosus* (BROCCHI), *T. horridus* (BROCCHI), and *Mitrella compta borealis* VOORTHUYSEN, to which should be added SPAINK's (1959, p. 18) mention of *Cancellaria lyrata* (BROCCHI).

An interesting feature is HEERING's picturing of a right valve of *Astarte omalii* from this borehole. The valve clearly has the same shape and sculpture (almost straight ventral margin, a faint carina from the umbo to the posterior corner and few, broad, concentric folds on the exterior) as *Astarte anus* PHILIPPI from the early beds of the Upper Miocene Mica Clay at Lieth, Langenfelde, Teufelsbrücke, Reinbek, and Lüneburg in Germany. This form hitherto has been adduced only from the Upper Miocene beds and by HINSCH is considered a subspecies of *A. omalii* (see HINSCH 1952, p. 157; cf. picture of *A. omalii* in HEERING 1950a, Pl. III, fig. 58, and picture of *A. anus* in GRIPP 1933, Pl. VI, fig. 2, and RASMUSSEN 1956, Pl. II, fig. 5a and b).

A number of other boreholes with Upper Miocene molluscs in the Peel region are mentioned by SPAINK (1959), thus at Bakel, where, at a depth of 66–88 m. *Astarte reimersi*, *A. omalii*, Turritellidae, etc., were found, and at Beers (a depth of 75–90 m.), which according to SPAINK yielded "typische Fauna der Grammer Stufe mit *Asthenotoma spec.* RASMUSSEN, *Isocardia forch-*

hammeri, Astarte reimersi usw." Also according to SPAINK, other boreholes, at Oploo, Boxmeer, and Maalbeek near Belfeld, amongst others contain many shells of the brachiopod *Lingula dumortieri* and the pelecypod *Pectunculus bimaculatus*. These and other beds in a further 10 boreholes are considered to be Upper Miocene by SPAINK.

Outcrops with beds of the same age, rich in disintegrated shark teeth, remnants of bones, and casts of molluscs, occur in other places in eastern Holland (SPAINK, loc. cit. p. 3).

It is important that SPAINK (loc. cit. p. 2) has recorded the following species from the Gram Formation in Dutch boreholes: *Nucula georgiana, Pecten clavatus, Astarte reimersi, A. rollei, Isocardia forchhammeri, Turris badense*, and *Asthenotoma sp.* (= *A. ravni nov. sp.*). Therefore, great things may be expected from a further working-up of the Dutch Miocene molluscan faunas, not least because in Holland there seems to be rich fossiliferous beds in the Miocene as well as the Pliocene formations. In this part of the North Sea Region we may expect important contributions to the stratigraphy based on molluscs.

Recently J. H. van VOORTHUYSEN (1963) has dealt with the Upper Miocene beds in Holland. As, however, his work is based on studies of foraminifera, I shall not here discuss all the deposits mentioned. What is characteristic of several of these is the poverty in fossils in the strata which are considered Upper Miocene. In boreholes at Spaarnwoude, Zaandam, and Ilpendam west and north of Amsterdam the upper edges of these strata are situated at depths of 628 m., 638 m., and 704 m., respectively.

C. Belgium

It is probable that the sea in Upper Miocene time stretched to the south over the present Belgium, but of deposits to be considered completely or partly synchronous, so far only early, now inaccessible deposits at Deurne on the eastern outskirts of Antwerp are known. The strata consist of sandy and gravelly deposits (Sables de Deurne), which contain molluscs, that are only known from the Gram Formation.

The molluscan fauna has been described by NYST (1881) and GLIBERT (1957–60). The borehole logs and the strata have been mentioned in detail by GLIBERT & DE HEINZELIN (1955), who later have set up the stage Deurnien for these special deposits (J. DE HEINZELIN & M. GLIBERT in DENIZOT 1957, pp. 62–63). They are deposited direct – without any interval – above the Antwerp Sand (Sables d'Anvers) deposited in the Middle Miocene Period, which for faunistic reasons is considered to be contemporaneous with the Reinbek Stufe in Germany.

The Deurne Sand amongst others contain two important pelecypod species, *Chlamys clavata* (POLI) and *Astarte trigonata* NYST. The latter has so great a similarity to *A. reimersi* (see RASMUSSEN 1956, p. 35, and HINSCH 1958, p. 469), that the two forms perhaps on closer examination will prove to be identical. *Chlamys clavata* is known from Upper Miocene beds in the North Sea Basin, viz. from the Glimmerton of Germany and from the Gram Formation of Denmark, and furthermore from the Pliocene formations in the Mediterranean Region. Besides, the species is of recent occurrence in the Mediterranean and in the Atlantic from Portugal to the Shetland Islands. Therefore, it is possible that it also lived in the North Sea Basin in the Pliocene Period.

Chlamys clavata has in Belgium been found only in the Deurnien and in Diestien typique (Sable de Diest). In the latter formation GLIBERT (1962) includes "Sables et grès à *Chlamys clavata*". The Diest Sand (Sable de Diest sensu stricto) has been exposed to secondary oxidation, so all the shells of molluscs are disintegrated and are only present in the form of casts and imprints. For faunistic reasons GLIBERT (1962) considers it probable that the Diest Sand may be of fairly the same age as the Deurne Sand, and in the resolutions in connexion with the 2nd Symposium on the Stratigraphy of the Neogene in the North Sea Basin, which was held in Ghent 1961, it was decided to range the Sables de Diest under the Deurnien (cf. the provisional stratigraphical table in the report on the Symposium, 1962, p. 171). The resolution (loc. cit. p. 169) includes the following statement:

"Deurnien, formé des Sables de Deurne et formations associées (Sables de Diest *s. str.*). Correspondrait a la Gram Stufe (*sensu* ANDERSON) at serait du Miocene superieur, et alors comparable au Messinien."

The Belgian biostratigraphical correlations to the Western North Sea Basin thus are extensive, but do not seem to me to be sufficiently convincing. For the sake of the comparison with the fauna of the Gram Formation I shall quote GLIBERT's latest list (1962, pp. 46–52) of the molluscan fauna in the Sables de Deurne, which are those beds which can first of all come into consideration, as they – as distinct from the Sables de Diest – contain *Astarte trigonata* NYST:

1. *Nuculoma haesendoncki* (N. et W.)
2. *Nucula nucleus* (L.)
3. *Nuculana westendorpi* (N.)
4. *Nuculana pygmaea* (MÜNST.)
5. *Yoldia sp.*
6. *Glycymeris deshayesi* (MAY.)
7. *Limopsis aurita* (BR.)
8. *Limopsis anomala* (EICHW.)
9. *?Bathyarca pectunculoides* (SC.)
10. *?Pleurodon ovalis* WOOD
11. *Arcoperna sericea* (BRONN)
12. *?Pecten brummeli* NYST
13. *Chlamys princeps* (SOW.)
14. *Chlamys duwelzi* (NYST)
15. *Chlamys angelonii* (MENEGH.)
16. *Chlamys lilli* PUSCH
17. *Chlamys clavata* POLI
18. *Chlamys tigerina* (MÜLL.)
19. *Limatula subauriculata* (MTG.)
20. *Lima strigilata* (BR.)
21. *Monia patelliformis* (L.)
22. *Heteranomia squamula* (L.)
23. *Ostrea edulis* L.
24. *Pycnodonte cochlear* POLI
25. *Astarte trigonata* NYST
26. *Astarte omalii* JONK.
27. *Astarte basteroti* JONK.
28. *Astarte goldfussi* HINSCH
29. *Astarte galeotti* NYST
30. *Astarte corbuloides* JONK.
31. *Astarte waeli* GLIB.
32. *Astarte burtinea* JONK.
33. *Digitaria digitaria* (L.)
34. *Goodallia triangularis* (MTG.)

35. *Cardita globulina* MICK.
36. *Cyclocardia orbicularis* (SOW.)
37. *Cyclocardia scalaris* (SOW.)
38. *?Pteromeris corbis* (PHIL.)
39. *Isocardia humana* (L.)
40. *Pygocardia rustica* (SOW.)
41. *Coralliophaga lithophagella* (LMK.)
42. *Diplodonta rotundata* (MTG.)
43. *Thyasira flexuosa* (MTG.)
44. *Hemilepton kautskyi* GLIB.
45. *Montacuta coarctata* (WOOD.)
46. *Laevicardium subturgidum* (ORB.)
47. *Parvicardium nodosum* (MTG.)
48. *Parvicardium straeleni* GLIB.
49. *Venus pseudoturgida* ORB.
50. *Spisula triangula* (REN.)
51. *Solenocurtus sp.*
52. *?Abra antwerpiensis* GLIBERT
53. *Abra cf. prismatica* MTG.
54. *Ensis cf. ensis* (L.)
55. *Saxicava arctica* (L.)
56. *Corbula gibba* OLIVI
57. *Teredo sp.*
58. *Pholadomya hesterna* SOW.
59. *Thracia pubescens* PULT.
60. *Dentalium costatum* (SOW.)
61. *Emarginula reticulata* SOW.
62. *Acmea ? deurnensis* GLIB.
63. *Margarites trochoideus* (WOOD)
64. *Calliostoma simile* (SOW.)
65. *Circulus hennei* GLIB.
66. *Turritella subangulata* BR.
67. *Turritella incrassata* SOW.
68. *Cirsotrema crassicostatum* (DESH.)
69. *Acrilla subreticula* (ORB.)
70. *Scala frondicula* WOOD
71. *Chrysallida pygmaea belgica* GLIB.
72. *Eulimella acicula* (PHIL.)
73. *Aporrhais alata* (EICHW.)
74. *Euspira catena* (DA COSTA)
75. *Cassidaria cf. bicatenata* (SOWERBY)
76. *Ficus simplex* BEYR.
77. *Ficus conditus* BRONGN.
78. *Typhis fistulosus* (BR.)
79. *Liomesus sp.*
80. *Mitra sp.*
81. *Scaphella sp.*
82. *Narona jonkairiana* (NYST)
83. *Conus dujardini* DESH.
84. *Ancystrosyrinx corneti* (KOEN.)
85. *Spirotropis modiola* (JAN)
86. *Asthenotoma ornata* (DEF.)
87. *Acteon cf. semistriatus* (BASTEROT)
88. *Cylichna cylindracea* (PENN.)
89. *Sabatia utricula* (BROCCHI)
90. *Scaphander grateloupi* MICH.

Of these 90 species only some 30 have been found in the Gram Formation (including closely related and perhaps identical species). Probably it is not precluded that such species as *Nuculoma haesendoncki*, *Nuculana westendorpi*, *Astarte goldfussi*, *Conus dujardini*, and *Ancystrosyrinx corneti*, which have all been found in the Reinbek Stufe in Germany and in early Miocene beds, can be derivatives from decomposed beds of Middle Miocene age. The same may be the case with several of the species which are included among the about 30 species known from the Gram Formation, viz. *Limopsis aurita*, *L. anomala*, *Circulus hennei*, *Turritella subangulata*, *Aporrhais alata*, *Ficus simplex*, and *F. conditus*. After reduction by these Miocene species we obtain an almost pure Pliocene fauna to which *Astarte trigonata* may belong, as it is not precluded that this species may have survived into the Pliocene Period, even though it may prove to be identical with *A. reimersi*.

As the Deurne Sand has been deposited in an environment very close to the coast, there is no possibility of a sure biostratigraphical paralleling with the very argillaceous facies of the Gram Formation before other deposits are found in the North Sea Basin which may elucidate the relations, e.g. in Holland.

D. The Occurrence of Astarte trigonata in Holland.

Astarte trigonata has been recorded from several boreholes in Holland, viz. according HEERING (1950b, pp. 73–74) at Oss, Reek, Mill (Escharen), Uden, Wanrooy, and Roosendaal, besides 70 reworked shells near Wester-Schelde (BRAKMAN 1937).

The fauna in the depth intervals in which *A. trigonata* has been found in the boreholes mentioned, is very rich in molluscs. Unfortunately it was a case of flush drillings, so we must assume the occurrence of contaminations and mixing-up of material from different stratigraphical levels. The borehole at Reek contains a total of 147 species of molluscs in the interval in which *A. trigonata* was found (14.00–31.80 m.) according to HEERING (1950) and BEETS (1946). Out of these at any rate 21 seem to be derivatives from Miocene strata. All the 21 species have been recorded from the Reinbek Stufe, but only 15 of them are known from the Upper Miocene beds in Denmark and Germany.

SPAINK (1959, p. 19) adduces *Astarte reimersi* from Beers, the interval of 75–90 m., while HEERING (1950, p. 74) mentions *A. trigonata* from 40.0–74.5 m. in the same borehole. This is hardly a case of the same shells under different specific names, but when HEERING (loc. cit.) mentions *A. trigonata* from 29.0–40.0 m. in a borehole at Wanrooy and SPAINK denotes the interval 29–50 m. in the same borehole as "Obermiozän", there may perhaps be different judgments of the same material.

Secondary deposition of washed-out shells of molluscs from early beds, Quaternary as well as Pliocene, takes place in several places on the coasts of Holland and perhaps took place in the Pliocene Period, too, as regards the Miocene shells. This will always complicate the overall picture of the fauna in certain strata, but new drillings with casing of the boreholes in step with the drilling itself can prevent a fall and mixing-up of material from several levels. Such drillings in Holland in selected places will presumably be able to contribute appreciably to elucidating the transition between Miocene and Pliocene formations as regards the molluscan faunas. The information published so far is not sufficient to give an accurate picture of conditions there, but they show how rich possibilities are implied in careful biostratigraphical investigations in this part of the North Sea Basin.

E. England

Sometimes the view may be seen to have been advanced in the literature that the so-called Lenham beds in England are equivalent to the Upper Miocene beds in the eastern North Sea Basin (see e.g. GLIBERT & DE HEINZELIN 1955, ANDERSON 1961b, VOORTHUYSEN 1963).

The molluscan fauna in these strata was determined by R. B. NEWTON (1916) and the determinations have latest been revised by C. P. CHATWIN (in B. C.

WORSSAM 1963, pp. 91–99). It contains a mixture of Pliocene species of molluscs in large numbers of individuals and a few Miocene species in a small number of individuals.

Of the latter I may mention *Bathytoma cf. mioturbida* KAUTSKY, *Cassis saburon* (BRUGUIÈRE), *Clavus obeliscus* (DES MOULINS), *Streptochetus sexcostatus* (BEYRICH), *Terebra acuminata* BORSON, *Turris cf. zimmermanni* (PHILIPPI), and *Turritella subangulata* (BROCCHI).

None of these species are characteristic of the Gram Formation, but they rather put one in mind of the Reinbek Stufe (apart from *Cassis saburon*). There seem to be similar conditions to those in Holland and Belgium, viz. a primary Pliocene fauna with secondary contents of Miocene forms, which can be supposed to originate from decomposed or reworked Miocene beds.

Biostratigraphical Conditions in the Upper Miocene Glimmerton of Northern Germany

As regards Glimmerton there has previously been rich opportunity to study the strata as well as to collect fossils, but now most of the localities in question are no longer accessible. In various collections, however, there are still rather a large material of molluscs collected previously, and these fossils together with the few recorded or published observations on conditions of stratification, as well as the fairly modest material from later drillings, have formed the basis of a biostratigraphical classification of the whole of the formation which German geologists term Glimmerton.

The biostratigraphy is based on collected material and not on a quantitative material proper in the sense used in the present paper.

In my work of 1956 there is on pp. 122–126 an account of the development of this Glimmerton stratigraphy. Here there will only be reason to discuss the latest classification which by German geologists has been accepted as valid, viz. that suggested by W. HINSCH in 1952, in which the following "Stufen" have been set up:

Uppermost:	Sylter Stufe	
	Grammer Stufe	
Lowermost:	Langenfelder Stufe	Langenfelder Unterstufe Lüneburger Unterstufe

The classification is exclusively based on molluscs and therefore is biostratigraphical. It is first of all due to statistical studies on the variations of populations of species of the genera *Astarte*, *Sipho*, *Aquilofusus*, *Uromitra*, *Cancellaria* (*Narona*), *Bathytoma*, and *Gemmula* from a few localities, mainly Langenfelde and Gram.

In RASMUSSEN 1956 (pp. 125–126) there is a summary of HINSCH's faunistic characterization of the three "Stufen". In 1958 HINSCH changed the term "Langenfelder Stufe" into "Lüneburger Stufe". Against this GRIPP (1964, Note 52, p. 364) made objections. GRIPP (1964, p. 131) even thinks that STAESCHE's "Gühlitz-Mecklenburg Stufe" in his experience is an independent stage (or zone), which, besides in Mecklenburg, also seems to occur at Wohltorf near Reinbek (cf. concerning the "Gühlitz-Mecklenburg Stufe" the mention on p. 293). GRIPP, however, identifies this "Stufe" with the term "Lüneburger Unterabteilung" or "Lüneburg-Stufe" (see below).

Because of many years' experience and his personal knowledge of most of the localities that have disappeared long ago, K. GRIPP must be considered the most competent present-day expert on the molluscan fauna of Glimmerton. His revision of HINSCH's above-mentioned faunistic characterization of the various zones therefore is of interest in this connexion, for which reason the characterization in GRIPP's edition is rendered here entire (from GRIPP 1964, pp. 129–130):

Guiding species for all Glimmerton are

Chlamys (Peplum) clavatus POLI
Nucula (Nucula) georgiana SEMP.
Cardita (Cyclocardia) orbicularis forma bella SEMP.
Dentalium badense PARTSCH
Natica koeneni SACCO
Aquilofusus puggaardi BEYR. sp.
Terebra forchhammeri BEYR.
Drillia (Spirotropis) modiola JAN.

The characteristic guiding species for the various subsections of Glimmerton are:

Sylter Abteilung:
Carinastarte rollei SEMP.
Astarte (Astarte) syltensis RAVN
Liomesus ventrosus BEYR. sp.
Aquilofusus eximius BEYR. emend. HINSCH
Nassa (Telasco) syltensis BEYR.
Aporrhais pes pelicani L.
Natica (Polinices) hemiclausa SOW.
Hipparion gracile SOW.

