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Two Sediment Cores from the Norwegian Continental Shelf between Haltenbanken and Frøyabanken (64°06'N, 7°39'E)

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Two sediment cores, 1.5 and 4.5 m long, were obtained on the continental shelf west of the coast of Trøndelag, W. Norway, from a depression 320 m deep, and in an area with a very thin cover of Quaternary deposits. The upper part of the cores consists of stratified silt and clay with a mainly Post-glacial fossil assemblage, a grading with increased clay content downwards, and a clay mineral content of 10–20% kaolin, 50% illite, 0–10% chlorite and 10–20% mixed layer minerals of different kind. The lower part of the cores is different from the upper part in its more uniform grain size distribution, its content of poorly consolidated sedimentary rock-fragments in a finer matrix, and in a higher content of organic matter. The fossil assemblage of the rock-fragments, as well as of the matrix, indicates material of Jurassic, Cretaceous and Lower Tertiary age. Furthermore the clay mineral composition is different, with approximately 30–40% kaolin, 1–20% illite, 0–5% chlorite and 30–40% montmorillonite.

The lower part of the cores is believed to represent till, consisting mainly of short-transported rock debris from the underlying bedrocks.

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Introduction

Holtedahl (1955) concluded that glacial sediments covered the entire continental shelf and upper continental slope in an area west of Møre in western Norway. He also demonstrated that the glacial material had mainly two sources and two means of transport: 1) from the adjacent land brought out by glaciers, and 2) from the Oslo–Skagerrak area transported by floating icebergs.

Since 1968 sediment investigations have been carried out, mainly on the Møre–Trøndelag shelf between 62°N and 65°N. Seismic work has also been carried out in the same area, refraction work as well as seismic profiling. (Sellevoll et al. 1967, Eldholm, 1970, Nysæther 1970, Holtedahl & Sellevoll 1971). One of the results of the seismic investigations was the demonstration of the great variation in thickness of the Quaternary desposits, from almost nothing to more than 400 m (Eldholm & Nysæther, 1969, Holtedahl &

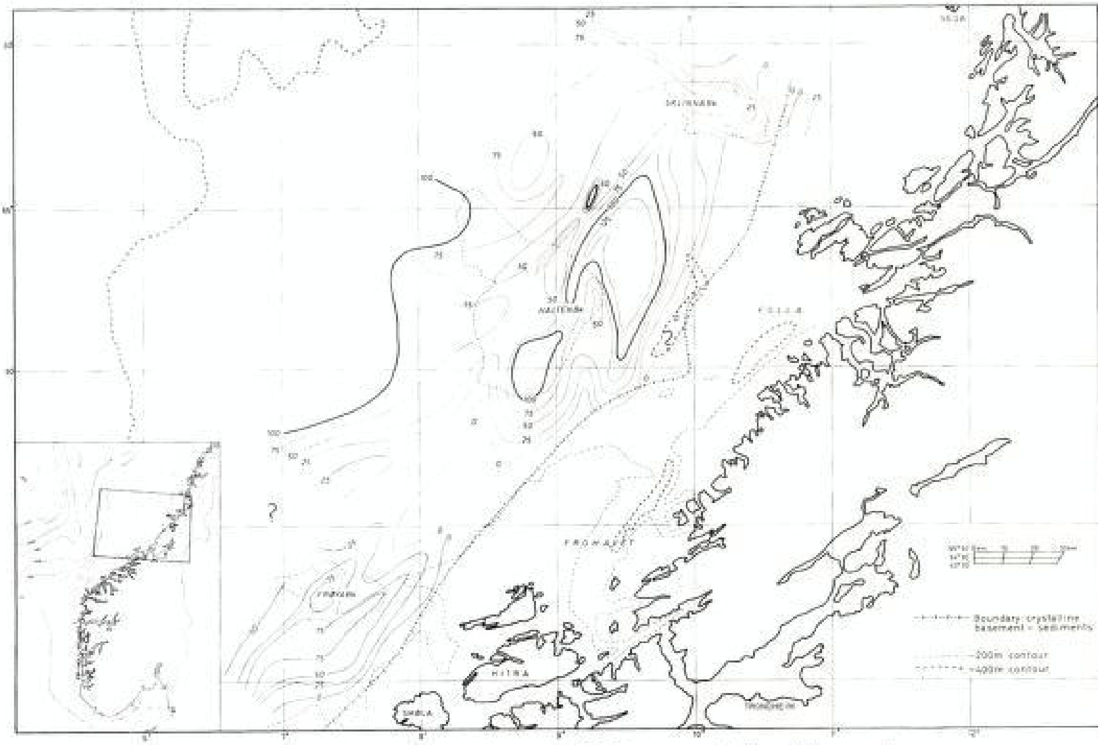


Fig. 1. Variation in thickness of Quaternary sediments off the coast of Trøndelag and Nordland. Contours in milliseconds. (Eldholm & Nysæther, 1969.)

Sellevoll 1972), as well as the rather irregular and uneven sub-Quaternary surface, supposed to have been formed to a great extent by selective glacial erosion. In Fig. 1 is shown the variation in thickness of Quaternary sediments on the continental shelf off the coast of Trøndelag and Nordland. As will be seen the greatest accummulations are found on the eastern flank of Haltenbanken, to a great extent filling in the submarine depression in that area. Further south another thick accumulation of Quaternary sediments is present in the Frøyabanken area, here with its maximum conciding more with the shallowest part of the bank.

The Quaternary deposits appear to be practically absent or very thin, in a zone which more or less coincides with the longitudinal channel between the banks and the 'skjærgårdsregion', and also in the wide and low depression which exists betwen the two bank areas.

Sediment samples, previously taken from shelf areas with thick Quaternary deposits, showed almost exclusively rock material from the adjacent mainland, with the exception of long-transported iceberg-drifted material. Rocks from the younger sedimentary formations on the shelf were not recovered. It was therefore of considerable interest to collect sediment samples in areas where the Quaternary cover, according to the seismic recordings, was thin and possibly absent. A remarkably high content of unmetamorphosed sedi-