Grammer Abteilung:
Carinastarte reimersi SEMP. sp.
Sipho distinctus BEYR. emend. HINSCH
Liomesus fossulatus grippi HINSCH
Aquilofusus semiglaber BEYR. sp.
Uromitra cimbrica OPPENHEIM in KAUTSKY
Cancellaria (Narona) rothi SEMP. sp.

Langenfelder Abteilung:

Carinastarte vetula PHIL. sp.
Aquilofusus luneburgensis PHIL. emend. HINSCH
Uromitra wirtzi HINSCH
Cancellaria (Narona) lyrata parvicarinata KAUTSKY

Lüneburger Unterabteilung:

Astarte (Ashtarotha) omalii var. anus PHIL. emend. HINSCH
Cardita laevicosta weingärtneriana GRIPP
Aquilofusus lategradatus KAUTSKY
Murex (Hexaplex) octonarius BEYR.

The most important guide fossils are undoubtedly the species of *Astarte* and *Aquilofusus*. The biostratigraphical classification of the Upper Miocene in North Germany accepted at present is therefore most clearly expressed in the following extract of GRIPP's Schichten-Tabelle 9 (in 1964, p. 348):

Upper Miocene	Messin	Sylt-Stufe	*Astarte rollei* *Astarte syltensis*
		Gram-Stufe	*Astarte reimersi* *Aquilofusus semiglaber*
	Torton	Langenfelde-Stufe	*Astarte vetula* *Aquilofusus lüneburgensis*
		Lüneburg-Stufe	*Astarte omalii var. anus* *Aquilofusus lategradatus.*

The conditions mentioned above are of primary interest for a comparison with the biostratigraphical conditions of the Gram Formation, as certain guiding species have also been found in the latter formation. An elucidation of the relations, however, can only take place after an explanation of the qualitative and quantitative conditions in the fauna assemblages of the Gram Formation.

Biostratigraphical Conditions in the Gram Formation

During the collection of material in the outcrops as well as the analyzing of the clay samples collected from outcrops as well as boreholes it soon appeared that the molluscan faunas were of a varying composition.

It was possible clearly to distinguish three fauna assemblages, but it was only after the investigation of the samples the position of which in the total series of strata had been elucidated in more detail, that it was possible to find the actual relative sequence of the occurrence of the assemblages.

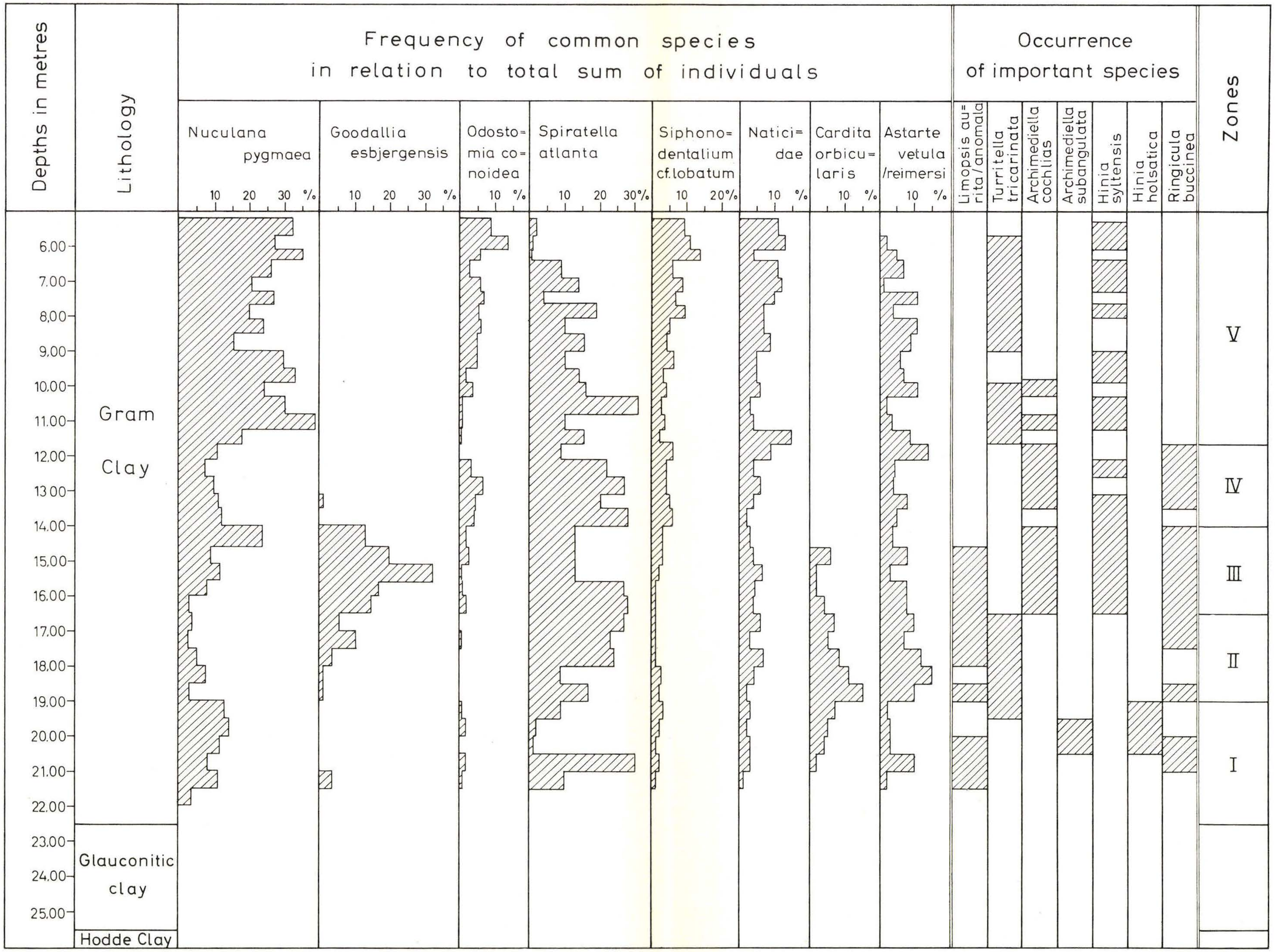

Depths in metres
Lithology
Frequency of common species in relation to total sum of individuals
Nuculana pygmaea
Goodallia esbjergensis
Odostomia conoidea
Spiratella atlanta
Siphonodentalium cf. lobatum
Naticidae
Cardita orbicularis
Astarte vetula/reimersi
Occurrence of important species
Limopsis aurita/anomala
Turritella tricarinata
Archimediella cochlias
Archimediella subangulata
Hinia syltensis
Hinia holsatica
Ringicula buccinea
Zones
Gram Clay
Glauconitic clay
Hodde Clay
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
18.00
19.00
20.00
21.00
22.00
23.00
24.00
25.00
V
IV
III
II
I

Fig. 100.

This sequence had actually been demonstrated before D.G.U. made the borehole at Gram Brickworks, but it was only through this boring that an opportunity arose for thorough investigations of the continued sequence of strata. An examination and characterization of the assemblage zones found can therefore best be introduced by a presentation of the results of the analysis of the boring at Gram.

A grouping in Assemblage Zones on the Basis of the Analysis of the Gram Borehole

In the diagram fig. 100 the frequencies are indicated in percentages of the total number of individuals per sample for the commonest species and furthermore the depths are sketched at which certain characteristic species have been found in the borehole.

A study of the diagram seems to justify a division of the section from the depth of 5.30 m. to the depth of 22.50 m. into the following five assemblage zones, which can be characterized by means of the mollusc species indicated. The zones are denoted by the Roman numerals I to V in agreement with fig. 100.

Zone I.

Depth: about 22.5 – about 19.0 m. Thickness: about 3.5 m.
Frequent species: *Limopsis aurita* and *Cardita orbicularis.*
Species present: *Archimediella subangulata*, *Nassa holsatica*, and *Ringicula buccinea.*
Of sparse occurrence: *Goodallia esbjergensis.*

Zone II.

Depth: about 19.0 – about 16.5 m. Thickness: about 2.5 m.
Frequent species: *Cardita orbicularis.*
Species present: *Limopsis aurita*, *Goodallia esbjergensis*, *Turritella tricarinata*, and *Ringicula buccinea.*

Zone III.

Depth: about 16.5 – about 14.0 m. Thickness: about 2.5 m.
Dominant species: *Goodallia esbjergensis.*
Species present: *Archimediella cochlias*, *Nassa syltensis*, and *Ringicula buccinea.*
In negligible numbers: *Limopsis aurita* and *Cardita orbicularis.*

Zone IV.

Depth: about 14.0 – about 11.5 m. Thickness: about 2.5 m.
Comparatively frequent species: *Siphonodentalium cf. lobatum* and *Odostomia conoidea.*
Species present: *Archimediella cochlias* and *Nassa syltensis.*
In negligible numbers: *Goodallia esbjergensis* and *Ringicula buccinea.*

Zone V.

Depth: about 11.5–5.3 m. Thickness: about 6 m.
Dominant species: *Nuculana pygmaea.*
Frequent species: *Siphonodentalium cf. lobatum*, Naticidae, and *Odostomia conoidea.*
Species present: *Turritella tricarinata* and *Nassa syltensis.*
In negligible number: *Archimediella cochlias.*

These five zones must of course be considered provisional until their existence can be corroborated through investigations and observations in other localities. In what follows we shall therefore make a comparison between the analyses from other localities and that of the fauna in the Gram borehole. The same denotation of zones with Roman numerals is used as in fig. 100.

Borings with Quantitatively Significant Fossil Material from Several Levels in the Same Borehole

From a few boreholes there are quantitatively valuable samples from various horizons in the Gram Clay in the same borehole. This applies to the boreholes at Drantum, Odderup, and Hesselho.

The *Drantum* borehole (Table 32, p. 243) in the case of the common species shows some quite characteristic frequencies, which appear from the diagram fig. 101.

The sample from 51.4–51.8 m., which represents an interval of only 40 cm., is the most valuable of the four samples available from the boring, as the three others are only fairly ample extracts of intervals of 6 m., 4 m., and 4 m., respectively. It shows a dominance of *Goodallia esbjergensis* so evident that it can with certainty be paralleled with Zone III in the Gram borehole. The comparatively small number of individuals in the sample must be seen against a background of the small quantity of clay in proportion to the large number of pieces of concretions which filled up some of the sample.

The overlying sample from 46.0–50.0 m. is difficult to parallel with certainty with the zones of the Gram borehole. The fact that *Goodallia esbjergensis* is still present, and that *Archimediella cochlias* is the only Turritellida in the sample, even in numerical excess of the other species, suggests that at any rate some of the interval from 46 to 50 m. must be referred to Zone III.

On the other hand, the dominance of *Nuculana pygmaea* and the absence of *Goodallia esbjergensis* in the samples from 40.0–44.0 m. and 36.0–40.0 m. shows that we are now in an assemblage zone which corresponds to Zone IV. The comparatively many shells of *Odostomia conoidea*, *Siphonodentalium cf. lobatum*, and Naticidae are also suggestive of this. The occurrence of *Limopsis aurita*, however, indicates that we are still in the lower part of Zone IV, as this species disappears by Zone III in the Gram borehole.

The *Odderup* borehole (Table 40, p. 249), the most frequent species of which are also indicated in the diagram fig. 101, as regards the lowermost sample (20.0–21.0 m.) seems to have to be clearly paralleled with Zone III. The overlying sample comprises an interval of 5.5 m. (14.5–20.0 m.) and cannot be placed precisely in relation to the zonation in the Gram borehole. The frequencies of species show that there are still some shells of *Goodallia esbjergensis*, but an increasing content of *Nuculana pygmaea*. As both *Cardita orbicularis*, *Limopsis aurita*, and *Ringicula buccinea* are present, there is a possibility that the sample must be ranged in the borderland between Zones III and IV.

The *Hesselho* borehole (Table 43, p. 251) is unfortunately represented by three good-sized samples, only, which are stated to have been taken at intervals of 9 m., 6 m., and 6 m., respectively. In advance it is therefore probable that material from several zones has been mixed up in the samples. Nevertheless it can with great probability be substantiated by means of the frequencies of species that the lowermost sample (from 56.0–65.0 m.) contains the fauna of Zone III, *Goodallia esbjergensis* being highly dominant. There are also many shells of *Cardita orbicularis* and *Limopsis aurita*, and *Archimediella cochlias* is the dominant Turritellida.

The overlying sample (from 50.0–56.0 m.) still contains many valves of *Goodallia esbjergensis*, but an increasing content of *Nuculana pygmaea*. *Cardita orbicularis*, *Limopsis aurita*, and *Archimediella cochlias* are still present. This fauna has an affinity with the fauna in Zone III so close that it is tempting to place it in this zone.

The uppermost sample, from 44.0–50.0 m. lacks *Goodallia esbjergensis*, *Limopsis aurita*, and *Archimediella cochlias*, but in return contains *Turritella tricarinata* and has a slightly increased content of *Odostomia conoidea*, *Siphonodentalium cf. lobatum*, and Naticidae. Thus we here seem to get into Zone IV.

Besides these three boreholes there are samples from several levels in another number of boreholes. These samples, however, are quantitatively considerably smaller than those from the three boreholes mentioned above. The following six have yielded a sufficient number of molluscs for them to be included in the discussion: (1) Muldbjerg (83.1006), (2) Kodal-Fjaldene (84.1749), (3–4) Videbæk (84.1727 and 84.1748), (5) Brodersmark (166.351 b), and Rends (167.236). A comment will be made on each of these boreholes.

The *Muldbjerg* borehole (Table 20, p. 231) contains many shells of *Goodallia esbjergensis* from the interval 6–10 m., although decreasing in number downwards. In the same interval are *Limopsis anomala* (from 6–9 m.), *Cardita orbicularis* (the whole interval), and *Archimediella cochlias* (from 7–9 m.). Furthermore, *Ringicula buccinea* has been found at a depth of 7–8 m. These facts suggest affinity with the fauna of Zone III.

The overlying sample from 5.0–6.0 m. has a comparatively high content of

Nuculana pygmaea and contains *Turritella tricarinata*, but lacks *Goodallia esbjergensis*, *Limopsis aurita*, *Cardita orbicularis*, and *Archimediella cochlias*. Here, thus, an approach to the fauna in Zone IV is indicated.

The borehole at *Kodal-Fjaldene* (Table 21, p. 232) contains *Goodallia esbjergensis* from 17.55–23.55 m. *Limopsis aurita* occurs in the same interval, and *Archimediella cochlias* occurs from 15.55–19.55 m., while *Cardita orbicularis* is found in all the samples from 14.55–23.55 m. The samples from 14.55–17.55 m. contain no shells of *Goodallia esbjergensis* and perhaps this interval belongs to Zone IV. The beds below 17.55 m. seem to contain the fauna of Zone III.

Perhaps the deepest strata of the borehole belong to Zone II, as *Cardita orbicularis* and *Limopsis aurita* are in numerical excess together with *Turritella tricarinata*, which in the sample from 19.55–20.55 m. replaced *Archimediella cochlias*. Therefore, it is not improbable that under the depth of 20 m. we are in Zone II.

One of the boreholes at *Videbæk* (84.1748) does not give any clear picture of the frequencies of species (see Table 22, p. 234). *Goodallia esbjergensis* has been found in the two lowest samples (22.95–24.95 m.), which also applies to *Limopsis anomala*, whereas *Cardita orbicularis* has also been recorded from 16.95–17.95 m. The overlying samples from 14.95–17.95 m. contain no shells of *Goodallia esbjergensis*, but an increasing content of *Nuculana pygmaea*. Perhaps there is a boundary between faunas between the depths of 18 and 23 m. The fauna in the beds above this boundary can best be paralleled with Zone IV, while Zone III may have been somewhere between the two depths mentioned. Under the depth of 23 m. there is nothing to prevent the view that we are already in Zone II.

Conditions seem to appear a little more clearly in the other borehole at *Videbæk* (84.1727), where the analysis of the fauna (Table 24, p. 235) shows that the strata from the depth of 10.4–12.4 m. contain the fauna of Zone III, *Goodallia esbjergensis* here being the most dominant species by far. *Limopsis aurita* and *Cardita orbicularis* are present as well as *Archimediella cochlias*, the latter two species also in the overlying beds from 8.4–10.4 m., while *Limopsis aurita* was only found from the depth of 9.4 m. downwards, like *Goodallia esbjergensis* (three specimens in the sample from 9.4–10.4 m.). The strata above the depth of 10.4 m. perhaps penetrate into Zone IV.

Quite different conditions appear in the boreholes at *Brodersmark* and *Rends*. In the former borehole (Table 63, p. 280) large samples were taken at each metre in the interval 22.6–32 m. All samples show completely the same frequency of species: Numerous shells of *Nuculana pygmaea*, *Turritella tricarinata*, Naticidae, and *Odostomia conoidea*, whereas there are no shells of *Limopsis aurita*, *Goodallia esbjergensis*, *Archimediella cochlias*, and *Ringicula buccinea*. Even though there were a few shells of *Cardita orbicularis*, the whole fauna must be characterized as a typical counterpart to the fauna in Zone V.