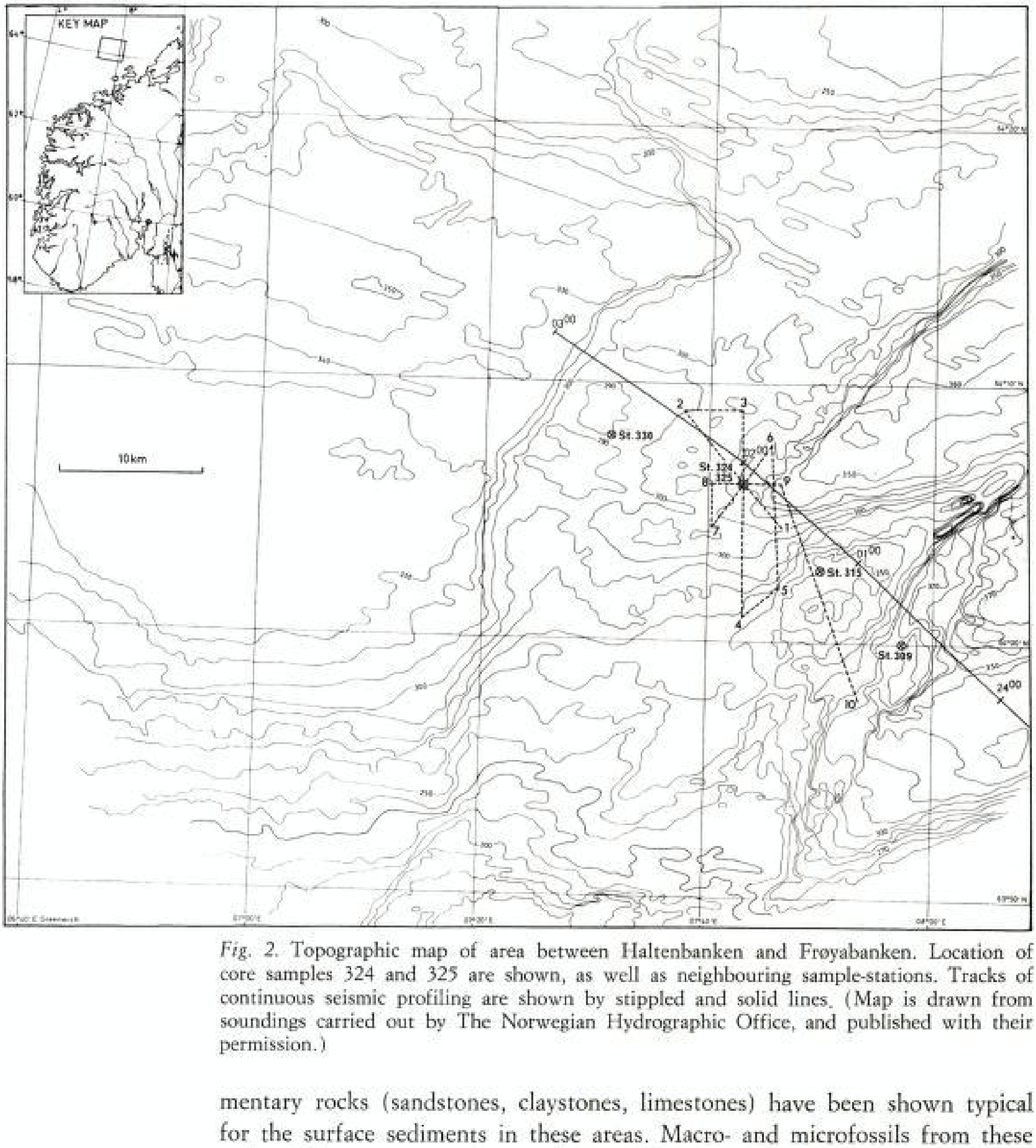


Fig. 2. Topographic map of area between Haltenbanken and Frøyabanken. Location of core samples 324 and 325 are shown, as well as neighbouring sample-stations. Tracks of continuous seismic profiling are shown by stippled and solid lines. (Map is drawn from soundings carried out by The Norwegian Hydrographic Office, and published with their permission.)

mentary rocks (sandstones, claystones, limestones) have been shown typical for the surface sediments in these areas. Macro- and microfossils from these rocks indicate an age corresponding to Upper Jurassic to Cretaceous (Holtedahl 1970).

During a cruise in 1969 on the research-vessel *Johan Hjort,* belonging to the Institute of Ocean Research, Directory of Fisheries, Bergen, a number of sediment samples: dredge- grab- and core-samples, were collected in the area between Frøyabanken and Haltenbanken. A number of the core-samples have been described by Haldorsen (1974). Core No. 324, collected in the depression at 64°06′N, 7°39′E, at a depth of 320 m, proved to be especially