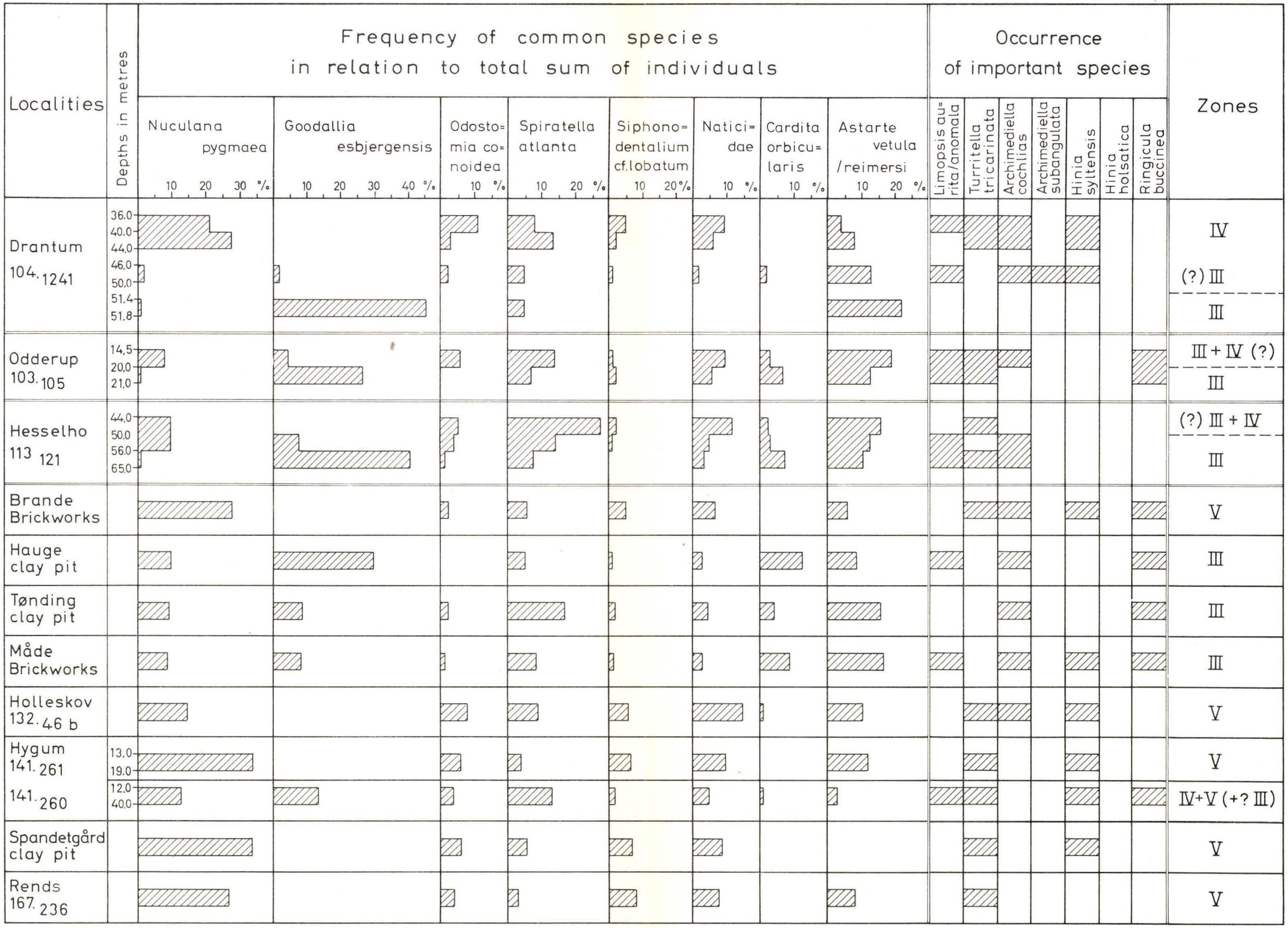

Localities
Depths in metres
Frequency of common species in relation to total sum of individuals
Occurrence of important species
Zones
Nuculana pygmaea
Goodallia esbjergensis
Odostomia conoidea
Spiratella atlanta
Siphonodentalium cf. lobatum
Naticidae
Cardita orbicularis
Astarte vetula /reimersi
Limopsis aurita/anomala
Turritella tricarinata
Archimediella cochlias
Archimediella subangulata
Hinia syltensis
Hinia holsatica
Ringicula buccinea
10 20 30 %
10 20 30 40 %
10 %
10 20 %
10 20%
10 %
10 %
10 20 %
Drantum 104.1241
36.0
40.0
44.0
46.0
50.0
51.4
51.8
IV
(?) III
III
Odderup 103.105
14.5
20.0
21.0
III + IV (?)
III
Hesselho 113 121
44.0
50.0
56.0
65.0
(?) III + IV
III
Brande Brickworks
V
Hauge clay pit
III
Tønding clay pit
III
Måde Brickworks
III
Holleskov 132.46 b
V
Hygum 141.261
13.0
19.0
V
141.260
12.0
40.0
IV+V (+? III)
Spandetgård clay pit
V
Rends 167.236
V

Fig. 101.

The same applies to all the samples from Rends (Table 66, p. 285), the frequencies of species of which are seen in the diagram fig. 101. There is there an evident dominance of *Nuculana pygmaea*, and there are many shells of *Siphonodentalium cf. lobatum*, Naticidae, and *Odostomia conoidea*, while *Goodallia esbjergensis*, *Limopsis aurita*, *Cardita orbicularis*, *Archimediella cochlias*, and *Ringicula buccinea* are completely missing.

Borings with a Small Material of Fossils from Several Levels in the Same Borehole

The boreholes from which few molluscs are available, cannot of course, be grouped among the assemblage zones of the Gram borehole with the same certainty as the samples from the boreholes which have yielded numerous fossils. It is, however, of importance to be able to ascertain whether conditions within the former category of borings contradict or corroborate the regularities found in the latter boreholes.

Below, the boreholes in question are arranged in a table. They are listed in the succession in which they are mentioned in the geological part.

Locality	D.G.U. File No.	Analysis in Table No.	Remarks	Presumed zones
Lillelund	73.88	16	As to both samples: *Goodallia esbjergensis* together with *Limopsis aurita* and *Cardita orbicularis*. *Turritella tricarinata* common. No shells of *Archimediella cochlias*.	II ?
Aulum	74.321	17	*Goodallia esbjergensis* present from 10.4 m. with *Cardita orbicularis*. No further characteristics.	II or III
Gjødstrup	85.861	27	The upper part of the borehole from 48.0–50.0 m. contains *Archimediella cochlias*. *Goodallia esbjergensis* found in two samples only: 51.0 m. and 57.0 m. *Limopsis aurita* and *Cardita orbicularis* found in beds below 53.0 m.	II + III

Locality	D.G.U. File No.	Analysis in Table No.	Remarks	Presumed zones
Snejbjerg	85.775	28	*Limopsis anomala*, *Goodallia esbjergensis* and *Cardita orbicularis* found in the beds from 28.25 to 30.25 m. Above these *Nuculana pygmaea* and *Turritella tricarinata* seem to play a certain part.	(?II) + III + IV
Nyholm	104.1166	33	*Goodallia esbjergensis* and *Archimediella cochlias* were found at a depth of 17.2–18.2 m. together with *Limopsis aurita* and *Cardita orbicularis*. *Ringicula buccinea* was found from 14.2–16.2 m. The beds from 4.2 to 13.2 m. are very much characterized by *Nuculana pygmaea*.	III + IV + V
Store Langkjær	104.1158	34	*Goodallia esbjergensis* was found in one of the three samples and *Limopsis aurita* in another.	III
Skjerris gårde	104.1165	35	*Goodallia esbjergensis* was found at a depth of 11.5–12.5 m. together with *Cardita orbicularis*. *Archimediella cochlias* has been recorded from 7.5–8.5 m. and 10.5–11.5 m. *Nuculana pygmaea* obviously plays a quantitative part in the beds above 11.5 m.	III + IV
Leding	93.155	36	*Goodallia esbjergensis* is present at a depth of 16–17 m. together with *Limopsis aurita*. *Cardita orbicularis* was found from 10–12 m., 12–14 m., 16–17 m., and 18–19 m. *Archimediella cochlias* perhaps occurs at the depths of 10–12 m. and 17–18 m. *Turritella tricarinata* has been recorded from 18–19 m.	II + III
Alkærsig	93.101	37	*Goodallia esbjergensis* was found at the depths of 9 m. and 10 m. and *Cardita orbicularis* at 9 m. *Archimediella cochlias* at 8 m., 8.5 m., and 10 m.	III

Locality	D.G.U. File No.	Analysis in Table No.	Remarks	Presumed zones
Lønborg	102.55	38	*Goodallia esbjergensis* only recorded from a depth of 6.3–7.3 m. *Cardita orbicularis* from 6.3–7.3 m. and 9.3–12.3 m.	II + III
Ålbæk Eng	102.59	42	In spite of the fact that there is material available from a total of eight intervals in immediate succession, there is no species of special value for a grouping in the zones of the Gram borehole. *Cardita orbicularis* was found at a depth of 18.8–20.8 m.	
Hjortvad	141.178	54	*Goodallia esbjergensis* was found at a depth of 15.1–20.1 m. and *Cardita orbicularis* at 20.1–23.1 m.	II + III + IV
Lintrup	132.140	55	The grouping in zones is very uncertain. As to the more characteristic species only one shell of *Limopsis aurita* was found at 9.8–14.8 m. and one specimen of *Archimediella cochlias* at 19.8–24.8 m. A fair number of shells of *Nuculana pygmaea* were found at a depth of 9.8–14.8 m.	? IV
Rødding	141.75	57	*Goodallia esbjergensis* recorded at 16.75–25.60 m. with *Limopsis aurita*.	Partly III
Rødding	141.76	57	The only characteristic species found was *Cardita orbicularis*; recorded from 37.15–42.40 m.	
Vester Lindet	141.246	58	The large number of species of *Nuculana pygmaea* recorded from a depth of 30.9 m. suggests that the uppermost beds in this borehole can be grouped in Zone V.	(?IV) + V
Spandet	150.184	61	*Goodallia esbjergensis*, *Limopsis aurita*, and *Cardita orbicularis* were found at a depth of 27.0–33.0 m. together with *Ringicula sp.*	Partly III

Locality	D.G.U. File No.	Analysis in Table No.	Remarks	Presumed zones
Tønder	166.398	62	*Nuculana pygmaea* and *Siphonodentalium cf. lobatum* seem to play a part in the uppermost samples (from 24 m., 37 m., and 43.5 m.), whereas *Limopsis aurita* and *Cardita orbicularis* are present at 58.85–59.0 m. *Limopsis aurita* seems to play a considerable quantitative part at the depth of 72 m. and 74 m.	All the five zones

These boreholes seem to be in support of the regularities found in the Gram borehole and those described in the preceding section as regards the vertical relations of the assemblage zones to one another.

The boreholes also clearly showed that it is necessary to have a sample material of a certain order of magnitude in order that a sure characterization of the composition of the fauna can be given.

Good-sized Samples of Clay from Outcrops and from Boreholes at Sønder Hygum

The boreholes from which large samples were available, have only, as mentioned on p. 304, yielded a large material of fossils from fairly great intervals of depth, by which the fossils of several zones may have been mixed up.

Therefore, it is of interest to evaluate the analyses of large samples of clay taken in outcrops at small intervals. The analyses of fairly large samples of clay from smaller intervals in boreholes are of the same interest. Through such samples there should be possibilities of obtaining a large quantitatively valuable material of single zones without appreciable contaminations from other zones. It will then be possible to work out as well as to stabilize the quantitative and the qualitative picture of the fauna of the zones obtained from the fauna analyses of the Gram borehole and other boreholes.

In what follows I shall therefore make an evaluation of fairly large samples of clay from outcrops and from boreholes (cf. the diagram fig. 101).

From *Brande Brickworks* (Table 31, p. 241) there is a fairly large sample of clay available the contents of molluscs of which show a great dominance of *Nuculana pygmaea* and comprise some shells of *Odostomia conoidea*, *Siphonodentalium cf. lobatum*, and Naticidae. These features show a great similarity of the fauna to Zone V in the Gram borehole. A comparatively large number of specimens of *Archimediella cochlias* and the presence of *Ringicula buccinea* point to the early and lower part of Zone V.

A fairly large sample from the clay pit of Hesselho Brickworks at *Hauge* (Table 44, p. 252) through its considerable contents of *Goodallia esbjergensis* and the numerous shells of *Cardita orbicularis* as well as the large number of specimens of *Ringicula buccinea* shows a clear affinity to Zone III. This is also corroborated by the presence of *Archimediella cochlias*, of which there are many shells, whereas *Turritella tricarinata* is absent.

From the clay pit of Østbæk Brickworks at *Tønding* (Table 45, p. 254) a corresponding frequency of species is known: many shells of *Goodallia esbjergensis* and some shells of *Cardita orbicularis*, whereas *Archimediella cochlias* is the only Turritellida species represented. *Ringicula buccinea* is present. The whole fauna must with certainty be placed in Zone III.

The same applies to the only fairly large sample taken in *the eastern clay pit of Måde Brickworks* (Table 49, p. 258): the large number of shells of *Goodallia esbjergensis* and *Cardita orbicularis* as well as the presence of *Archimediella cochlias* and *Ringicula buccinea* reveal that the fauna belongs to Zone III.

From *Spandetgård* in North Slesvig (Table 60, p. 277) a statistical sample of clay is available which shows great dominance of *Nuculana pygmaea* and furthermore the presence of numerous shells of *Siphonodentalium cf. lobatum*, Naticidae, and *Odostomia conoidea*, thus a distinct parallel to the fauna of Zone V.

A statistical sample of clay from *Møltrup Brickworks* (Table 25, p. 236) has also been examined. The analysis is not indicated in the diagram fig. 101, but the dominance of *Goodallia esbjergensis* and the presence of *Archimediella cochlias* with certainty refers the fauna to Zone III.

As to the boreholes there is reason to mention an early borehole at *Holleskov* (Table 52, p. 262), from which material carefully sorted out (by P. Harder), shows a clear dominance of *Nuculana pygmaea* and Naticidae, to which should be added numerous shells of *Astarte reimersi, Siphonodentalium cf. lobatum, Turritella tricarinata*, and *Odostomia conoidea*, thus a sure Zone V fauna.

Two boreholes at *Sønder Hygum* in North Slesvig (Table 56, p. 265) have also yielded a quantitatively valuable material. One borehole (141.261) has yielded large samples from the depths of 13–19 m. and 20 m., respectively. Both of them contain *Nuculana pygmaea* as dominant species and furthermore particularly many shells of *Siphonodentalium cf. lobatum*, Naticidae, and *Odostomia conoidea*, a fact which with certainty places the faunas in Zone V.

From the other Hygum borehole (141.260) the sample is composed of several rather large samples of clay, found mixed up in a heap, which in its entirety represented the interval from 12 to 40 m., thus 28 m. Gram Clay in all. Indeed, it shows no affinity with one single zone. There are many specimens of *Nuculana* *pygmaea*, *Turritella tricarinata*, Naticidae, and *Odostomia conoidea*, thus the species characteristic of Zone V, but there are also numerous shells of *Goodallia esbjergensis*, to which are added species clearly characteristic of Zone III, as seen in shells of *Limopsis aurita*, *Cardita orbicularis*, and *Ringicula buccinea*. It is evidently material from several levels, viz. Zones III, IV, and V.

The quantitative examinations of large samples of clay mentioned here corroborate the view that there exist two well-defined fauna assemblages in two recognizable assemblage zones in the Gram Clay, viz. in Zone III and Zone V, respectively.

Furthermore, besides the borehole at Gram Brickworks the boreholes at Drantum, Odderup, Hesselho, and Sønder Hygum have shown that Assemblage-Zone III is situated deeper than Zone V, which observation could not be set aside by the results obtained by an examination of the fossils in the boreholes which have only supplied a quantitatively poor material.

As to Assemblage-Zones I and II in the Gram borehole and its possible equivalents elsewhere in Denmark reference may be made to the accounts in a later section (see p. 316).

Assemblage-Zone IV in the borehole at Gram must be characterized as a transitional zone in which there is not an assemblage of fossils so characteristic that it can with certainty be recognized in isolated samples. According to the diagram of the frequencies in the Gram borehole (fig. 100) there are no sharp boundaries between the assemblage zones, but more or less even transitions. It is these transitional intervals which have been denoted as Zone II and Zone IV, respectively.

Characterization of the Assemblage Zones in the Gram Clay

Before a close characterization, quantitatively as well as qualitatively, of Zones III and V, I shall out of consideration for the qualitative conditions offer a detailed account of the occurrence of certain species which notoriously seem to play a part for the composition of species in these zones.

The fairly large species as a rule are underrepresented in the drilled samples and the clay samples in proportion to collected material from the outcrops, because they are particularly conspicuous. In a clay pit it is in practice possible to collect most of the dug-out large molluscs shells found on the bottom or the sides. Collected material will therefore show frequencies quite different from quantitatively treated material from a clay sample.

Before giving an account of the species and forms among the large species characteristic of Zones III and V, a comparison will in what follows be made between the distribution of frequencies in the material collected and in sorted-out material from large samples of clay taken in the same strata in the same outcrops.

Comparison between the Frequencies for the Individually Collected Species and the Sorted-Out Ones

All previous investigations into the molluscan fauna of the Gram Clay are based on material collected from the outcrops. The frequencies for the occurrence in the clay pit of Gram Brickworks appear partly from the list of species in RASMUSSEN 1956, pp. 106–107, and partly from the statements in SORGENFREI 1965, p. 76 (by the latter converted to percentages of the total fauna). According to this information the Gram fauna is dominated by *Astarte reimersi* (25.5%), while *Aquilofusus semiglaber* (11.2%) and *Gemmula badensis* (14.8%) are next in frequency. On this basis SORGENFREI (op. cit.) speaks about an *Astarte reimersi – Aquilofusus semiglaber – Gemmula badensis* community Other frequent species are *Turritella tricarinata* (8.2%), *Sipho distinctus* (5.2%), *Gemmula annae* (4.5%), *Bathytoma cataphracta* (6.9%), and *Conus antediluvianus* (3.5%), whereas all the other species (57 in all) show frequencies below 2%.