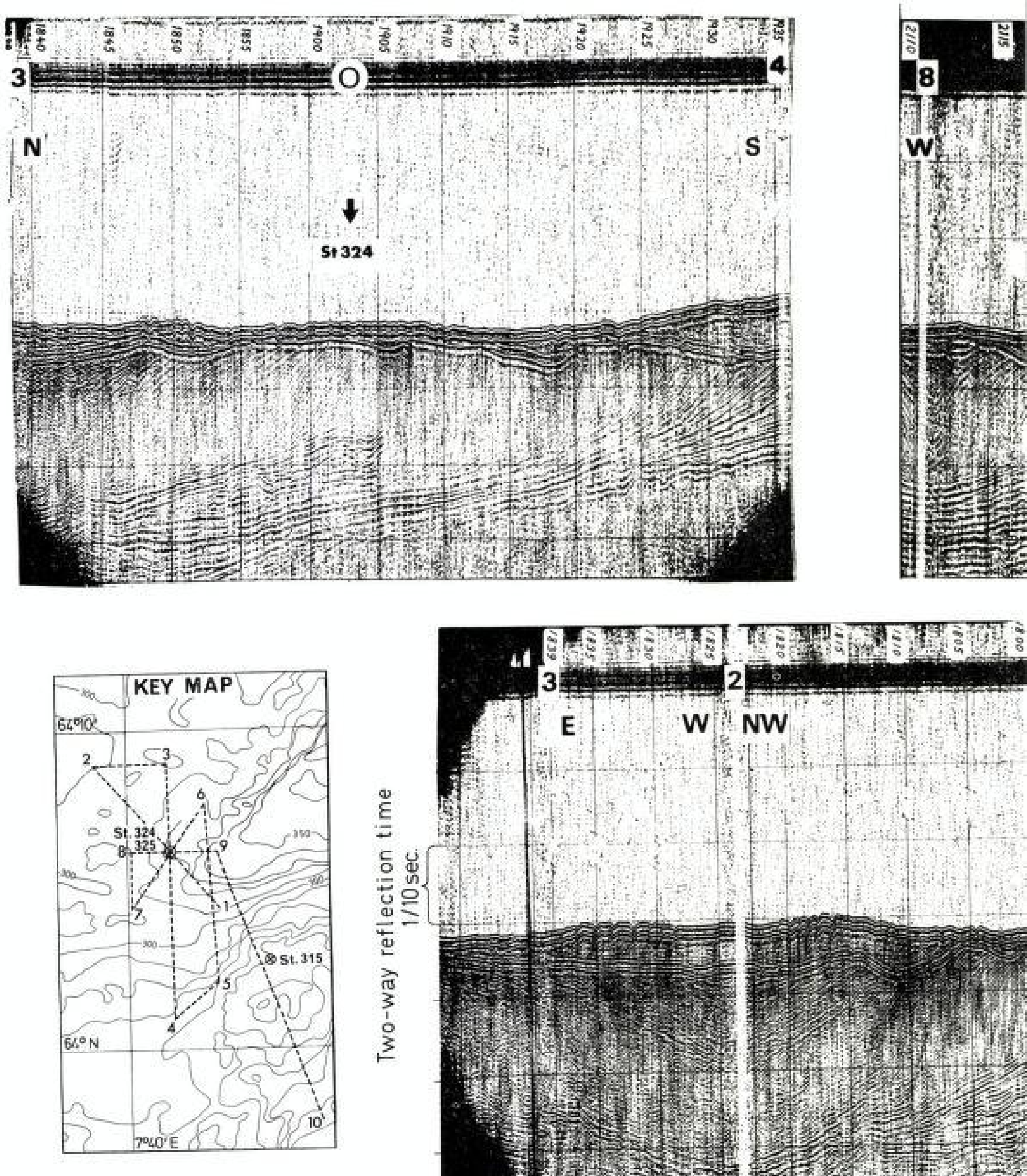
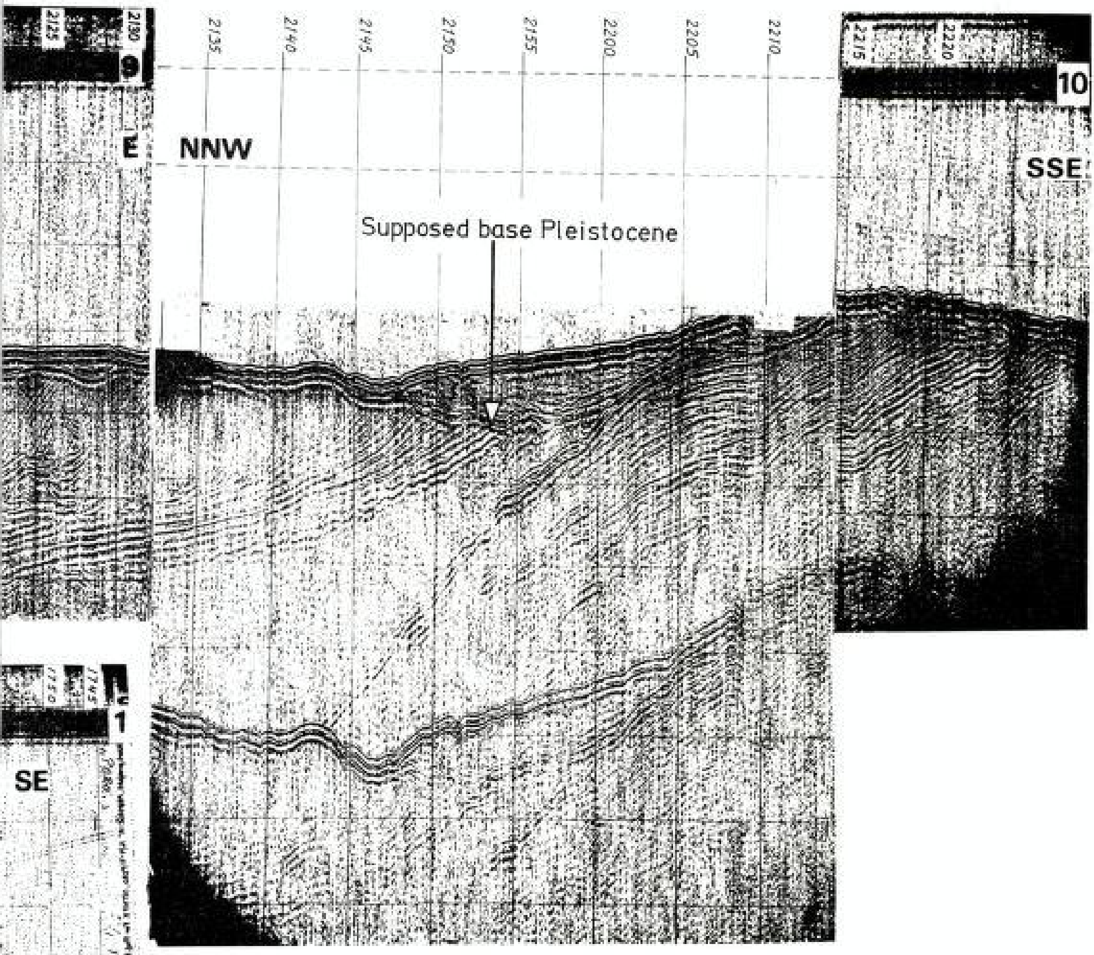


Fig. 3. Continuous seismic profiler records from area of samples 324 and 325. Distance between horizontal lines 1 millisecond. (NTNFK registration.)

interesting, both lithostratigraphically and biostratigraphically; another and longer core, No. 325, was obtained from about the same location in 1970, also from the vessel *Johan Hjort*. These two sediment cores will be described in the present paper.



Submarine topography

The area under consideration has recently been surveyed by the Norwegian Hydrographic Office, and data from these soundings have kindly been placed at the disposal of the authors.

The map, Fig. 2, has been drawn from the sounding data with a contour interval of ten metres, and the location of the core samples 324 and 325 and some neighbouring samples stations are shown.

The localities of the described core samples are in the northwestern part of a large depression with a roughly north-easterly direction. This depression, which increases in depth northeastwards to about 500 m, is bounded by the Haltenbanken bank-area in the north, and the Frøyabanken bank-area in the south. A smooth ridge of about 280–290 m separates the depression from another depression further west, which leads out to the edge of the shelf.

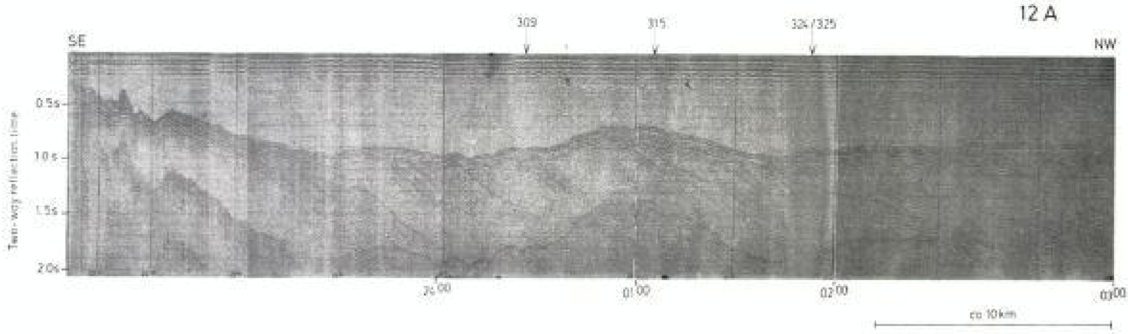


Fig. 4. Continuous seismic profiler record across the inner part of the continental shelf between Haltenbanken and Froyabanken. Distance between horizontal lines 1 millisecond. Location of samples 324 and 325 shown. (Seismological Observatory, Univ. Bergen registration.)