Against this spectrum are the frequencies (and percentages) which appear from the quantitative analyses and samples from 5.30–7.30 m. in the borehole at Gram (Table 59). These are also representative of the beds which crop out in the clay pit itself. According to these analyses the dominant species of the fauna assemblage is *Nuculana pygmaea* (20–35%), which is followed by *Siphonodentalium cf. lobatum* (10–14%), Naticidae (10–13%), and *Odostomia conoidea* (3–14%). In certain beds (from 6.90 to 7.30 m.) the frequency of *Spiratella atlanta* is 13.9%. On this basis the fauna must be characterized as a *Nuculana pygmaea – Siphonodentalium – Natica spp.* assemblage.

The difference between the two results is very conspicuous. The most objective characterization of the assemblage must of course be due to the quantitative analyses. It is also corresponding analyses, made by almost corresponding methods, which have been executed by TH. SORGENFREI (1958) on the basis of his material from the shell beds in the Arnum Formation. If, therefore, we are to compare the fauna assemblages in this formation with those of the Gram and the Hodde Formations, it must be done only by means of quantitative analyses of a sufficiently great material.

The shells collected, however, give a valuable supplement to the characterization of the fauna assemblage in question. In Tables 31, 44, 45, and 60, lists are set up from outcrops from which we have collections and quantitatively examined samples.

Zone V. Of these localities those of Brande (Table 31) and Spandetgård (Table 60) belong to Assemblage-Zone V. As at Gram Brickworks the following species are the commonest in the collected material:

Astarte reimersi, Turritella tricarinata, Sipho distinctus, Aquilofusus semigla-

ber, Gemmula badensis, G. annae, Bathytoma cataphracta, and *Conus antediluvianus.*

According to the quantitative analyses of the samples of clay from the two localities the following species are actually the commonest:

Nucula sp., Nuculana pygmaea, Yoldia glaberrima, Astarte reimersi, Siphonodentalium cf. lobatum, Putilla gottscheana, Naticidae, *Brachytoma obtusangula, Odostomia conoidea,* and *Spiratella atlanta.*

Zone III. The other localities represented by the tables mentioned, viz. Hauge (Table 44) and Tønding (Table 45), as mentioned on p. 311, belong to Assemblage-Zone III. The collections in both localities contain most shells of the following species:

Astarte reimersi (large form with numerous fine concentric ribs), *Archimediella cochlias, Sipho distinctus, Aquilofusus semiglaber* (and *A. eximius*), *Conus antediluvianus, Gemmula badensis, G. annae,* and *Bathytoma cataphracta.*

Completely the same frequencies as regard the material collected appear in the old clay pits and on the beach SE of Esbjerg (Table 48) as well as the late Gram Clay in the eastern part of the easternmost clay pit of Måde Brickworks (Table 49).

Samples of clay examined quantitatively are available from Hauge, Tønding, and Måde.

They show the following frequencies of species:

Nuculana pygmaea, Astarte reimersi, Goodallia esbjergensis, Cardita orbicularis, Putilla gottscheana, Archimediella cochlias, Naticidae, and *Spiratella atlanta.*

Qualitative Characteristics in Zones III and V

During the collections in the field as well as later during the analyzing of the quantitative samples in the laboratory certain special conditions were observed which only poorly – in some cases not at all – appear from the analytical tables.

The first observations were made as early as 1940–41 at the collections in the Gram Clay on the beach immediately SE of Esbjerg. At that time I only knew the molluscan fauna in the clay pit of Gram Brickworks, and as compared with this collected fauna, there now proved to be some differences between the two faunas:

(1) The shells of *Astarte reimersi* are often somewhat larger at Esbjerg and have finer and more numerous concentric ribs than the shells from Gram.

(2) There is only one form of Turritellidae with two strong spiral ribs, viz. *Archimediella cochlias,* while only *Turritella tricarinata* can be demonstrated with certainty in the material from the parts of the clay pit of Gram Brickworks now accessible.

(3) The *Aquilofusus* material from Esbjerg contains both the species *A. semiglaber* and the species *A. eximius.* The former species differs a little from

A. semiglaber from Gram by having more collabral ribs and more distinct spiral ribs, also on the younger whorls of the shells. At Gram only the typical *A. semiglaber* occurs.

(4) *Aquilofusus puggaardi* is fairly common at Esbjerg, but rare at Gram.

(5) *Uromitra cimbrica* does not occur in the present clay pit of Gram Brickworks, but is not rare at Esbjerg.

(6) *Bathytoma cataphracta* occurs as large, vigorous specimens at Esbjerg, but does not attain to such a considerable size at Gram.

(7) On the whole there are more individuals of the large-shelled mollusc species at Esbjerg than at Gram.

The characteristics found at Esbjerg proved to occur to a full extent also in the clay pits at Hauge and Tønding as well as in the late Gram Clay in the easternmost clay pit of Måde Brickworks.

To me there is no doubt that the Esbjerg fauna as well as the Gram fauna has its special qualitative character, which fairly soon becomes conspicuous when the faunas are found elsewhere.

The conditions mentioned can be supplemented by a few other qualitative features. Thus the following observations have been made:

(1) *Limopsis aurita* is fairly common in Zone III, but disappears at the transition to Zone V.

(2) *Cardita orbicularis* is also fairly common in Zone III and disappears at the transition to Zone V.

(3) *Ringicula buccinea* disappears at the transition to Zone V.

As mentioned on p. 312, I have not reckoned with the actual existence of a Zone IV, which has only been established as a "transitional zone". The three last-mentioned species just disappear in or around this "transitional zone" (cf. the diagram fig. 100).

Overall Characterization of Zones III and V

Before conditions in connexion with Zones I and II in the Gram borehole are investigated in detail, I shall make a survey of the malacological characteristics of Zones III and V on the basis of the information given in the preceding sections.

Zones III + V together:

Qualitative features: Occurrence of *Astarte reimersi*, *Aquilofusus semiglaber*, and *Nassa syltensis*.

Quantitative features: Numerous specimens of *Nuculana pygmaea*, *Putilla gottscheana*, and *Spiratella atlanta*.

Zone III alone:

Qualitative features: Occurrence of *Goodallia esbjergensis*, *Astarte reimersi* (large form with numerous concentric ribs), *Aquilofusus semiglaber* (form with comparatively many collabral and spiral ribs), and *Uromitra cimbrica*.

Quantitative features: Dominated by *Goodallia esbjergensis*, *Cardita orbicularis*, and *Archimediella cochlias*.

Zone V alone:

Qualitative features: Occurrence of *Astarte reimersi* (form of moderate size with comparatively fewer concentric ribs) and *Aquilofusus semiglaber* (form with comparatively few collabral ribs and smooth young whorls).

Quantitative features: Dominance of *Nuculana pygmaea*, *Yoldia glaberrima*, *Astarte reimersi*, *Siphonodentalium cf. lobatum*, Naticidae, and *Odostomia conoidea*.

The Molluscan Fauna in Zones I and II in the Gram Borehole and in the Early Gram Clay at Måde Brickworks

The deepest beds of the Gram Clay in the borehole of D.G.U. at Gram Brickworks, from 16.5 to 22.5 m., contain a fauna of a special character.

As regards *qualitative features* especially the occurrence of *Astarte radiata*, *Dentalium badense*, *Archimediella subangulata*, *Nassa holsatica*, and *Lathyrus rothi* should be emphasized. These are all of them species which have not been recorded from Zones III, IV, and V.

The *quantitative conditions* in part appear from the diagram fig. 100: specimens of *Cardita orbicularis* are numerous, just as *Limopsis aurita* is very common, whereas *Goodallia esbjergensis* is less common.

In the interval mentioned, the fauna as a whole is rather poor in individuals and species as compared with Zones III and V.

Numerous specimens of the species characteristic of the interval in a qualitative respect have been found in the easternmost clay pit of Måde Brickworks. The collection from this locality (see Table 49) therefore is the main source for a characterization of the qualitative conditions in the early parts of the Gram Clay.

In the clay pit in question at Måde the early Gram Clay is found in the western part of the south wall and in parts of the north wall. Among the commonest great species in these strata the following must be pointed out:

Limopsis aurita, *Astarte vetula*, *A. radiata*, *Cardita orbicularis*, *Dentalium badense*, *Turritella tricarinata*, *Sipho distinctus*, *Nassa holsatica*, *Aquilofusus luneburgensis*, *Lathyrus rothi*, *Uromitra wirtzi*, *Narona lyrata*, *Conus antediluvianus*, *Gemmula badensis*, *G. annae*, and *Bathytoma cataphracta*.

Unfortunately samples of clay have not been analyzed from the beds in which this fauna was collected, as the quantitative analyses were not started until the clay pit had been abandoned and become water-logged. The fauna, however, is so characteristic and sufficiently different from the fauna in Zones III and V, that it must immediately be recognized as belonging to a special assemblage zone.

It is obvious that there is a close similarity between the fauna in Zones I +

II of the Gram borehole and the fauna in the early Gram Clay at Måde. Therefore, it may be maintained that they belong to the same assemblage zone. The analysis of the material from 16.5–22.5 m. in the Gram borehole, as shown in the diagram fig. 100, suggests a division into a Zone I and a Zone II, mainly because *Archimediella subangulata* and *Nassa holsatica* only occur in the interval from 19.00 to 22.5 m. It should, however, be noted that the number of fossils is fairly modest in the samples from 18.00 m. and downwards. The species mentioned perhaps also occur in the nearest couple of metres above the depth of 19.00 m. At any rate it is a fact that *Astarte radiata* occurs at a depth of 18.00 m., *Dentalium badense* at 16.50 m., and *Lathyrus rothi* at 18.00 m., and these species have not been recorded from Zones III and V in the Danish Miocene region. Therefore, we ought provisionally to consider the whole interval from 16.5 to 22.5 m. (thus Zones I and II) in the Gram borehole to contain a homogeneous fauna, which clearly differs from that found in the younger beds. To this Zone I + II we should also refer the older Gram Clay at Måde.

Occurrences of the Assemblage Zone I + II Elsewhere in Denmark

As distinct from conditions at Gram, the lower and older parts of the Gram Clay seem to be rather poor in fossils in Denmark. At Hauge (see description on p. 92 and the analyses of fossils in Table 44, p. 252) there was rather a modest number of molluscs in very glauconitic greenish clay, among them, however, many shells of *Dentalium badense*. This small fauna can best be included in the Assemblage Zone I + II.

Collections made in the slopes of the Karlsgårde Canal at Hoddemark and in dug-up clay from the same locality (see Table 46, p. 255) of i.a. *Dentalium badense* and *Lathyrus rothi* show that there, too, excavations have been made in Zone I + II. Conditions of findings, however, are obscure, but is seems that the fossils originate from normal Gram Clay and not from particularly glauconitic clay.

Thus findings of sure signs of occurrences of Zone I + II are very modest outside Gram and Måde. However, it is improbable that the two zones should not be or previously have been present in several other places. It has been mentioned that there almost seems to be poverty in fossils in the lowermost Gram Clay in several places, and in the localities in Regions I, II, and III e.g. conditions at Hauge suggest that deposits of Glauconite Clay have continued into Zone I + II. For some reason the Glauconite Clay itself is very poor in, and almost without fossils.

Characterization of Zone I + II

The faunistic observations made in Zone I + II can be summed up as follows:

Qualitative features: Occurrence of *Astarte vetula*, *A. radiata*, *Dentalium* *badense*, *Nassa holsatica*, *Aquilofusus luneburgensis*, *Lathyrus rothi*, and *Narona lyrata*.

Quantative features: Numerous specimens of *Limopsis aurita*, *Astarte vetula*, and *Cardita orbicularis*.

The Special Assemblage Zone in the Borehole at Sæd (Zone VI)

The drilling made at the custom-house at Sæd by D.G.U. (File No. 167.445, see p. 173) in the interval from the depths of 58.00 to 100.10 m. penetrated a 42 m. thick series of strata which must be considered to be of Tertiary age.

The beds from 90.30 to 100.10 m. consist of typical Gram Clay with a demonstrable content of silt and concretions of clay ironstone. These beds are marine and fossiliferous, whereas the overlying Tertiary beds, the stratigraphical position and age of which will be discussed below, only in places contain remnants of fossils or seem to be completely empty of fossils.

The fauna assemblages in the Gram Clay

The molluscan assemblage in the interval from 92.70 to 100.10 m. (cf. the diagram fig. 102) is dominated by the species *Nuculana pygmaea*, *Astarte reimersi*, *Siphonodentalium cf. lobatum*, Naticidae, and *Odostomia conoidea*. Through this the assemblage is clearly associated with the fauna of Zone V.

The composition of the fauna in the interval 90.30–92.70 m. on the other hand holds a special position as compared with the other, known part of the Gram Formation in Denmark (cf. Table 65 and the diagram fig. 102).

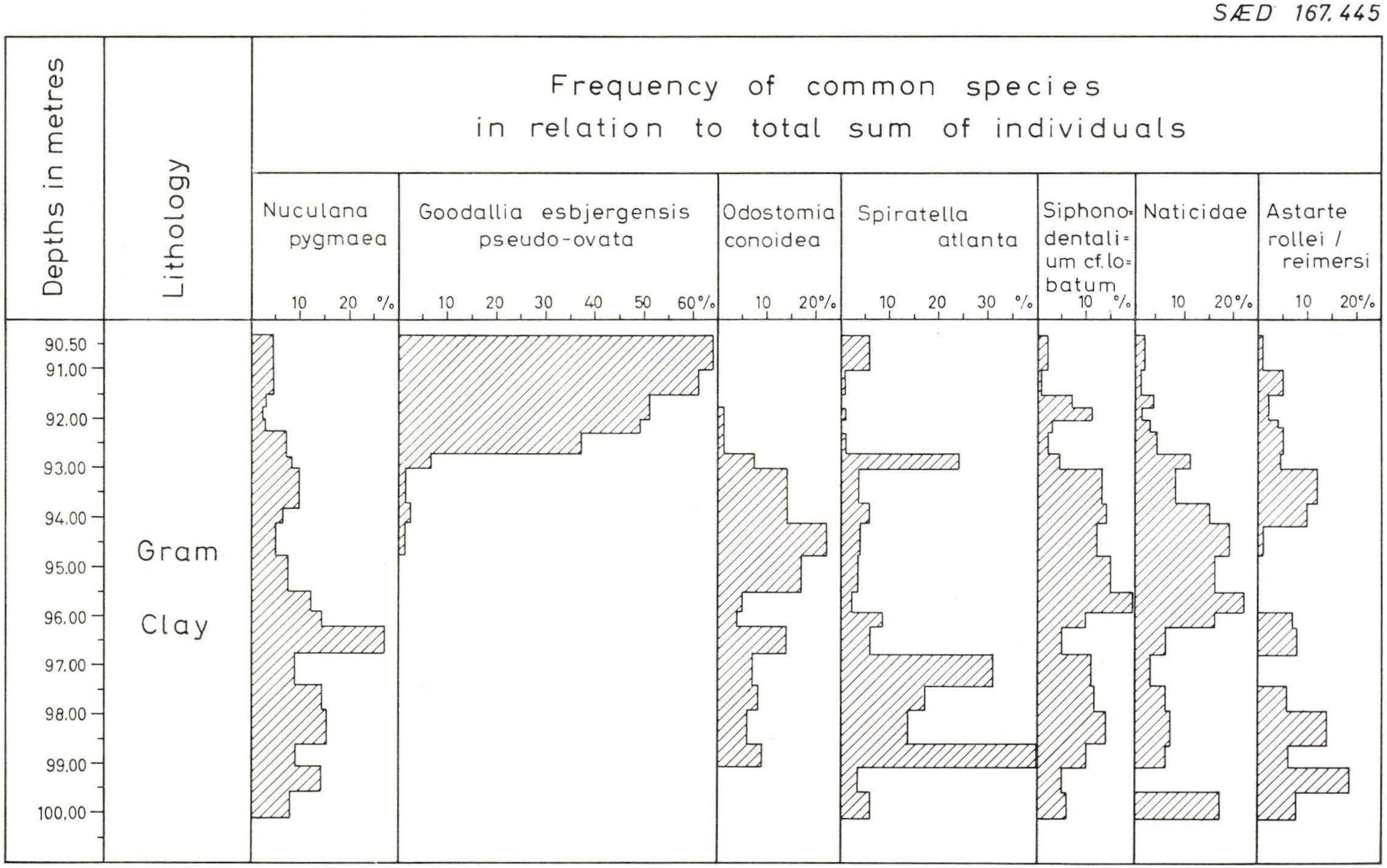
The assemblage in this interval is highly dominated by a slightly deviating form of *Goodallia esbjergensis*, in the section: "Remarks on molluscs" termed *G. esbjergensis pseudo-ovata*, which comprises 40–50 per cent. of the total number of individuals. It is also remarkable that neither this form nor the species *G. esbjergensis* itself has been found in the beds under the depth of 92.70 m.

In the interval 90.30–92.70 m. other forms occur which have not been recorded from Gram Clay elsewhere in Denmark.

(1) The shells of *Astarte* seem to be flatter than the shells of *A. reimersi*, and their ventral margin is convex as distinct from that of the latter species. Therefore they compare best with *A. rollei* from Morsum Kliff on the island of Sylt, but as only few fragments of *Astarte* are available from Sæd, it is not possible to verify the determination.

(2) Instead of *Chlamys clavata*, which is otherwise common in the Gram Clay, only *C. tigerina* has been recorded.

(3) Besides *Nassa syltensis*, which is most generally known from the Gram Clay, there are many shells and fragments of a large *Nassa*, *N. slieswicia*, which


SÆD 167.445
Depths in metres
Lithology
Frequency of common species
in relation to total sum of individuals
Nuculana pygmaea
Goodallia esbjergensis pseudo-ovata
Odostomia conoidea
Spiratella atlanta
Siphono-dentali-um cf. lo-batum
Naticidae
Astarte rollei / reimersi
10 20 %
10 20 30 40 50 60%
10 20%
10 20 30 %
10 %
10 20%
10 20%
90.50
91.00
92.00
93.00
94.00
95.00
96.00
97.00
98.00
99.00
100.00
Gram
Clay
Fig. 102.

is quite different from the species of *Nassa* previously known from the Gram Clay.