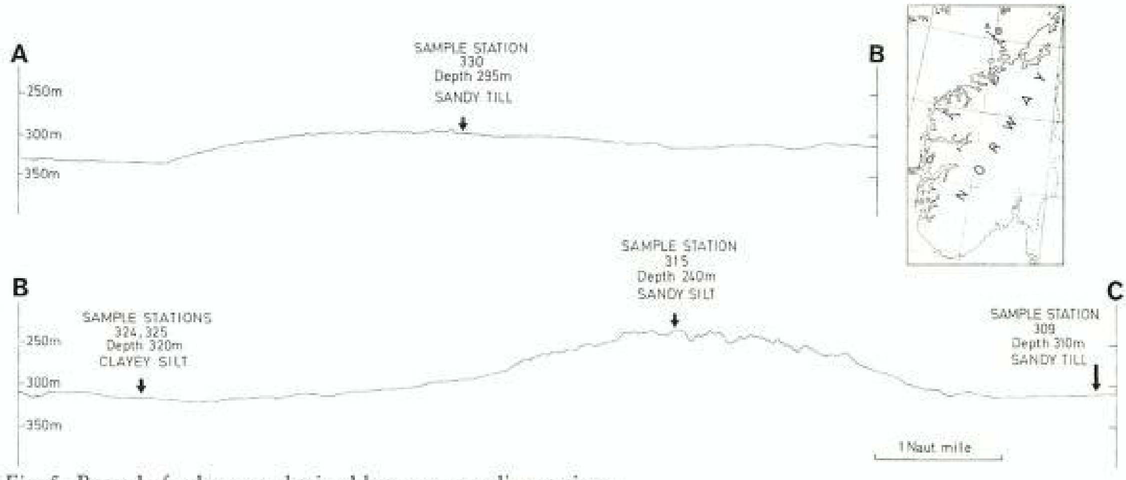


Fig. 5. Record of echogram obtained between sampling-stations.

The most conspicuous feature topographically is the ridge dividing the western part of the eastern depression in two. This ridge, which is especially noticeable NE of St. 315, is asymmetrical with a fairly steep southeast slope and a gentle slope to the northwest. The fairly steep southeast slope of the northern part of the depression, NE of St. 324 and 325, and the parallelism in direction between these steep slopes are also conspicuous. From a purely geomorphological point of view one would interpret this landscape as one which was to a large extent determined by bedrock with strata dipping slightly to the northwest and striking northeast. As will be seen from the seismic profiles taken in the area, Fig. 3 and Fig. 4, the landscape is determined by the pre-glacial sedimentary rock surface, as well as glacial and postglacial deposits. In Fig. 5 is shown a record of echograms taken between sample-stations.

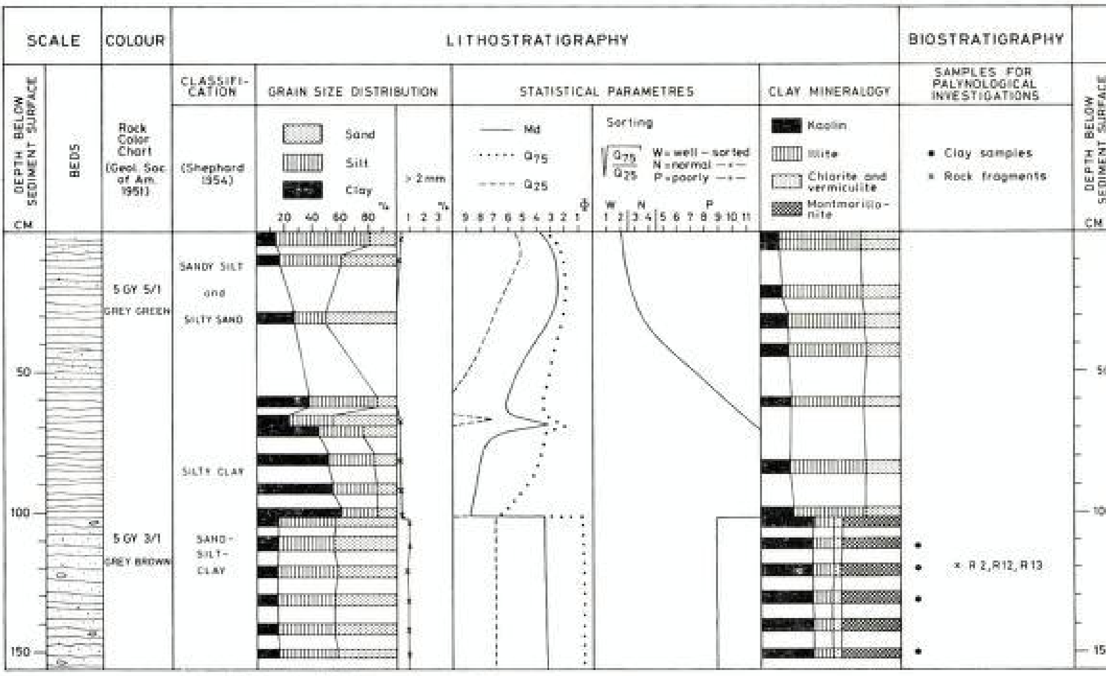


Fig. 6. Sedimentological data of core 324.

Description of the Cores

The two cores examined were collected in 1969 and 1970 with a gravity corer and piston corer respectively. The two cores, Nos. 324 and 325, were taken in approximately the same locality. The material was kept in airtight plastic tubes until the laboratory investigations were carried out.

The total length of core 324 is 1.5 m (Fig. 6). The upper 1.0 m consists of a stratified grey green clayey and sandy silt and silty clay. There is a distinct increase in the percentage of clay towards the bottom of this section. This part of the core contains marine fossils of Quaternary age. No systematic investigation was carried out on the Foraminifera in this core, but there was shown to be a definite change in the benthonic fauna from the top towards the bottom of the section. *Uvigerina peregrina* is the predominant species in the upper 60 cm of the core, with *Höglundina elegans, Hyalinea baltica, Nonion barleeanum, Cassidulina laevigata* and others as less commonly occurring forms. From 60 to 100 cm *Nonion labradoricum* and *Virgulina loeblichi* occur and increase in number, while *Uvigerina peregrina* disappears. *Elphidium incertum clavatum* is present in the lowest 10 cm of this section.