(4) Instead of *Neoguraleus kochi* of the Gram Clay, a deviating form has been recorded: *N. sæthensis*.

(5) The species *Pleurotomoides luisae* known from the Gram Clay has been replaced by another species: *P. sp.*

(6) Furthermore, protoconchs and other fragments have been found of gastropods so far indeterminable and unknown from the other fauna of the Gram Clay.

Besides these positive features it can be mentioned that a few species which are otherwise very common in the Gram Clay, have not been found in the interval mentioned. This applies to e.g. the genuine *Astarte reimersi* and *Putilla gottscheana*. Nor has *Odostomia conoidea* been found above the depth of 92.25 m., but it is very common in the beds under the depth of 93.00 m.

As regards the absence of characteristic species, the relative smallness of the faunal section must be taken into consideration.

In what follows the assemblage zone is provisionally termed Zone VI.

Remarks on the Gram Clay at Sæd

Lithologically the beds above 92.70 m. differ but slightly from the underlying Gram Clay. They contain a little more quartz silt and comparatively little pyrite, but otherwise the wash residues are dominated by micro-ellipsoids, as is normally the case of the Gram Clay (cf. p. 17). Nor do the untreated samples of clay by simple visual observation show any actual difference from the Gram Clay. The clay must therefore undoubtedly be termed Gram Clay.

Previously (RASMUSSEN 1958, p. 5) the Mica Clay in an older borehole at Sæd (D.G.U. File No. 167.4a) was mentioned as "Sæd Clay", because it was more brownish and silty than the Gram Clay. The fauna in samples of this clay (see Table 64) includes i.a. *Nassa slieswicia* and *Neoguraleus sæthensis* and therefore seems closely connected with the assemblage in the interval 90.30–92.70 m. in the new borehole.

A few samples of clay from the early borehole have later been washed separately, among them some samples which had more of the colour and consistency of the Gram Clay proper.

These samples proved to contain an assemblage of the typical species of the Gram Clay (cf. Table 64). Thus it could be established with certainty that at least two assemblage zones had been passed also in the early boring at Sæd.

The samples from this boring have been collected in the place of the drilling from a heap of clay drilled up, the depths of the samples thus being uncertain.

Comparison with the Tertiary beds on Sylt

The custom-house at Sæd is situated only 28 km. east of Morsum Kliff on the island of Sylt, from where Younger Miocene and Pliocene deposits have long been known and described. Unfortunately the strata are highly dislocated and disconnected, so that the occurrence of a really sharply defined series of strata is out of the question.

It has long been discussed how the sequence is to be assumed to have been (see literature mentioned in RASMUSSEN 1956, pp. 117–118), but now there seems to be an agreement as to the following series (cf. GRIPP 1964, pp. 133–144):

Uppermost: f. Kaolin Sand, in places with beds of rounded grains of quartz gravel and beds of clay, fluviatile.
e. Silt, white, marine, with traces originating from burrowing animals.
d. Silt, marine, with lignite and precipitations of limonite.
c. Limonite Sandstone, marine.
b. Mica Clay with beds of Mica Silt, marine.
Lowermost: a. Mica Clay.

a and b. The Mica Clay and the overlying Mica Clay with Beds of Silt

Lithologically the oldest beds in Morsum Kliff compare immediately with the Gram Clay, but above the Mica Clay there is rather a thick series of strata containing numerous thin beds of grey silt.

The series of strata in the section of the cliff is highly complicated, partly as a consequence of the dislocations, partly because of landslides. On the other hand, it was in 1926 possible to study the series in a clay pit behind the cliff, where clay was excavated for the building of the Hindenburg Dam. An impression of the sequence can be obtained in WETZEL (1929, fig. 33, p. 147), but a detailed description of the section made by BENTZ has been published by STAESCHE (1930, pp. 62–63), who sums up the sequence of strata in three lithological main groups:

III. About 30 m. black, fractured, in part glauconitic clay, above often more sandy; rich in fossils at the base and poor in or empty of fossils at the top.
II. About 15 m. pale grey clay and silt, poor in fossils.
I. About 5 m.; exposed: black and dark grey clay and silty clay, very rich in fossils.

Roughly these beds remind of the series of beds from 86.40 to 100.10 m. in the borehole at Sæd, where, however, a corresponding division cannot be made. Furthermore, there is a difference between the thickness of the beds and the contents of fossils.

The beds on Sylt are considered late Upper Miocene.

c. and d. The Limonite Sandstone and the silt containing limonite

In Morsum Kliff there is above Series b a bed of Limonite Sandstone that in places contains many fossils, which by GRIPP (1922) and WIRTZ (1949) are considered to be Pliocene. Besides a large number of forms known from Glimmerton, the molluscan fauna contains the Pliocene species *Mactra arcuata* Sow. and *Nassa reticosa* Sow.

In one of the five glacially displaced floes in Morsum Kliff the Limonite Sandstone is found as a layer, but in another floe there is in a single locality (called "Klein-Afrika") pale sand with detached limonitized casts of molluscs. The species are the same as those in the Limonite Sandstone.

In the borehole at Sæd there is no Limonite Sandstone, but Mica Silt with round concretions of siderite and siderite casts of gastropods (the interval 72.00–86.40 m.). As the limonite on Sylt can be the result of a transformation of previous sideritic beds and concretions it is thus a case of originally rather closely corresponding facts.

Figs. 103 and 104a, b show casts of fossils partly from "Klein-Afrika", partly from Sæd, in order to demonstrate the uniform character of these deposits. The gastropod casts from Sæd can neither be determined as to genus nor as to species.

Another concordant character is the contents of lignite in the sand in both places.

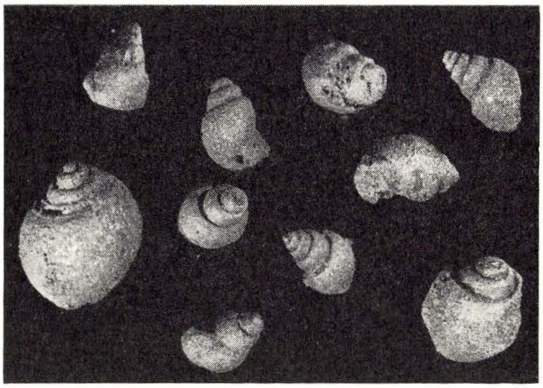
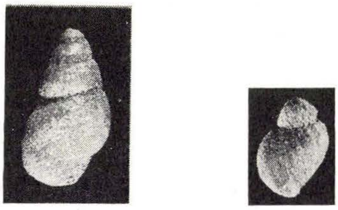


Fig. 103. Collection of casts of gastropods from "Klein-Afrika" at Morsum Kliff on Sylt (Germany).

Phot. Chr. Westergaard



a b

Fig. 104. Casts of gastropods from the borehole at Sæd (167.445). Depth: 80.0 m.

Phot. Chr. Westergaard

e. and f. The white, marine silt and the Kaolin Sand

The limonite-bearing silt on Sylt is overlain by white silt which has been termed Kaolin Sand, but by Gripp (1963) is now considered to be marine because of the traces of burrowing presumably left by marine animals which are seen in it.

It is again overlain by the proper, cross-bedded, fluviatile Kaolin Sand, which contains quartz gravel and, in places, beds of clay. Furthermore, there is a one metre thick "Flötz" of lignite which according to a pollen analysis made by U. Rein (see Weyl, Rein & Teichmüller 1955) is of Upper Pliocene age.

Perhaps the Mica Silt from 58.00–72.00 m. at Sæd can be compared with the white kaolin-bearing sand on Sylt, as it also contains quartz gravel, beds of clay, and many bits of lignite.

Result of the Comparison with Sylt

At the comparisons of the two series of sediments it should be kept in mind that the series on Sylt has been exposed to a more advanced geochemical action, while the sediments at Sæd obviously were situated deeper below ground level and more protected during the Quaternary Period.

The comparatively high contents of mica in the sediments at Sæd seem to be missing on Sylt.

Even though thus there seem to be plenty of factors of uncertainty at a comparison, I venture to advance the following view of the connexion in time between the Tertiary series of beds in the two localities:

Sæd	Sylt	Age determination according to Gripp 1964	
Mica Silt, with quartz gravel, beds of clay and lignite, limnic-fluviatile?	Kaolin Sand, fluviatile, with quartz gravel, beds of clay and lignite	Upper Pliocene	
Mica Silt with concretions and siderite casts of gastropods, marine	Silt, white, with traces from burrowing animals, marine. Silt with lignite and limonite, marine. Limonite Sandstone, marine	Lower Pliocene (Morsum Stufe)	Pliocene
Mica Clay with beds of silt, marine Gram Clay, slightly silty Gram Clay	Mica Clay, with beds of sand, marine	Sylt Stufe Gram Stufe	Miocene

The chief result of the comparison seems to be that it has been made probable that the beds above 86.40 m. in the borehole at Sæd belong to the Pliocene Period.

Correction of the previous view of the Pliocene at Sæd

The fauna in the siderite oolite in the early borehole at Sæd (File No. 167.4a) is viewed by ØDUM (1934) as well as later by RASMUSSEN (1958) as Pliocene, as it was supposed to contain the Pliocene species *Nassa reticosa* SOW. and *Bela cf. harpularia rosea* LOV. Having examined the material again, I must, however, change my view of the identification of the two species as follows:

(1) The material of shells referred to *Nassa reticosa* has been rolled so much that there is a possibility that it should rather be interpreted as worn shells of *N. slieswicia.*

(2) The specimen determined as *Bela cf. harpularia rosea* has been rolled very much and may have been a shell of *Neoguraleus sæthensis.*

To these remarks it should furthermore be added that the *Nassa* found in the siderite oolite as well as the Gram Clay is not identical with the Pliocene *N. granulata*, but must be considered quite a new species, *N. slieswicia*, which has not yet been recorded from other localities.

Thus it is very probable that the fauna in the "Sæd Clay" of 1958 as well as in the siderite oolite in the early borehole at Sæd (File No. 167.4a) is contemporaneous with the fauna in the interval from 89.50 to 92.70 m. in the new borehole at Sæd (File No. 167.445), i.e. that the beds belong to the Gram Formation and must be regarded as Upper Miocene.

Characterization of Zone VI

On the basis of the information given in the preceding section as to the occurrence of the molluscs in Zone VI and the conditions pictured in the diagram fig. 102, as well as the analytical Table 65, the following survey of Assemblage-Zone VI may be given:

Qualitative features: Occurrence of *Astarte cf. rollei, Chlamys tigerina, Nassa slieswicia*, and *Neoguraleus sæthensis.*

Quantitative features: Dominance of *Goodallia esbjergensis pseudo-ovata.*

Survey of the Biostratigraphy of the Gram Formation

On the basis of the account given in the preceding sections it is possible to make a survey of the assemblage-zones of the Gram Formation as rendered in the table on p. 325.

Survey of the Biozones in the Gram Formation in Denmark

<table>
<tr><th colspan="2">Biozones (as denoted in the preceding sections by Roman numerals</th><th>Character fossils (Qualitatively important species)</th><th>Dominant species of molluscs (Quantitatively important species)</th><th>Guide fossils (According to experiences from North Germany)</th><th>Denotation of zones in North Germany (Gripp 1964)</th><th>Assemblage-zones in Denmark (New designations)</th></tr>
<tr><td rowspan="5">Gram Clay</td><td>VI</td><td>Goodallia pseudo-ovata
Astarte cf. rollei
Nassa slieswicia
Neoguraleus sæthensis</td><td>Nuculana pygmaea
Yoldia glaberrima
Goodallia pseudo-ovata
Cardium papillosum
Siphonodentalium cf. lobatum
Naticidae</td><td>Astarte rollei
Aquilofusus eximius</td><td>Sylt-Stufe</td><td>Nassa slieswicia Zone</td></tr>
<tr><td>V</td><td>Astarte reimersi
Aquilofusus semiglaber
Narona rothi</td><td>Nuculana pygmaea
Yoldia glaberrima
Astarte reimersi
Siphonodentalium cf. lobatum
Naticidae
Odostomia conoidea</td><td rowspan="3">Astarte reimersi
Aquilofusus semiglaber</td><td rowspan="3">Gram-Stufe</td><td rowspan="2">Astarte reimersi-
Nuculana pygmaea Zone</td></tr>
<tr><td>IV</td><td colspan="2">Thin zone with mixed fauna from III and V</td></tr>
<tr><td>III</td><td>Goodallia esbjergensis
Astarte reimersi
(large form with numerous regular ribs)
Aquilofusus semiglaber
(with many collabral and spiral ribs)
Uromitra cimbrica</td><td>Goodallia esbjergensis
Cardita orbicularis

Archimediella cochlias</td><td>Astarte reimersi-
Goodallia esbjergensis Zone</td></tr>
<tr><td>I + II</td><td>Astarte vetula
Astarte radiata
Dentalium badense
Nassa holsatica
Aquilofusus luneburgensis
Lathyrus rothi
Narona rothi
Uromitra wirtzi</td><td>Limopsis aurita

Astarte vetula
Cardita orbicularis</td><td>Astarte vetula

Aquilofusus luneburgensis</td><td>Langenfelde-Stufe</td><td>Astarte vetula Zone</td></tr>
<tr><td colspan="4">Glauconite zone (almost empty of fossils)</td><td>Astarte omalii anus
Aquilofusus lategradatus</td><td>Lüneburg-Stufe</td><td>No assemblage zone in Denmark</td></tr>
</table>

For each zone character fossils as well as dominant species have been recorded in this table, just as the North German experiences as regards guide fossils and division into stages (sensu GRIPP) have been placed in the table. The latter has been done in order to compare my results with the German geologists' experiences regarding the division of Glimmerton (see pp. 300 ff.).

The "Lüneburg Stufe" has not been recorded from Denmark. This also applies to the earliest, basal part of the "Langenfelde Stufe" with *Astarte vetula* sensu stricto (i.e. the form known from Lüneburg and Wohltorf which is pictured in HINSCH 1952, Plate A, figs. 1–2, and RASMUSSEN 1956, Plate II, fig. 4a, b). I am of opinion that these two zones in North Germany are equivalents of the Glauconite Clay in Denmark, which is practically empty of fossils. In several places it must even be assumed that the upper parts of the glauconitic zone are equivalents of the "Langenfelde Stufe", e. g. at Hauge (p. 317 and Table 44), where, in the uppermost part of the Glauconite Clay, there was a molluscan fauna which belongs to Zone I + II.

The so-called "Gram Stufe" in North Germany includes two assemblage-zones in Denmark (III and V, Zone IV, as mentioned above, being a thin transitional zone with a mixed assemblage of species), while the "Sylt Stufe" is assumed to have its equivalent in Zone VI, which is known from Sæd, only.

In Denmark we thus get four assemblage-zones in the Gram Clay. They all pass evenly into one another, but nevertheless it is often possible to refer the fauna of any large sample of clay to one of these assemblage-zones.

Instead of being denoted by Roman numerals, the zones may be characterized by the most prominent species in the faunal assemblage. The following names, therefore, are suggested (cf. the table on p. 325):

VI: The *Nassa slieswicia* Zone.
V: The *Astarte reimersi-Nuculana pygmaea* Zone.
(IV): (No special biozone).
III: The *Astarte reimersi-Goodallia esbjergensis* Zone.
I + II: The *Astarte vetula* Zone.

Distribution of the Assemblage Zones in the Gram Clay

The geographical distribution of the various assemblage zones in Denmark can be fairly indicated on the basis of Tables 15–66 and the characterization of the zones given on pp. 302–326. In the case of many localities the affiliation of the assemblage zone is uncertain, and from some localities so few molluscs have been recorded that it has not been possible to indicate the zone.

In the following list the localities are indicated for each assemblage zone. Within each zone the sure localities are stated first and then the uncertain localities in a group apart. The succession of the localities corresponds to that in the Geological Part.

1. *The Astarte vetula Zone*

Region I:
Kodal-Fjaldene (84.1749) and Lille Torup (85.379).

Region III:
Hauge (clay pit) and Hoddemark (the Karlsgårde Canal).

Region IV:
Måde Brickworks (eastern clay pit) and Strandgård Brickworks (clay pit).

Region V:
Gram (141.277) and Tønder (166.398).

Less certain occurrences:
Lillelund (73.88), Tværmose (85.381), Gjødstrup (85.861), and Esbjerg (130.59).

2. *The Astarte reimersi-Goodallia esbjergensis Zone*

Region I:
Skærum Mølle (clay pit), Lillelund (73.88), Lille Spåbæk (lignite pit), Grønbjerg (clay pit of brickworks), Muldbjerg (83.1006), Kodal-Fjaldene (84.1749), Spjald (83.127), Brejning Kro (83.197), Videbæk (84.344, 84.358, 84.417, 84.456, 84.483, 84.492, 84.1727, and 84.1748), Møltrup (clay pit of brickworks), Gjellerup (85.380), Snejbjerg (85.775), and Bording (86.177).

Region II:
Drantum (104.1241) and Nyholm (104.1166).

Region III:
Leding (93.155), Alkærsig (clay pit of brickworks and 93.101), Forsom (clay pit of brickworks), Odderup (103.150), Oddum (lignite pit), Hesselho (113.121), Hauge (clay pit), Tønding (clay pit), Grøde (the Karlsgårde Canal), and Hoddemark (the Karlsgårde Canal and 113.33a).

Region IV:
Esbjerg (130.59, clay pit of brickworks and beach), Måde Brickworks (eastern clay pit), and Måde-Strandgård (clay pit of brickworks).

Region V:
Hjortvad (141.178), Hjerting (141.238), Sdr. Hygum (141.260), Rødding (141.75), Gram (141.277), and Spandet (150.184).

Less certain occurrences:
Aulum (74.321), Kjærgårde (83.210), Spjald (83.104), Randbæk (83.591, 83.597, 83.602), Gjødstrup (85.861), Høgild (95.1510 b), Skjerrisgårde (104.1165), Store Langkjær (104.1158), Hjortsballe (105.320), and Lønborg (102.55).

3. The Astarte reimersi-Nuculana pygmaea Zone

Region I:
Videbæk (84.1748).

Region II:
Brande (clay pit of brickworks) and Drantum (104.1241).

Region V:
Holleskov (132.46 b), Ravning (clay pit of brickworks), Sdr. Hygum (141.260, 141.261, and 141.273), Rødding (141.76, 141.247, 141.242, 141.243), Vester Lindet (141.246), Gram (the clay pit of the brickworks and 141.277), Spandetgård (the clay pit), Tønder (166.398), Brodersmark (166.351 b), Sæd (167.4 and 167.445), and Rends (167.236).

Less certain occurrences:
Ålbæk Eng (102.59), Sønderskovgård (132.34), Tobøl (132.37), Hjortvad (141.178), Lintrup (132.40), Brøstrup gård (141.224), Rødding (141.241), Rojbøl (141.194), and Tiset (141.244).

A number of localities can with certainty be referred to the two *Astarte reimersi* Zones together, but without the small material of fossils permitting a determination to a single one of them:

Vinding (74.329), Muldbjerg (83.377), Kodal-Fjaldene (84.763, 84.766, 84.770, 84.233, and 84.238), Videbæk (84.288, 84.313, 84.493, and 84.525), Gjellerup (85.380), Frølund (85.383), Bording (86.215), Fasterholt Plantage (95.849), Sandfeldbjerg (clay pit), Harkes (clay pit of brickworks), Østbæk (103.152), Stenderup (113.36), Måde Brickworks (northwestern clay pit), Gørding (clay pit), Storlund (clay pit), Arnum (150.25 b), Hønning (150.197), Tønder (166.227), and Heds (167.234 b).

4. The Nassa slieswicia Zone

So far only recorded from Sæd (167.4 and 167.445).

The geological distribution of the localities within each zone shows that the *Astarte vetula* Zone can be recorded from all the regions with the exception of Region II. As, however, no drillings have been made in this region from which large samples of clay from the deeper beds of the Gram Clay are available, it is still probable that the zone is present there, too. The type locality of the *Astarte vetula* Zone in Denmark is the eastern clay pit of Måde Brickworks, but the delimitation of the zone is best studied in the borehole at Gram Brickworks (141.277).

The general impression and the number and distribution of the localities, for that matter, is to some degree disturbed by the fact that the taking of samples in many boreholes only comprises a single minor sample, which as a rule has been taken in the upper beds of the Gram Clay interval. This may be the main reason why the *Astarte reimersi-Goodallia esbjergensis* Zone is the most frequent zone recorded. It has been found in all the five regions, but mainly in North Jutland, where the Gram Clay in all outcrops, with the exception of Brande Brickworks, belongs to this zone. The occurrence at Esbjerg (the old clay pits of brickworks on the south-eastern outskirts of the town and the beach off these pits) must be considered the type locality of the zone.

The *Astarte reimersi-Nuculana pygmaea* Zone is also found in all the five regions, but it is characteristic that the zone is first of all distributed in North Slesvig. The type locality is the classic occurrence in the clay pit of Gram Brickworks.

The *Nassa slieswicia* Zone, as mentioned above, is only known from Sæd, the southernmost locality in Region V, close to the German frontier.

The distribution of the assemblage-zones offer certain main features of the history of distribution of the Gram Formation.

After the deposition of the Hodde Clay the more stagnant conditions reflected in the character of this clay seem to have changed. More moved, and probably somewhat shallower water, in which the Glauconite Clay was deposited, was the predominant feature.

In Danish territory this probably took place in the same period in which the "Lüneburg Stufe" was deposited in North Germany, and lasted somewhat into the period of the "Langenfelde Stufe". There is a possibility that Glauconite Clay was deposited over large parts of the North Jutland area of Gram Clay in the whole period of the *Astarte vetula* Zone (cf. the occurrence at Hauge), but at any rate the deposition of Gram Clay was already at that time in active progress in Southwest Jutland at Esbjerg (Måde) and Varde (the Karlsgårde Canal at Hoddemark) and in North Slesvig (Gram).

The accumulation of Gram Clay then in the period of the *Astarte reimersi-Goodallia esbjergensis* Zone took place over the whole area of the formation and probably continued in all regions into the period of the *Astarte reimersi-Nuculana pygmaea* Zone. The later Quaternary erosion, however, seems to have removed the beds of the latter zone in most of North Jutland so that it is found to an appreciable extent only in North Slesvig.

The uppermost, and younger, beds during the period of the *Astarte reimersi-Nuculana pygmaea* Zone gradually got a somewhat changed character: a higher content of mica and a slight content of silt (Gram). At Sæd in southwestern North Slesvig we can already in the uppermost beds of the Gram Clay demonstrate a change in the composition of the molluscan assemblage (the *Nassa slieswicia* Zone), but the overlying, more sandy parts of the Gram Formation are empty of fossils.

In the period of the Gram Formation the sea thus seems to have regressed towards the southwest, which may perhaps be explained by structural conditions in the subsurface. The Jutland-Funen ridge (the Ringkøbing-Funen structure; see Sorgenfrei & Buch 1964, p. 23ff.), which has a demonstrable influence on the tectonical situation and thickness of the Mesozoic and Tertiary beds, can be supposed to have contributed to the palaeogeographical development, as movements in the structure can hardly have avoided influencing the course of the coastline and the bottom relief in the period of the Gram Formation.

A relative upheaval of the ridge can furthermore have caused the uppermost and younger beds of the deposits of the formation to have been exposed to being removed by erosion during Pliocene time or by glacial erosion during the Quaternary Period. In this way the sediments of the period of the *Astarte reimersi-Nuculana pygmaea* Zone may have been removed in large parts of the areas overlying the structure, only minor deposits (e.g. at Brande) being left behind.

Remarks on Ecological Conditions in the Hodde and Gram Formations

The almost sand-free sediments of the Hodde Clay as well as the Gram Clay reflect mainly calm conditions of deposition, whereas the great contents of glauconite in the Glauconite Clay suggest that the depth of the water during the period between the accumulations of the two other deposits of clay was comparatively lower. Perhaps the sea floor in this period was so high that it was partly affected by the movements of the water.

The character of the Hodde Clay, with its great contents of pyrite, suggests a reducing environment, the Glauconite Clay mainly an oxidizing, and the Gram Clay, again, mainly a reducing environment. The Gram Clay in certain upper beds in places becomes less pyritic, which suggests that the reducing conditions gradually were decreasing.

The molluscan fauna thus during the deposition of the Hodde Clay and the Gram Clay must have had rather extreme conditions of life. At Måde Brickworks all the mollusc shells of the Hodde Clay are conspicuously smaller than the shells of the same species in the North German localities, e.g. at Twistringen. The same seems to apply to the other localities in Denmark in which fossils have been found in the Hodde Clay. As the sediments at Twistringen are considerably more silty and on the whole less pyritic than the Hodde Clay (see Köwing 1956, pp. 73–78), the environment during the deposition of this clay seems to have been especially unfavourable. It may also be pointed out that in North Germany the clay sediments in the Reinbek Stufe are considerably richer in fossils than the corresponding types of sediment in the Upper Miocene Glimmerton, while the reverse is the case in Denmark.

In the deepest beds of the Gram Clay a similar unfavourable influence on the dimensions of the molluscs is seen at Måde Brickworks, but not quite as pronounced as in the case of the Hodde Clay. The smaller size of the individuals of the molluscan assemblage is best illustrated by a comparison with the assemblage in the upper beds of the Gram Clay in the same section, as seen in the photographs rendered as figs. 5 and 6 in RASMUSSEN 1961. The shells from the deeper beds, i.e. the *Astarte vetula* Zone, are clearly smaller than those from the *Astarte reimersi-Goodallia esbjergensis* Zone. The explanation of this fact must be that the ecological conditions in the former zone were more unfavourable to the molluscs than those in the latter. One of the causes of this may perhaps be expressed in the greater contents of pyrite in the *Astarte vetula* Zone which are immediately noted on a visit to the locality at Måde. All the mollusc shells in this zone are highly marked by infection with pyrite. If a collection of shells from the *A. vetula* Zone and a corresponding collection from the *A. reimersi-G. esbjergensis* Zone are steeped in water and dried, many of the shells from the former zone will be covered by a reddish yellow, limonite-coloured film as a consequence of the action of the pyrite, whereas the latter collection will not be visibly affected.

The reducing environment must be due to bad airing of the sediment, but hardly needs having been combined with poor circulation in the upper layers of the water. In the period of accumulation of the Gram Clay, conditions seem to point towards a closed basin with barriers towards the open sea, as e. g. the great contents of pelagic molluscs, especially pteropods (*Spiratella* species), if anything, indicate frequent supply of fresh sea water.

The foraminifera in the Gram Clay point the same way. The assemblage has preliminarily been investigated by DROOGER & FELIX (1961, p. 323), who state that it is dominated by the species *Epistomia elegans* and *Uvigerina rugulosa*, the former being abundant in recent pelitic sediments from depths of 30–150 m., while the recent substitute of the latter, *Uvigerina perigrina*, prefers pelitic sediments at depths of less than 30 m. Another frequent species in the Gram fauna, *Sphaeroidina bulloides*, at present mainly occurs in pelite and pelitic sediments at depths below 110 m. The depths mentioned refer to conditions off the mouth of the Orinoco, where DROOGER & FELIX found an assemblage of foraminifera that looks like that of the Gram Clay. On the basis of these comparisons (loc. cit.) they advance the following conclusion: "As a whole the great numbers of *Epistomia elegans* and *Uvigerina rugulosa* in the Gram deposits would indicate an open marine muddy environment, and because of the admixture of the *Nonion*, *Cancris* and *Sphaeroidina* species, a depth of about 70 to 100 metres would seem most likely."

A recent assemblage of molluscs of a composition corresponding to that in the Gram Formation does not seem to have been recorded, but GRIPP (1964, p. 125) calls attention to the fact that in the Golfe de Gascogne (the Bay of Biscay) there lives a fauna which in certain features reminds of that occurring in Glimmerton, as an assemblage is found there which among other species includes *Limopsis aurita* (BROCCHI), *Isocardia cor* L., *Cassis saburon* BRUG., *Cassidaria echinophora* LAM., and *Sipho jeffreysianus* FISCHER. These species occur on a bottom of silty sediments at depths of 50–80 m. Unfortunately we have no special knowledge of this assemblage of molluscs and its environment.

Bottom conditions in the period of the deposition of Hodde and Gram Clay must have been characterized by soft clay or ooze which was hardly appreciably affected by movements of the water. The bryozoan *Cupuladria canariensis* occurring everywhere in the Gram Clay has recently been examined by LAGAAIJ (1963), who concerning its relation to the sea floor states that neither this species nor other lunulitiform bryozoa can attach themselves to particles exposed to being removed because of movements in the water (rough sea, current, etc.). This fact thus is a corroboration of the view that calm conditions prevailed on the sea floor in the period of accumulation of the Gram Clay. Other signs of this are the large number of pelecypoda, which are everywhere found embedded in the clay with both valves in situ.

Apart from pieces of driftwood, which has often been bored by *Teredo*, no plant remains have been found in the Hodde Clay and the Gram Clay, but the often rather great contents of organic matter (see RASMUSSEN 1956, p. 17) can perhaps originate from marine algae.

The question of mass appearance of algae is touched on by GRIPP (1964, p. 125), who refers to such occurrences as a possible explanation of the great contents of humus in certain beds of Glimmerton. As a vegetation of algae can only be found in so shallow water that daylight can penetrate to the sea floor, it must probably first of all be a case of floating seaweed. It is more uncertain whether the numerous small Rissoidae (*Putilla gottscheana*) found in the *Astarte reimersi-Nuculana pygmaea* Zone can be taken as a sign of an originally large vegetation of algae, but certain Rissoidae in the present time mainly live on algae and feed on them.

The main impression of the accumulation area of the two types of clay is the presence of one or more bays which were wide open towards the sea, and on the bottom of which clay or mud was mainly deposited.

The depth of the water hardly exceeded 50–100 m., but really cannot be estimated with only fair certainty. Thus we cannot disregard the fact that the fauna of the Gram Clay contains several species which are dominant in the argillaceous Gram Formation as well as in the sandy Arnum Formation developed in shallow water, viz. *Nuculana pygmaea* and *Yoldia glaberrima*, and other species common to the two formations are dominant in the Arnum Formation, viz. *Varicorbula gibba*, *Aporrhais alata*, and *Ringicula buccinea*. These species, however, also all live in deeper water than the 20–50 m. which according to SORGENFREI seems to have been the maximum depth at which the Arnum Formation must be supposed to have been deposited.

Conditions of temperature in the periods of the Hodde and Gram Formations must have been different from recent conditions in the same area, as a number of genera such as *Xenophora*, *Galeodea*, *Semicassis*, *Ficus*, *Murex*, *Lathyrus*, *Scaphella*, *Conus*, *Gemmula*, and others, in the present time require temperatures higher than those in the North Sea.

As the molluscan faunas in the Gram Clay, however, are represented by numerous individuals of such genera as *Astarte* and *Sipho*, which in the present time prefer colder (arctic and boreal) seas, the very flourishing of these genera seems to point towards a decreasing mean temperature in relation to the Arnum Formation.

SORGENFREI (1958, p. 445) supposes that the original conditions of temperature of this formation correspond to the present-day conditions in the Atlantic off Northern Spain and Portugal (Boreo-Lusitanian conditions), especially because of the presence of *Chlamys tigerina* and *Cancellaria cancellata*. The former is a typical boreal species. It has also been found in the Gram Clay at Sæd. On the other hand, the typical Lusitanian *C. cancellata* has not been recorded from the Gram Clay. Instead there is here a comparatively great population of Cancellariidae (*Narona lyrata–N. rothi*). There is, however, hardly any reason to picture to oneself any appreciable difference from the original mean temperature of the Arnum Formation as regards the Gram Formation.

Perhaps conditions of temperature in that period compare best with recent conditions in the Golfe de Gascogne (the Bay of Biscay), to which reference was made on p. 331 with GRIPP as source, i.e. with southern Boreal conditions. However, more studies are required before an approach to the solution of the problem can be expected.

As to the salinity in the sea during accumulations of the Hodde Clay as well as the Gram Clay, the above-mentioned (p. 330) increasing size of the shells of molluscs from the former type of clay up to the *Astarte reimersi-Goodallia esbjergensis* Zone would seem to indicate an increasing salinity.

In connexion with these remarks on the ecology there might be reason to discuss a number of other biological conditions that might be deduced from the molluscan faunas in the Hodde and Gram Clay. This is, however, considered to be outside the framework of this paper, just as more thorough investigations into the conditions already sketched can best be made together after the sedimentological investigations in progress have been finished and after the other groups of animals have been investigated more closely, especially the foraminifera and the ostracods.

It may, however, be of interest for an evaluation of the molluscan faunas to point to one more interesting fact, viz. how the composition of the assemblage of particularly frequent species (and certain characteristic species) repeats itself from one formation of clay to the other, right from the Upper Oligocene time to the Upper Miocene time. It seems to be a downright case of a molluscan assemblage of Mica Clay. In what follows these examples will be adduced:

The *Upper Oligocene*, dark brown, glauconitic clay at Århus, Denmark (HARDER 1913), is characterized by numerous shells of *Limopsis aurita*, *Dentalium* (*kickxi* and *sp.*). *Natica Nysti*, *Aporrhais speciosa megapolitana*, and *Pleurotoma Duchasteli*. Furthermore, many shells of *Nucula compta*, *Venericar-*

dia tuberculata, Astarte kickxi, Teredo sp., Pleurotoma Selysi, Surcula regularis, and *Dolichotoma subdenticulata* have been found there.

The *Lower Miocene* Mica Clay at Itzehoe, Holstein, North Germany (GRIPP 1914), which consists of highly calcareous, greyish brown, Mica Clay with glauconite, contains many shells of *Limopsis aurita anomala, Astarte concentrica, Nassa schlotheimi, Aquilofusus gürichi, Pleurotoma Duchasteli,* etc.

The *lower part of the Hemmoor Stufe* (= Unter Hemmoor DITTMER 1957 = Behrendorfer Unterstufe DITTMER 1959) has in Slesvig-Holstein at Oxlund and Behrendorf been developed into brown, humous, argillaceous silt and silty clay with much glauconite and pyrite. The molluscan fauna according to DITTMER (1957 and 1961) is characterized by i. a. containing numerous shells of *Limopsis aurita, Astarte radiata,* and *A. goldfussi* (= *A. gracilis*), *Cardita chamaeformis,* etc. Among Turridae *Turris zimmermanni* is the commonest. Furthermore, as distinct from the actual beds of sand in the Hemmoor Stufe, the fauna contains *Sipho grippi, Aquilofusus* species (*A. beyrichi* and *A. oppenheimi*), and *Mitra* species.

On the frequencies of species in the Reinbek Stufe see Table 14, which shows the fauna in the silty Mica Clay at Twistringen, North Germany.

It seems to be a feature common to the Mica Clay faunas mentioned, including the faunas of Hodde and Gram Clay, that the following forms play a quantitatively dominant part:

Limopsis aurita, Astarte species, and *Cardita* species. To these should be added many shells of Dentaliidae and occurrence of Aquilofusidae (including other Fusidae), and certain Turridae.