From these sedimentological and micropaleontological data, it seems reasonable that the deposition of the upper 100 cm of core No. 324 has taken place during the Holocene and possibly into the late parts of the Weichselian. This sediment type is described by Haldorsen (1974) and these investiga-

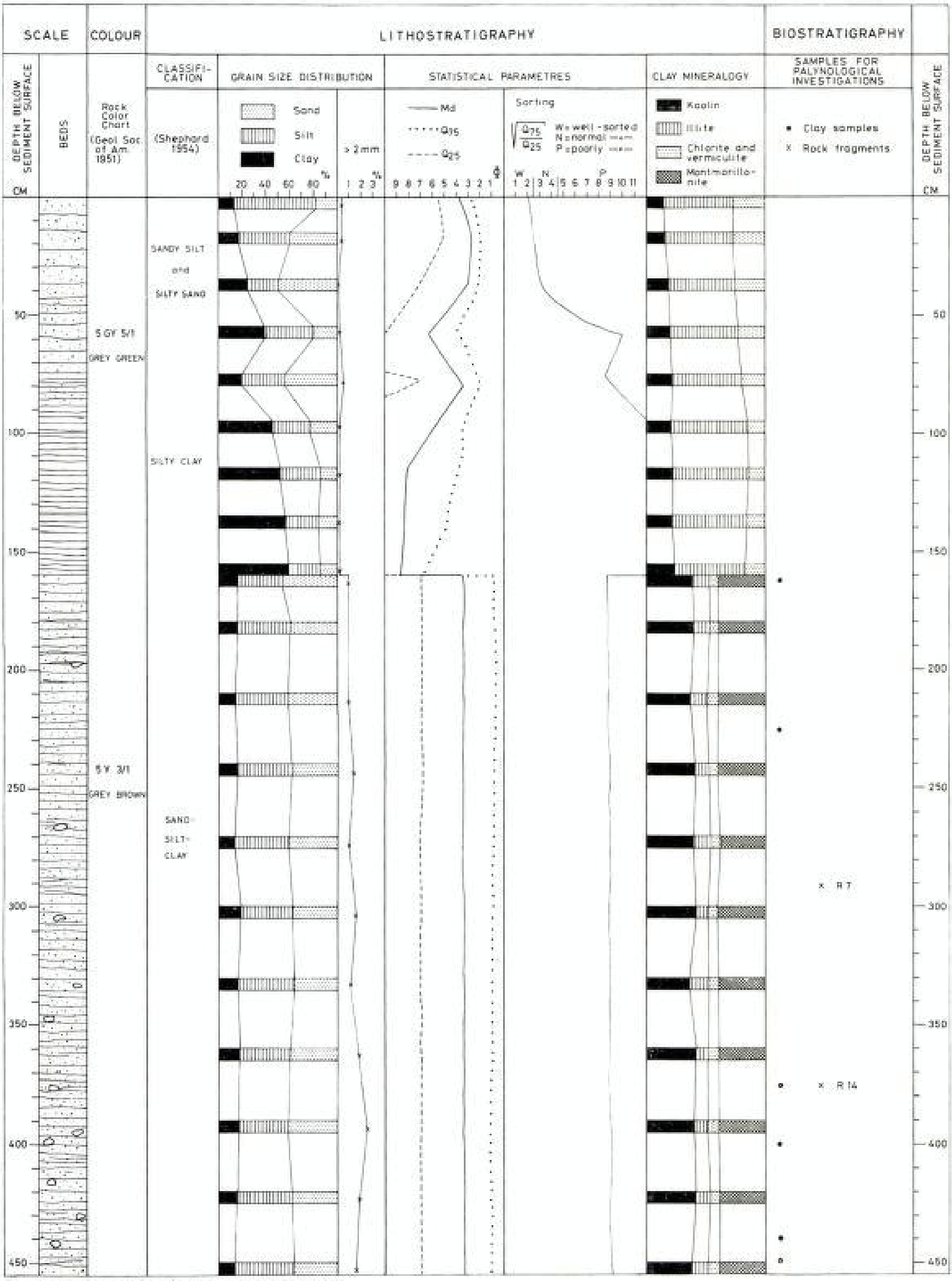


Fig. 7. Sedimentological data of core 325.

tions will not be further discussed in this paper. At 1.0 m below the sediment surface there is a very distinct boundary between the upper grey green material and a brownish sediment. This lower part of the core consists of material which is coarser and somewhat more homogeneous than the upper 100 cm. No fossils of Quaternary age have been found, though the sand fraction has been thoroughly examined and palynological investigations have been carried out.

The length of the other core, No. 325, is 4.5 m (Fig. 7). The upper 1.6 m of this core consists of the same type of material as the upper part of core 324. The lower part of core 325 below the level of 1.6 m contains a brownish sediment similar to the lower part of core 324. There is some material of gravel- and stone-size in the lower parts of the cores. By inspection this coarse material is shown to consist of more or less fragile rock fragments, with claystones and siltstones as common components.

The loss of ignition of the lower part was measured in relation to the dry weight of the samples and the content of organic matter was calculated to be about 3%.

The shear strength varied between 1.1 and 1.5 t per m^2 and the sensibility was about 1.0.

GRAIN SIZE DISTRIBUTION

Organic matter and salt pore-water were removed from the samples, and grain size analysis was carried out by the sieving and pipette methods. Samples were taken from each tenth to twentieth centimetre through the cores, and about 10 g material was used for the pipette analysis.

The grain size distribution for the two cores is shown in Fig. 6 and Fig. 7. While the upper parts of the cores show varying grain size distribution, with a distinct increase in clay content downwards, the material below the boundary has a more even distribution consisting of about 40% sand, 40 % silt and 20% clay. (The limits between the different size classes are shown on Fig. 6 and Fig. 7.) The median value of this lower part is 36 μ and the sediment is poorly sorted, according to Trask (1932). The content of material $>$ 2 mm varies between 1 and 3%, the greatest values found in the lowest part of core 325. The material $>$ 2 mm mainly consists of claystones, which are easily decomposed into clay. Though sieving was carefully carried out, decomposition of claystones undoubtedly has altered the grain size composition of the samples during the laboratory work, giving too high a clay content.

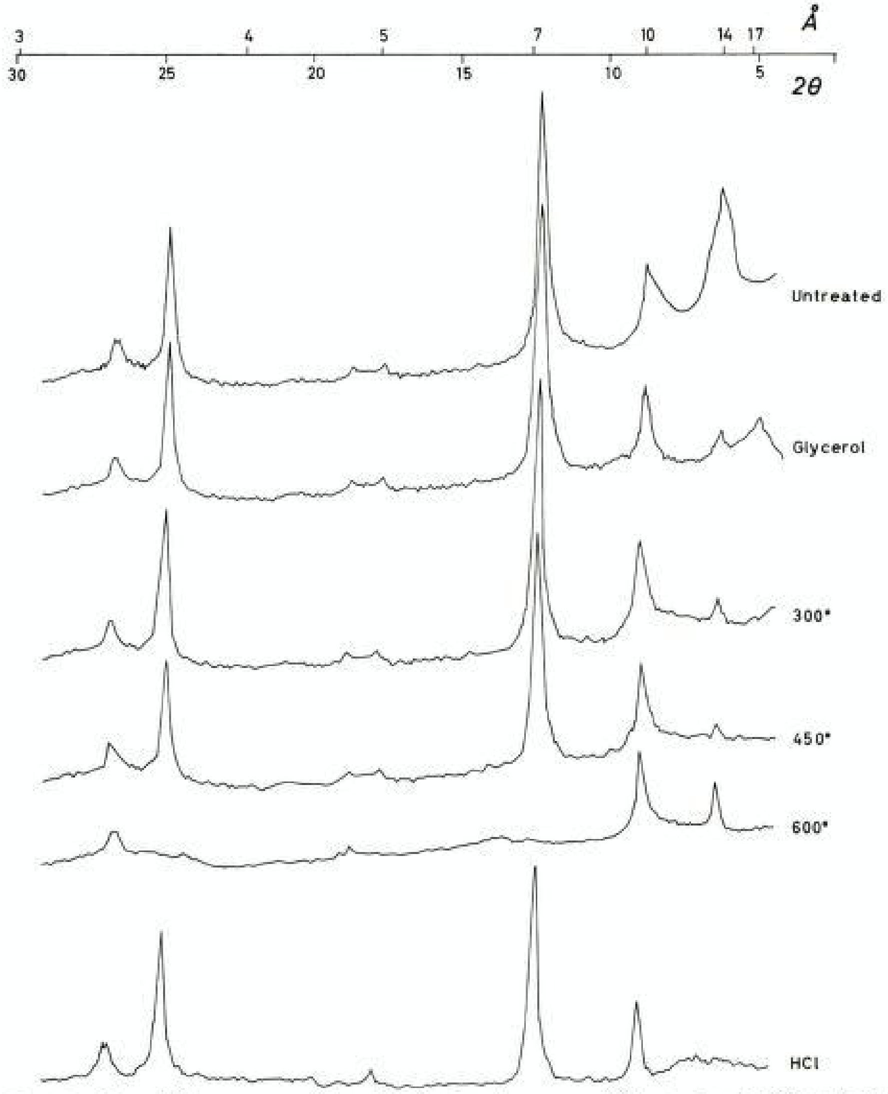


Fig. 8a. X-ray diffractogram of the clay fraction from core 324, at a level 130 cm below the surface. Oriented sample.

CLAY MINERALOGY

The clay fraction of several samples from the two cores has been subjected to X-ray diffraction analysis. A Philips diffractometer with a Ni-filtered CuKα radiation was used. The goniometer speed was ½°2Θ per minute.

Iron oxide was removed from the samples by using a buffered dithionite-citrate solution (Mehra & Jackson 1960).

The oriented samples were made by sedimenting an aqueous suspension of clay particles on a glass slide and drying in air at room temperature. In addition, one unoriented sample was made by using the technique of By-

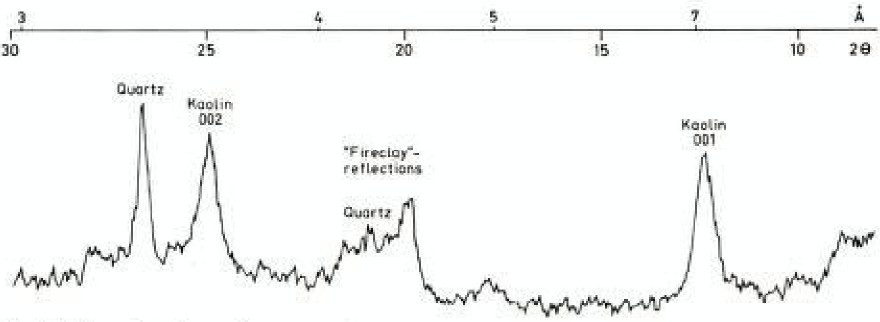


Fig. 8b. Unoriented sample.

ström–Asklund (1966). The mineral constituents were identified according to the criteria used by Brown (1961). DTA has been carried out on the clay fraction.

Fig. 8a shows the diffraction patterns for a sample from the lower part of core 324. The principal mineral constituents are kaolin, montmorillonite and illite, with smaller amounts of chlorite and quartz. Montmorillonite minerals are identified by the expansion of the 14 Å peak to 17–18 Å by a glycerol-treatment. The 10 Å mineral is mainly a dioctahedral illite. The 7 Å reflection is a combination of the (001) reflection of kaolin and the (002) reflection of chlorite. The presence of both these minerals is seen from the pattern of the 600°C heated specimen and the pattern of the specimen treated with 6 N HCl.

Fig 8b shows the diffraction pattern of an unoriented clay sample from the lower part of core 324. The reflection band at 20°2Θ is typical for a kaolin of the 'fireclay' type. (Graff-Petersen 1960, p. 26). A DTA-curve for the same size fraction showed that this mineral has no exothermal reaction at 900°C. According to Brindley et al. (1963) it is evident that b-axis disordered kaolinite ('fireclay' minerals) is the main kaolin mineral in this sediment.

The semiquantitative evaluations of the mineralogical composition have been done by using the methods of Gjems (1965) and Biscaye (1964). The estimations give the weighed intensity ratios of the different minerals. Fig. 6 and Fig. 7 show the composition of the bulk clay fraction given in the form of bars. The quantity of quartz in the samples has not been estimated.

The vertical variation in the clay mineral composition of the lower parts of cores 324 and 325 is small. The clay fraction consists of approximately 30–40% kaolin, 10–20% illite, 0–5% chlorite and 30–40% montmorillonite. In comparison the part above the boundary has a composition of 10–20% kaolin, 50% illite, 0–10% chlorite and 10–20% mixed layer minerals of different kinds.