When quantitative investigations into the faunas of the formations in question have been carried through, we shall have a good basis for the study of the evolution of the molluscan assemblages and certain species from the Upper Oligocene to the Upper Miocene. On the other hand, I have not succeeded in finding an assemblage with a corresponding composition of species recorded from the recent seas.

Phylogenetic Remarks on Certain Species of Molluscs in the Hodde and Gram Clay

In the Gram Formation it can be seen how certain species change appearance from the lower beds of the Gram Clay to the upper zones. The extreme forms of these species, i.e. the oldest and the youngest, respectively, often show so great differences in character that they may be considered as completely different species if the two groups are observed isolatedly (as was done by HINSCH 1952). In order to ascertain whether they are connected through intermediate forms, it is necessary to have a continued series of strata and to provide sufficient material of fossils from each small vertical interval of the whole series. In the case of the Gram Formation this has been partly fulfilled in several cases, and therefore it is possible to establish the following eight evolutional series:

(1) *Astarte vetula vetula*[1] → *A. vetula reimersi* (with regular fine ribs) → *A. vetula reimersi* (with irregular and partly effaced ribs).
The series can be continued to *A. vetula rollei* in the Mica Clay in Morsum Kliff (Sylt) and ? at Sæd (147.445). The series *A. vetula* → *A. reimersi* → *A. rollei* was first demonstrated by HINSCH (1952), who, however, did not know the two varieties of *A. reimersi.*

(2) *Nassa holsatica* → *N. syltensis.*

(3) *Aquilofusus luneburgensis luneburgensis* → *A. luneburgensis eximius* → *A. semiglaber.*
The evolutional series can be continued to *A. eximius* emend. HINSCH 1952 in Morsum Kliff (Sylt). This form of *A. eximius* is somewhat different from the form which I have named *A. eximius* (in the not yet published Part II of this work). The series *A. luneburgensis* → *A. semiglaber* → *A. eximius* (Sylt) has been demonstrated by HINSCH (1952), who, however, did not know the stratigraphical position of the form *eximius* from Esbjerg.

(4) *Uromitra cimbrica wirtzi* → *U. cimbrica cimbrica.*
The series was first demonstrated by HINSCH (1952). who, however, did not consider the two forms as subspecies.

(5) *Narona lyrata* → *N. rothi.*
The series demonstrated by HINSCH 1952.

(6) *Gemmula badensis* (with many knobs) → *G. badensis* (with fewer knobs).

(7) *Bathytoma cataphracta jugleri* → *B. cataphracta* (transitional form between *jugleri* and *mioturbida*) → *B. cataphracta mioturbida.*

(8) *Spirotropis modiola* (with sharp adapically directed carina) → *S. modiola* (with rounded carina).

Less certain series can be supposed to have developed from the Hodde Clay into the Gram Clay. The break in continuity represented by the Glauconite Clay, which is almost empty of fossils, gives rise to a certain uncertainty, but it is tempting to point out the following exchange of species from one formation to the other:

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[1] Concerning the sub-species mentioned in this section reference is made to the forthcoming Part II of this work.

Hodde Clay	Gram Clay
Limopsis aurita (with *L. lamellata* as the juvenile form)	*L. aurita* (with *L. anomala* as the juvenile form)
Cardita chamaeformis	*C. orbicularis*
Astarte goldfussi	*A. vetula*
Aquilofusus festivus	*A. luneburgensis* (perhaps with *A. lategradatus* in the Elbe-Mecklenburg area as intermediate link)
Bathytoma cataphracta jugleri.	*B. cataphracta mioturbida.*

These comparisons have only been made in order to call attention to the problem. It will only be possible to solve the problem if an opportunity arises of investigating an abundant material from a continued fossiliferous series of strata.

Perhaps *Limopsis lamellata* is only an ecological form, as the juvenile form of *L. aurita* is = *L. anomala* in the Vierlande Stufe (GRIPP 1914) as well as the Arnum Formation (SORGENFREI 1958) and in the Gram Clay. *L. lamellata* is restricted to the Hodde Formation and the Reinbek Stufe, and in this way seems to indicate the identity of these two formations.

Cardita chamaeformis was originally set up on the basis of material from the English Crag (Pliocene). Therefore it is tempting to consider the fact that *C. orbicularis* is its successor in the Gram Clay as a sign that the form in the Hodde Clay (as in the Hemmoor Stufe and Anversien) actually is not identical with the species in the Pliocene of England and Belgium. All the forms in the Miocene referred to *C. chamaeformis* therefore may belong to another species.

There is a possibility that also other species in the Gram Formation than those already mentioned, on closer examination will prove to be evolutional forms of one another, but it will undoubtedly be correctest to show great caution before a final decision is made, as ecological conditions can also be decisive.

Before the setting up of the above-mentioned eight series it has played a decisive part that the species (and subspecies) follow each other in time in a continued series of clay. So far we should, to be on the safe side, only assume successions in the Danish part of the North Sea Basin.

In recent years it has become fashionable to adopt phylogenetic points of view without too strict demands on ecology and continuity in the sequences of strata. In the case of the Miocene molluscs reference may be made to ANDERSON (1959, 1960), HINSCH (1961), and KAUTSKY (1962). Some of these observations may be correct, but in many cases sufficient grounds are missing.

Remarks on the Relations of the Hodde and Gram Formations to the International Stages

In a previous paper (RASMUSSEN 1956, pp. 135–137) the relations of the Gram fauna to the molluscan faunas in the other European and in the African Neogene formations were mentioned. It was pointed out how difficult it was to find temporal equivalents outside the North Sea Basin, not least because the Miocene sea towards the end of the period in large parts of Europe (especially Eastern Europe) became more and more brackish and gradually practically fresh.

The most serious obstacle to a biostratigraphical comparison with other basins of deposition is the extreme conditions of facies reflected in the Hodde and Gram Clay. These conditions, as mentioned on pp. 290–300, are also a difficulty for the correlation with the formations in the western part of the North Sea Basin. Therefore, no attempt will be made here at a correlation with these formations, but only a reference will be made to the immediate view as expressed at the "Internationale Symposium zur Stratigraphie des Miocäns im Nordseebecken" at Kiel in 1961, and in the Report on the Symposium (1961, p. 187) in the following table:

International division		Stage	Type locality
Pliocene	Piacentien	Morsum-Stufe	Morsum/Sylt HINSCH 1958
Miocene	Messimien	Sylt-Stufe	Morsum/Sylt STAESCHE 1930
		Gram-Stufe	Gram Brickworks HINSCH 1952
	Tortonien	Langenfelde-Stufe	Hamburg (STAESCHE 1930) HINSCH 1952
	Helvetien	Reinbek-Stufe	Reinbek GRIPP 1919
	Burdigalien	Hemmoor-Stufe	Boring Hamburg-Grasbrook GRIPP 1919
	Aquitanien	Vierland-Stufe	Boring Vierlande GRIPP 1919
Upper Oligocene	Chattien	Chatt Stufe	Kassel.

These correlations must be considered provisional and are weakly founded. An accurate synchronization between the formations of the North Sea Basin and the other Neogene formations in Europe is not possible at present.

SUMMARY AND CONCLUSIONS

The Younger Miocene series of clay in Denmark, also termed the *Måde series* (RASMUSSEN 1961), comprises Hodde Clay, Glauconite Clay, and Gram Clay.

The *Hodde Clay* consists of black Mica Clay, dark brown on fresh fractured surfaces. After washing by means of a screen with a width of meshes of 0.1 mm., there will as a rule be only a residue of 1–2 per cent. of the original sample.

This residue mainly consists of scoriaceous, cavernous bits of pyrite, sometimes with an admixture of grains of glauconite or quartz. The contents of fossils are comparatively small.

The *Glauconite Clay* is dark and more or less greenish. After washing with the screen mentioned above, a residue is obtained which comprises 20–33 per cent. of the original sample and almost only consists of grains of glauconite.

The *Gram Clay* consists of dark grey, sometimes slightly brownish clay. In the lower beds we often find one or two concretion beds of clay ironstone. After washing with the usual screen as a rule 2–6 per cent. are left behind as a residue, which mainly consists of micro-ellipsoids (perhaps mainly coprolites) and pyrite, mostly in the shape of needles or stems. The upper beds often contain numerous mica flakes, and at the top there are beds of silt alternating with clay, which finally gives way to beds of pure sand (Sæd). The contents of fossils in the Gram Clay are comparatively high.

The series of clay can be demonstrated within the whole of the area of distribution of the Gram Clay in Denmark (fig. 8). Its various strata have in the majority of the localities been dislocated as a consequence of glacial tectonics.

The localities in Regions II and III (see fig. 8) are gathered in areas with a northwest-southeast strike, which either suggests the presence of two original oblong basins (or bays) or two areas in which the series of clay for other reasons has been situated more deeply than the surroundings and therefore has avoided glacial erosion in the Quaternary Period. Both explanations presuppose tectonic movements, which in the two strikes have either resulted in a subsidence of the strata which are older than the series of clay (i.e. in Pre-Hodde periods) or in a subsidence of the early strata including the series of clay (i.e. in Post-Gram periods). As no deposits in shallow water of a corresponding age as the clay beds have been recorded, the latter view is the most probable.

The levels of the present top of the Gram Clay is mainly determined either by the height of the glacial upthrust or by the level reached by the Quaternary erosion.

A survey of the levels, however, shows that the Gram Clay in Central Jutland (the Bording region; see p. 54) nearly reaches the level + 60 m., while the same beds in West Jutland and northern North Slesvig at most reach the level + 30 — + 40 m. In south-western North Slesvig the present top of the beds is below Level 0. Thus it can be stated with certainty that the central parts of Jutland have risen more than 60 m. after the Upper Miocene Period.

The thicknesses of the strata vary somewhat as a consequence of the glacial deformations, but in the only locality in which they seem to be almost undisturbed by the Quaternary glaciation, viz. at Gram in North Slesvig, the thickness of the Gram Clay is 20 m., of the Glauconite Clay 2.5 m., and of the Hodde Clay 12 m. These figures seem to correspond to the order of magnitude around which the thicknesses of the various strata seem to be grouped in Denmark. In south-western North Slesvig, at Sæd and perhaps north of Tønder as well, there may be a greater thickness of the Gram Clay, as this has been situated deeper than has been recorded from any other places. The youngest, more sandy deposits of the Gram Formation therefore have been preserved here and there in this region.

The series of clay everywhere is based on Middle Miocene sand or clay alternatively. In a few places the sand is limnic and contains beds of lignite (Odderup). These beds are referred to the Odderup Formation. In other places (Hoddemark, Enderupskov, Alkærsig, etc.) the sand is marine and contains whole beds of mollusc shells. These shell beds either (Hoddemark, Leding, etc.) belong to the earlier part of the Hodde Formation or (Alkærsig, Enderupskov, etc.) to the Arnum Formation.

The youngest of the biozones recorded by SORGENFREI (1958) from the Arnum Formation, the *Nassa cimbrica* Zone (with a *Varicorbula gibba-Nassa cimbrica* assemblage), occurs at Hoddemark (as Shell Bed III (+ IV)) in the deepest part of the Miocene series of strata. Higher in this series is another shell bed (II), which is referred to a *Nassa pölsense* Zone, which has also been recorded from Enderupskov i North Slesvig. Direct below the Hodde Clay at Hoddemark there is one more shell bed (I) with an assemblage which again is dominated by *Nassa cimbrica*, but in a form slightly different from the specimens in the early *Nassa cimbrica* Zone. Furthermore, the fauna includes a number of other species than those which occur in the strata described by SORGENFREI, among them *Streptochetus abruptus* and *Aquilofusus festivus*, which are considered as guide fossils for the Reinbek Stufe in North Germany. This zone is termed the *Nassa cimbrica-Aquilofusus festivus* Zone.

The succession in the nearest strata under the Hodde Clay thus, from below upwards, seems to be: the *Varicorbula gibba-Nassa cimbrica* Zone, the *Nassa pölsense* Zone, and the *Nassa cimbrica-Aquilofusus festivus* Zone. Of these the two first-mentioned zones belong to the Arnum Formation, while the last-mentioned zone lithologically (Hodde Clay with beds of sand) forms a transition to the Hodde Clay and is included in the Hodde Formation. It should be emphasized that the fauna assemblages in question need not always be of different ages, but that the possibility should also be taken into consideration that they are ecologically conditioned and can appear simultaneously.

The Hodde Clay, which constitutes the basal part of the Younger Miocene series of clay (the Måde Series), contains a molluscan fauna rather poor in species. So far 74 species have been recorded, of which, however, it has not been possible to determine 10 more definitely. The material is so small that it is not possible to make a division into biozones, but the Hodde Clay as a whole is referred to a *Nassa fuchsi-Limopsis lamellata* Zone, it thus being pointed out what species are commonest in the clay. Other important species are *Strepto-*

chetus abruptus and *Aquilofusus festivus*, which, as mentioned above, are guide fossils for the Reinbek Stufe in North Germany. The Hodde Formation therefore is probably in part equivalent to this stage.

The Glauconite Clay contains very few fossils, and they are not sufficient for the setting up of a special biozone. The clay seems to be equivalent to the earliest strata of Upper Miocene Mica Clay in North Germany, mainly the "Lüneburg Stufe" (sensu GRIPP 1964), but perhaps also comprises the lowermost part of the overlying "Langenfelde Stufe" (sensu GRIPP). In places the Glauconite Clay perhaps even reaches into the upper strata of the *Astarte vetula* Zone (Hauge). This zone corresponds to parts of the "Langenfelde Stufe", and its sediments are at Gram, Måde, and Hoddemark developed into a Gram Clay facies with a rich molluscan fauna.

In the Gram Clay as a whole 126 species of molluscs have been recorded so far, 10 of which it has not been possible to identify. Previously the molluscs have mainly been known through collections in outcrops, but now it has proved that fresh samples of clay of 3–4 kg. contain so large quantities of determinable shells (often 100–200 or more specimens) that it is possible to sort out a fairly complete fauna, which gives a clear picture of the composition, quantitatively as well as qualitatively. Large shells are rare in the samples, but by combining the analysis of a collected fauna and a sorted-out fauna an almost complete picture of the molluscan fauna can be provided.

Four assemblage zones have been demonstrated in the Gram Clay in Denmark, of which, however, the youngest has only been found at Sæd in North Slesvig. The four zones are: the *Astarte vetula* Zone, the *Astarte reimersi-Goodallia esbjergensis* Zone, the *Astarte reimersi-Nuculana pygmaea* Zone, and the *Nassa slieswicia* Zone.

At Gram the *Astarte vetula* Zone is 6 m. thick. The thickness at Måde cannot be stated with accuracy, as the strata have been glacially deformed, but it can be estimated to be at most 10 m. The deposits of clay of this zone seem to be more pyritic than the strata of the younger zones in the Gram series of clay. At Måde the specimens of molluscs are clearly smaller than in the other zones. In certain places, thus at Gram and Drantum, the lower strata contain large quantities of brownish grains which presumably are transformed glauconite.

The Gram Clay above the *Astarte vetula* Zone is divided into two assemblage zones, in which *Astarte reimersi* is the characteristic species common to both zones. In the lower zone the fauna is dominated by *Goodallia esbjergensis* and in the upper zone by *Nuculana pygmaea*. Both zones have an abundance of fossils.

In the *Astarte reimersi-Nuculana pygmaea* Zone the deposits upwards become more silty and at Sæd there is above this zone an interval with a fauna assemblage which so far is unique. This interval is biostratigraphically referred to a *Nassa slieswicia* Zone. Above this the deposits become more and more sandy and finally pass into beds of pure sand without fossils. Findings of a few casts of molluscs to so high a degree remind of deposits in Morsum Kliff on the island of Sylt, which are assumed to be Pliocene, that these beds at Sæd must be supposed to be of a similar age.

The younger marine series of clay thus seems to represent an unbroken sedimentation of deposits of clay from the Middle Miocene Period to somewhere near the transition from the Upper Miocene to the Pliocene Period and to comprise the zones indicated in the following table:

Formations	Assemblage zones	Periods
The Gram Formation	The *Nassa slieswicia* Zone The *Astarte reimersi-Nuculana pygmaea* Zone The *Astarte reimersi-Goodallia esbjergensis* Zone The *Astarte vetula* Zone	Upper Miocene
The Hodde Formation	The *Nassa fuchsi-Limopsis lamellata* Zone The *Nassa cimbrica-Aquilofusus festivus* Zone	Middle Miocene
The Arnum Formation	The *Nassa pölsense* Zone The *Nassa cimbrica-Varicorbula gibba* Zone	Middle Miocene or Lower Miocene

Apart from the *Nassa slieswicia* Zone it seems that the assemblage zones can be demonstrated within the whole area of distribution of the Gram clay (fig. 9). In Regions I, II, III, and IV of Jutland the *Astarte reimersi-Nuculana pygmaea* Zone has mainly been found in spots, but this zone is the commonest in the outcrops in North Slesvig. Presumably the structural conditions as well as the Quaternary glacial erosion have influenced these facts.

DANSK SAMMENDRAG

De danske marine yngre miocæne formationers molluskfaunaer og biostratigrafi

I. Geologi og biostratigrafi

Indledning

Den foreliggende afhandling er en detaljeret undersøgelse over biostratigrafien i de yngste marine miocæne formationer i Danmark, foretaget på grundlag af deres indhold af mollusker.

De pågældende formationer er defineret tidligere. Der henvises angående disse definitioner og vedrørende en oversigt over det danske miocæn til et tidligere arbejde, skrevet på dansk: "De miocæne formationer i Danmark' (RASMUSSEN 1961 b).

I nærværende bog koncentreres opmærksomheden om den ler-serie, som i Danmark udgør de yngste miocæne aflejringer, og som omtales nærmere nedenfor.

Afhandlingen er delt i en geologisk del, hvor sedimenterne og hver lokalitet beskrives og en biostratigrafisk del, som indeholder faunaanalyser for hver lokalitet, samt den stratigrafiske diskussion.

Lokaliteterne

Lokaliteterne er grupperet i 5 regioner (betegnet ved I–V) og omtalen af de enkelte lokaliteter er inddelt i følgende rubrikker:

1) Beliggenhed (= Situation) med henvisning til beliggenhedskort,

2) Terrænkote (= Ground level),

3) Boreprofil (= Borehole log) eller, for daglokaliteternes vedkommende, beskrivelse af de geologiske forhold med omtale af lagfølgen (= Sequence of strata), lagstillingen (= Position of strata) o.s.v.,

4) Koten på miocænets overflade (= Level of the surface of the Miocene),

5) Foreliggende materiale af mollusker, med henvisning til tabellerne (1–67), hvori de fuldstændige faunaanalyser med angivelse af samtlige arter og antal eksemplarer er anført for hver lokalitet (se iøvrigt "Index of Danish localities" sidst i bogen) og

6) Beskrivelse af de fossilførende prøver (= Description of the fossiliferous samples), ofte med angivelse af prøvernes vægt før og efter slæmningen.

Sedimenterne

Den yngre miocæne lerserie i Danmark, også kaldet *Måde serien* (Rasmussen 1961), omfatter Hodde ler, glaukonitler og Gram ler.

Hodde leret består af sort, på friske brudflader mørkebrunt, glimmerholdigt ler. Efter slæmning på sigte med 0.1 mm maskevidde bliver der som regel kun en rest på 1–2% af den oprindelige prøve tilbage. Denne rest består overvejende af slaggeagtige, kavernøse pyritstumper, undertiden iblandet flere eller færre glaukonitkorn eller kvartskorn. Fossilindholdet er relativt ringe.

Glaukonitleret er mørkt og mere eller mindre grønligt. Efter slæmning på sigte med 0.1 mm maskevidde fås en rest, der omfatter 20–33% af den oprindelige prøve og næsten kun består af glaukonitkorn.

Gram leret består af mørkegråt, undertiden svagt brunligt ler. I de nedre lag træffes ofte et eller to konkretionslag af lerjernsten. Efter slæmning på sigte med 0,1 mm maskevidde bliver som regel 2–6% tilbage som en rest der fortrinsvis består af mikroellipsoider (muligvis overvejende "koprolitter") og pyrit, oftest i form af nåle eller stængler. De øvre lag indeholder ofte talrige glimmerblade, og øverst forekommer lag af finsand vekslende med ler, der tilsidst giver plads for rene sandlag (Sæd). Fossilindholdet i Gram leret er relativ stort.

Udbredelse og mægtigheder

Lerserien kan påvises inden for hele Gram lerets udbredelsesområde i Danmark (Fig. 9). Dens enkelte lag er på den overvejende del af lokaliteterne dislocerede som følge af glacial tektonik.

Lokaliteterne i region II og III (se fig. 8) er samlede i områder, der har en nordvest–sydøstlig strygning, hvilket enten tyder på tilstedeværelsen af to oprindelige, langstrakte bassiner (eller bugter) eller på to områder, hvor lerserien af andre grunde har ligget dybere end omgivelserne og derfor er undgået glacial borterodering i kvartærtiden. Begge forklaringer forudsætter tektoniske bevægelser, der i de to strøg enten kun har resulteret i en nedsænkning af de lag, som er ældre end lerserien (d.v.s. i præ-Hodde tid) eller i en sænkning af de ældre lag inclusive lerserien (d.v.s. i post-Gram tid). Da der ikke er påvist lavtvandsaflejringer af tilsvarende alder som lerlagene er det sidste foreløbig mest sandsynligt.

Koterne på den nuværende overkant af Gram leret er fortrinsvis bestemt af enten højden af den glaciale oppresning eller af det niveau, hvortil den kvartære erosion er nået.

Et samlet overblik over koterne viser imidlertid, at Gram leret i det centrale Jylland (Bording området, se p. 54) når op omkring kote + 60 m, medens de samme lag i Vestjylland og det nordlige Sønderjylland højst når op omkring kote + 30 – + 40 m. I det sydvestlige Sønderjylland ligger lagenes nuværende overkant under kote 0. Det kan således med sikkerhed siges, at Jyllands centrale dele har hævet sig mere end 60 m siden øvre miocæn tid.

Lagenes mægtigheder veksler en del som følge af glaciale deformationer, men på den eneste lokalitet, hvor de synes at være næsten uforstyrrede af den kvartære nedisning, nemlig ved Gram i Sønderjylland, er Gram leret 20 m, glaukonitleret $2\frac{1}{2}$ m og Hodde leret 12 m mægtigt. Disse tal synes at svare til den størrelsesorden, som de enkelte lags mægtigheder grupperer sig om i Danmark. I det sydvestlige Sønderjylland, ved Sæd og muligvis også N for Tønder, kan der være tale om en større mægtighed af Gram leret, idet dette her ligger noget dybere end påvist andre steder. De yngste, mere sandede, aflejringer af Gram formationen er derfor bevaret stedvis i dette område.

Lerseriens underlag

Lerserien hviler overalt på mellemmiocænt sand eller ler og sand i veksellejring. Enkelte steder er sandet limnisk og indeholder lag af brunkul (Odderup). Disse lag henføres til Odderup formationen. Andre steder (Hoddemark, Enderupskov, Alkærsig etc.) er sandet marint og indeholder hele lag af molluskskaller (Skallag (= Shell Beds) I–IV). Disse skallag tilhører enten (Hoddemark, Leding etc.) Hodde formationens ældste led eller (Alkærsig, Enderupskov etc.) Arnum formationen.

Biostratigrafi

Lagene under Hodde leret

Den yngste af de biozoner, som SORGENFREI (1958) påviste i Arnum formationen, *Nassa cimbrica* zonen (med et *Varicorbula gibba-Nassa cimbrica* selskab), forekommer ved Hoddemark (som skallag III (+ IV)) i den dybeste del af den miocæne lagserie. Højere i denne serie findes et nyt skallag (II), som henføres til en *Nassa pölsense* zone, der også er påvist ved Enderupskov i Sønderjylland. Direkte under Hodde leret ved Hoddemark forekommer endnu et skallag (I) med et selskab, som igen domineres af *Nassa cimbrica*, men i en lidt afvigende form end i den ældre *Nassa cimbrica* zone. Desuden omfatter faunaen en række andre arter end de, som forekommer i de af SORGENFREI beskrevne lag, deriblandt *Streptochetus abruptus* og *Aquilofusus festivus*, som anses for ledefossiler for Reinbek Stufe i Nordtyskland. Denne zone benævnes *Nassa cimbrica-Aquilofusus festivus* zonen.

Successionen i de nærmeste lag under Hodde leret synes således at være nedefra opefter: *Varicorbula gibba-Nassa cimbrica* zonen, *Nassa pölsense* zonen og *Nassa cimbrica-Aquilofusus festivus* zonen. Af disse tilhører de to første Arnum formationen, medens den sidste i lithologisk henseende (Hodde ler med sandlag) danner overgangen til Hodde leret og medregnes til Hodde formationen. Det må understreges, at de pågældende faunaselskaber ikke altid behøver at være af forskellig alder; men at der også må regnes med den mulighed, at de er økologisk betingede og kan optræde på samme tid.

Hodde leret

Hodde leret, som udgør den basale del af den yngre miocæne lerserie (Måde serien), indeholder en ret artsfattig molluskfauna. Der er hidtil påvist 74 arter, hvoraf dog 10 ikke har kunnet identificeres nærmere. Materialet er for lille til, at der kan foretages en opdeling i assemblage-zoner, men Hodde leret som helhed henføres til en *Nassa fuchsi-Limopsis lamellata* zone, hvorved det understreges, hvilke arter der findes hyppigst i leret. Andre vigtige arter er *Streptochetus abruptus* og *Aquilofusus festivus*, der regnes for ledefossiler for Reinbek Stufe i Nordtyskland. Hodde formationen er derfor sandsynligvis delvis ækvivalent med denne etage.

Glaukonitleret

Glaukonitleret indeholder kun meget få fossiler, og de er ikke tilstrækkelige til at oprette en særlig assemblage-zone. Leret synes at være ækvivalent med de ældste lag af øvremiocænt glimmerler i Nordtyskland, fortrinsvis "Lüneburg Stufe" (in sensu Gripp 1964), men omfatter muligvis også den nederste del af den overliggende "Langenfelde Stufe" (in sensu Gripp). Stedvis når glaukonitleret endda muligvis op i de øvre lag af *Astarte vetula* zonen (Hauge). Denne zone modsvarer dele af "Langenfelde Stufe", og dens sedimenter er ved Gram, Måde og Hoddemark udviklet i Gram ler facies med en rig molluskfauna.

Gram leret

I Gram leret som helhed er hidtil påvist 126 molluskarter, hvoraf 10 ikke har kunnet identificeres. Molluskerne har tidligere fortrinsvis været kendt gennem indsamlinger på daglokaliteter; men det har nu vist sig, at friske lerprøver på 3–4 kg indeholder så store mængder bestemmelige skaller (ofte 100–200 eller flere eksemplarer), at der kan frasorteres en ret fuldstændig fauna, der giver et klart billede af sammensætningen, såvel kvantitativt som kvalitativt. De store skaller er sjældne i prøverne, men ved at kombinere analyserne af en indsamlet fauna og en frasorteret fauna kan der skaffes et næsten fuldstændigt billede af molluskfaunaen.

Der er påvist 4 assemblage-zoner i Gram leret i Danmark, hvoraf dog den yngste kun er fundet ved Sæd i Sønderjylland. De 4 zoner er: *Astarte vetula*-zonen, *Astarte reimersi-Goodallia esbjergensis* zonen, *Astarte reimersi-Nuculana pygmaea* zonen og *Nassa slieswicia* zonen.

Astarte vetula-zonen er ved Gram 6 m mægtig. Mægtigheden ved Måde kan ikke opgives nøjagtigt, da lagene er glacialt deformerede; men den kan skønnes at være højst 10 m. Denne zones leraflejringer synes at være mere pyritholdige end de yngre zoners lag i Gram ler-serien. Molluskindividerne er ved Måde tydeligt mindre end i de øvre zoner. Visse steder, bl. a. ved Gram og Drantum, indeholder zonens nedre lag store mængder af brunlige korn, som formodentlig er omdannet glaukonit.

Gram leret over *Astarte vetula* zonen deles i to assemblage-zoner, hvor *Astarte reimersi* er den fælles, karakteristiske art. I den nederste domineres faunaen af *Goodallia esbjergensis* og i den øverste af *Nuculana pygmaea*. Begge zoner er rigeligt fossilførende.

I *Astarte reimersi-Nuculana pygmaea* zonen bliver aflejringerne opadtil mere siltholdige, og ved Sæd ligger der over denne zone et interval af Gram ler med et faunaselskab, som indtil nu er enestående. Dette interval henføres biostratigrafisk til en *Nassa slieswicia* zone. Over denne bliver aflejringerne mere og mere sandede og går tilsidst over i rene sandlag uden fossiler. Fund af enkelte kærner af mollusker erindrer i så høj grad om forekomster i Morsum Kliff på Sylt, som regnes for pliocæne, at man må formode en lignende alder af disse lag ved Sæd.

Oversigt over biostratigrafien

Den yngre marine lerserie synes således at repræsentere en uafbrudt sedimentation af leraflejringer fra mellemmiocæn tid til i nærheden af overgangen fra øvremiocæn til pliocæn tid og at omfatte de i det følgende skema anførte zoner:

Formationer	Assemblage-zoner	Tidsafsnit
Gram formationen	*Nassa slieswicia*-zonen *Astarte reimersi-Nuculana pygmaea*-zonen *Astarte reimersi-Goodallia esbjergensis*-zonen *Astarte vetula*-zonen	Øvre Miocæn
Hodde formationen	*Nassa fuchsi-Limopsis lamellata*-zonen *Nassa cimbrica-Aquilofusus festivus*-zonen	Mellem Miocæn
Arnum formationen	*Nassa pülsense*-zonen *Nassa cimbrica-Varicorbula gibba*-zonen	Mellem Miocæn eller Nedre Miocæn

Assemblage-zonernes udbredelse

Bortset fra *Nassa slieswicia*-zonen synes de øvrige assemblage-zoner at kunne påvises inden for hele Gram lerets udbredelsesområde (fig. 9). I Jyllands region I, II, III og IV er *Astarte reimersi-Nuculana pygmaea*-zonen dog kun fundet ret pletvis, medens denne zone er den almindeligste på daglokaliteterne i Sønderjylland. Formodentlig har både de strukturelle forhold og den kvartære glaciale erosion influeret på disse forhold.

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				Fig.	Page	Table	Page
Gram.	Clay pits		143	76	144		
–	Borehole	141.277	146	76	144	10	213
–	–	–				59	269
–	–	141.9 e	151	76	144		
–	–	141.27 a	152				
–	–	141.236	152	76	144		
Grøde	Canal section		97	46	96	7	210
–	–					46	255
Grønbjerg.	Clay pits		32	13	31	18	230
Grønnebæk.	Borehole	141.205	140	72	140	9	212
Gørding	Fossils only		122			51	261
Gørding, see Klostergården							
Hajstrup	Borehole	167.235	171	93	172	12	215
Harkes.	Clay pit		87	42	88	41	250
Hauge	–		92	43	91	44	252
Heds	Borehole	167.234 b	170	92	171	51	261
Hesselho	Clay pit		90	43	91		
–	Borehole	113.121	91	43	91	43	251
Hjerting.	–	141.238	129	68	130	51	261
Hjortsballe	–	105.320	70	29	70	34	245
Hjortvad	–	141.178	126	66	126	54	264
Hodde.	Canal sections		95	46	96		
Hodde, see Grøde							
Hodde, see Hoddemark							
Hoddemark	Canal section		98	46	96	1	197
–	–					2	200
–	–					3	204
–	–					46	255
–	Borehole	113.33 a	101	46	96	7	210
–	–	–				46	255
Holleskov	–	132.46 b	125	64	124	52	262
Hygum, see Sønder Hygum							
Høgild.	–	95.1510 b	57	24	57	30	241
–	–	85.274	58				
–	–	85.275	58				
–	–	85.276	58				
–	–	85.288	58				
–	–	85.298	59				
–	–	85.299	59				
–	–	95.1519	59	24	57		
–	–	95.1520	59	24	57		
–	–	95.1521	59	24	57		
–	–	95.1527	59	24	57		
–	–	95.1528	59	24	57		
–	–	95.1533	59	24	57		

Name of locality	Type of locality	D.G.U. File No.	Description or mention on page	Map of situation		Faunal analysis	
				Fig.	Page	Table	Page
Ravning	Clay pit		125	65	125	53	263
Rends	Borehole	167.236	178	95	178	66	285
Rødding	–	141.76	136	71	137	57	267
–	–	141.248	136	71	137		
–	–	141.247	137	71	137	57	267
–	–	141.241	137	71	137	9	212
–	–	–				57	267
–	–	141.242	137	71	137	9	212
–	–	–				57	267
–	–	141.243	137	71	137	9	212
–	–	–				57	267
–	–	141.75	139	71	137	57	267
Rojbøl	–	141.194	141	73	141	51	261
Sandfeldbjerg	Clay pits		61	26	64	30	241
Skjerris gårde	Borehole	104.1165	68	28	67	35	245
Skærum Mølle	Clay pit		25	10	26	15	228
Snejbjerg	Borehole	85.775	52	22	53	28	240
Spjald	–	83.104	38	16	39	19	230
–	–	83.127	38	16	39	19	230
Spandet	–	150.184	159	85	158	61	278
Spandetgård	Clay pits		157	85	158	60	277
Stenderup	Borehole	113.36	102	49	102	41	250
Store Langkjær	–	104.1158	69	28	67	4	208
–	–	–				34	245
Storlund	–	141.84	154	80	154		
Strandgård Brickworks	Clay pits		117	54	110	50	260
Sæd	Borehole	167.4a	173			64	281
–	–	167.445	173	94	174	65	282
Sønder Hygum	Borehole	141.215	130	69	131	11	214
–	–	141.260	132	69	131	56	265
–	–	141.261	132	69	131	56	265
–	–	141.273	132	69	131	56	265
–	–	141.170	133	69	131		
Sønderskovgård	–	132.34	123	63	123	51	261
Timring	Well-digging	84.22	46	18	45		
Tiset	Borehole	141.244	153	79	153	51	261
Tobøl	–	132.27	125	64	124	51	261
Tornskov	–	159.243	162				
Tværmose	–	85.381	47	20	48	26	237
Tønder	–	166.227	164	90	164	51	261
–	–	166.397	168	90	164		
–	–	166.398	165	90	164	11	214
–	–	166.398				62	279
Tønding	Clay pit		94	45	94	45	254

Name of locality	Type of locality	D.G.U. File No.	Description or mention on page	Map of situation		Faunal analysis	
				Fig.	Page	Table	Page
Vester Lindet	Borehole	141.246	142	74	142	58	268
Videbæk-Fjaldene	–	84.288	42	17	43	23	235
–	–	84.313	42	17	43	23	235
–	–	84.344	42	17	43	23	235
–	–	84.358	42	17	43	23	235
–	–	84.417	42	17	43	23	235
–	–	84.441	42	17	43		
–	.	84.456	42	17	43	23	235
–	–	84.473	42	17	43		
–	–	84.483	42	17	43	23	235
–	–	84.492	42	17	43	23	235
–	–	84.493	42	17	43	23	235
–	–	84.525	42	17	43	23	235
–	–	84.1727	42	17	43	24	235
–	–	84.1748	42	17	43	22	234
Vinding	–	74.329	28	11	28	17	229
Østbæk	–	103.152	89	42	88	4	208
–	–					41	250
Ålbæk Eng	–	102.59	86	41	87	42	250

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Correction

In the table p. 325, Zone I + II (*Astarte vetula* Zone), replace *Narona rothi* by *Narona lyrata*.