An oriented sample was made from the colloid fraction by using a supercentrifuge and making a clay film on a glass slide from the material still in suspension. The X-ray diffraction pattern for untreated and glycerol-treated

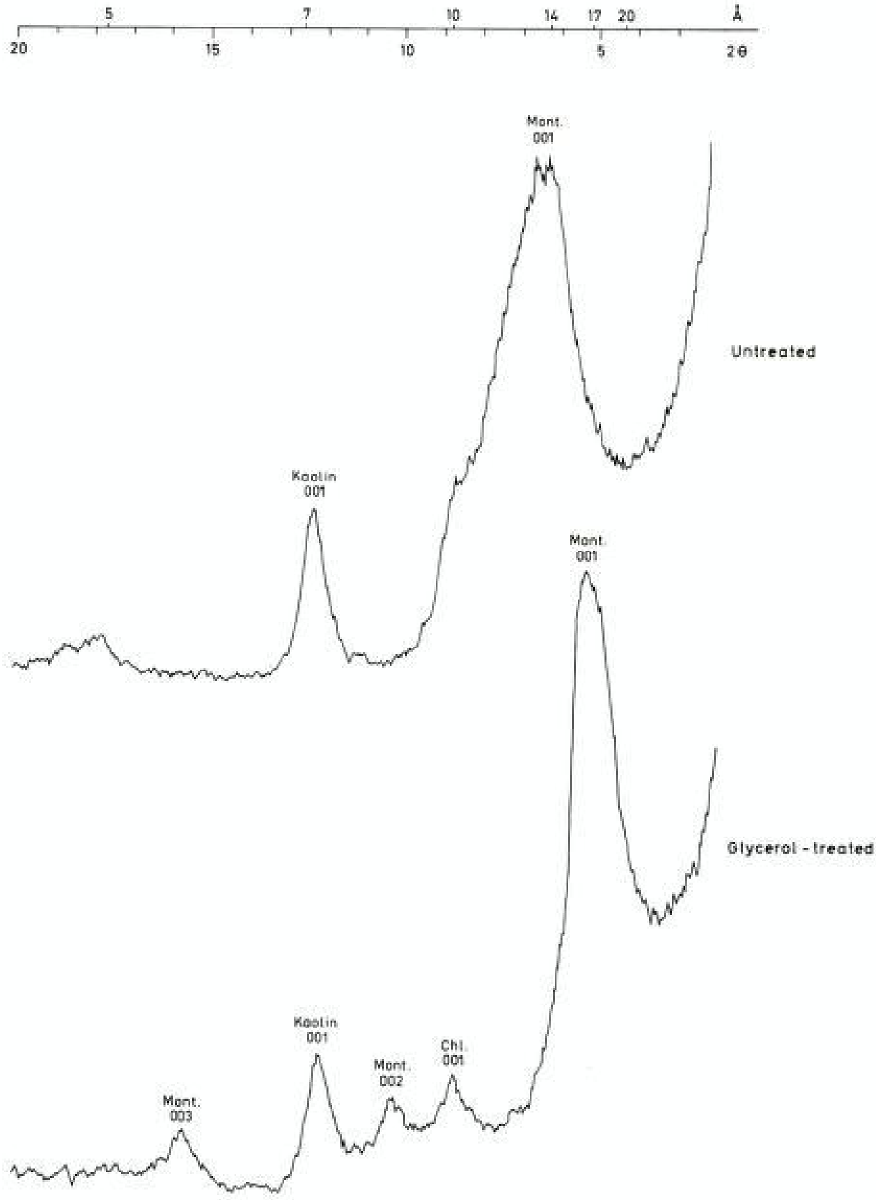


Fig. 8c. Oriented sample, colloid fraction.
Mont. = Montmorillonite, Chl. = chlorite.

specimens is shown in Fig. 8c. The sample consists of about 80% montmorillonite, and 20% kaolin with a small proportion of chlorite.

The claystone fragments in the sediment have not been systematically examined with respect to the clay mineralogy. For the fraction > 2 cm, however, some investigations have been carried out. First, the fragments were classified, and the following two main types were recognized: 1. A black, extremely fine-grained claystone, and 2. a grey, silty claystone. Of the bulk stone fraction 30% consists of type 1 and 60% of type 2. The black claystone has a clay mineral composition which is nearly identical to the colloid fraction of the sediment (Fig. 8c), while the grey claystone contains about 60% kaolin, 20% illite and smaller amounts of chlorite and quartz.

PALYNOLOGICAL INVESTIGATIONS

Samples of clay were taken first from core 324, later also from the longer core 325. The stratigraphic positions of the samples are shown in Fig. 6 and Fig. 7. Each sample, about 2 cm^3 of the deposit, was given a standard treatment, a maceration by chemicals, using hydrochloric acid, hydrofluoric acid, nitric acid, and ammonia. Judged from the gas evaporating when hydrochloric acid was added to the samples, carbonaceous material was present only in parts of the core. The time required for a sufficient oxidizing (by nitric acid) varied much, and it was supposed that the organic content was variably coalified. Further, remaining after the chemical treatment, were variable amounts of organic residues. These features are all in contrast to what would be expected from an evenly coloured deposit with no clear signs of a stratification.

The palynological assemblages extracted were rather variable, and it was suspected, at least in parts of the cores, that one was dealing with mixed assemblages of more than one geological age. However, no rebedded fossils could be traced from their state of preservation.

A repeated inspection of the still moist core material revealed small rock fragments of poorly consolidated claystones and sandstones. The rock fragments, being almost as soft as the embedding clay, had to be separated by hand, and their outermost layers were removed to prevent contamination from the adhering clay.

Such fragments could not be recovered when samples of the deposit were given a standard treatment. The claystones then got more or less crushed against the cloth used for separating larger rock fragments from the clay, and the sandstones, cemented by carbonates, were already disintegrated during the treatment by hydrochloric acid. Fossils from rocks of both lithologies therefore appeared in the mixed assemblage of the embedding deposit.

The palynological investigation had to be concentrated upon the assemblages of fossils enclosed in the various rock fragments. A group of 4 claystones and 2 sandstones were treated with the same chemicals as mentioned above. The stratigraphic positions of the analysed samples are shown in Fig. 6 and Fig. 7.

The claystones are the most frequent ones. Most of them are poor in carbonates, they are all of dark colour, and they are rich in organic residues. The organic residues are usually dominated either by finely disintegrated amorphous debris or by wood remains, or also by both. In addition are found pollen, spores, and supposed marine cysts. From the cyst assemblage it was concluded that the claystones were marine deposits formed during Middle and Upper Jurassic and Lower Cretaceous time. The oxidation of the material was needed more to remove unwanted organic debris sticking to the fossils, than to make the grains of lighter colour. Prolonged maceration tended to reduce the number of taxa present in the assemblages.

The sandstones, only two fragments, contained fossil assemblages of clearly different ages, and neither of them was dominated by disintegrated organic debris nor by wood remains. The older rock, a coarse sandstone with large grains of quartz, judged by the content of a few colporate grains (angiospermous affinity) was formed during the mid-Cretaceous or early Upper Cretaceous time. Such an age may also be supported by the cyst assemblage which indicates deposition in marine surroundings.

The younger of the sandstones, R 7, also represents the youngest of the rebedded rocks from the core material.

R 7 was a fragment the size of a small bean, embedded at about 120 cm below the upper Late- and Postglacial clay in core 325. It represents an extremely light-coloured deposit, an almost white sandstone, with only a few darker grains discernible. Half of this fragment was used for maceration. The rock disintegrated in hydrochloric acid within a very short time. Most of the minerals remaining, well-rounded grains of quartz and of variable sizes, were removed by passing the residue through a cloth with 200 μ meshes.

A sparse assemblage of fossils, only a couple of hundred grains, were left after the maceration, and the material was stained in order to detect, if possible, redeposited grains.

Explanation of Plate 1, Figures 1–16.

Photomicrographs were made using a Leitz Orthomat 698672 belonging to the Department of Botany, University of Trondheim.

Magnification: Figs. 1, 2, approximately $\times$ 700. Figs. 3–16, approximately $\times$ 1200.

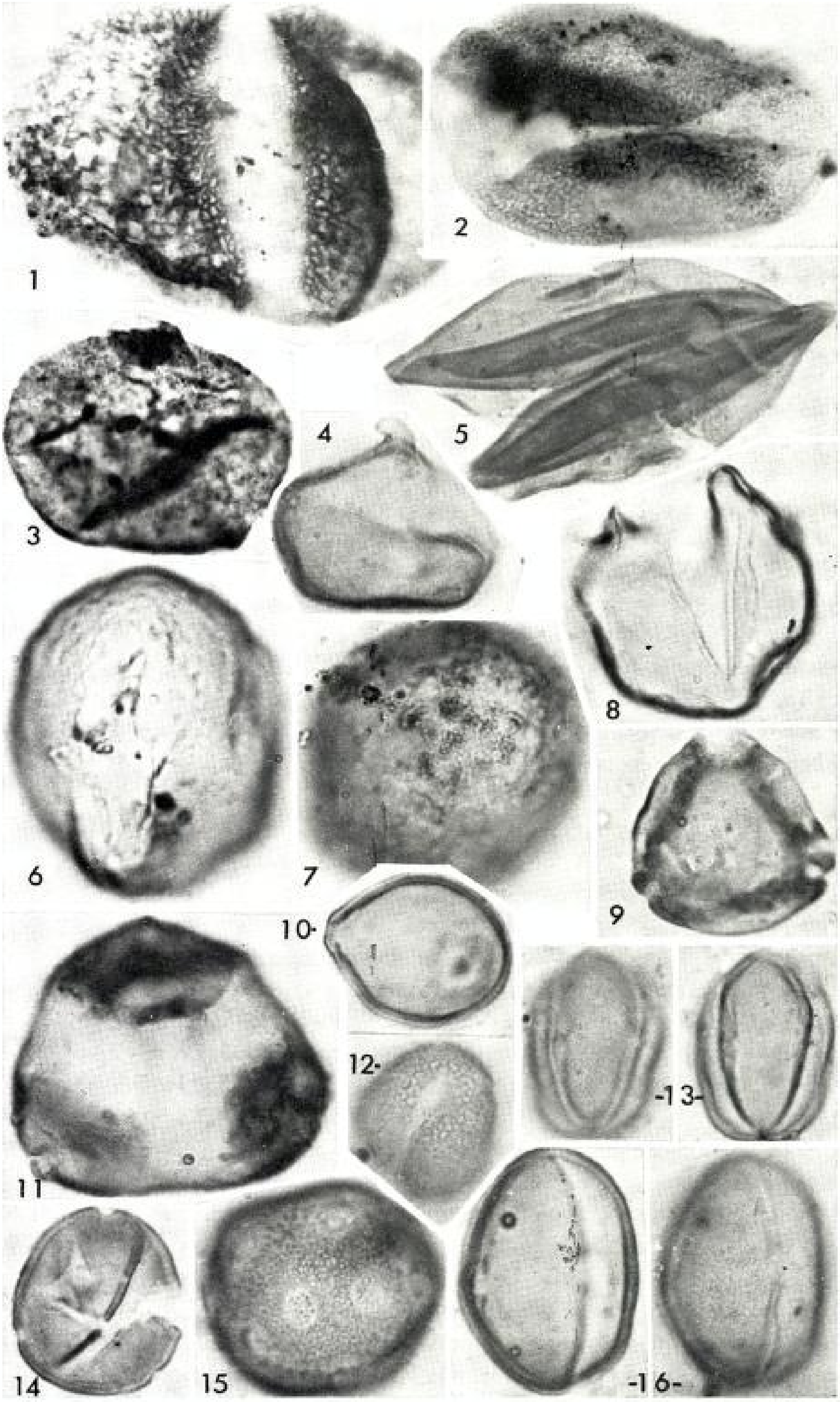
Coniferae (Figs. 1–8)

Pinaceae: Fig. 1, *Pinaceae* sp. A, Width of grain 95 μ. – Fig. 2, *Pinaceae* sp. B, height of corpus 80 μ.

Taxodiaceae: Fig. 3, *Metasequoia* (Fig. 35, Martin & Rouse, 1966) 34 μ – Fig. 4, *Sequoia* cf. *S. lapillipites* (Figs. 37, 38, Martin & Rouse 1966) 27 μ – Figs 5,? *Glyptostrobus* (Figs. 63, 64, Piel 1971) 53 μ – Fig. 6, *Sciadopitys* sp. 40 μ – Fig. 7, *Sciadopitys* cf. *S. serratus* (Pl. 11, Figs. 1–9, Manum, 1962, *Sciadopityspollenites serratus* and Fig. 33, Martin & Rouse, 1966) 35 μ – Fig. 8, *Taxodium* sp. (Fig. 36, Martin & Rouse, 1966) 30 μ.

Angiospermae (Figs. 9–16)

Fig. 9, *Betulaceae,* diameter of grain 22 μ – Fig. 10, *Betulaceae (Corylus*-type) 18 μ – Fig. 11, *Triatriopollenites* sp., 36 μ – Fig. 12, *Tricolpites* sp. Other flattened specimens are about 23 μ. The grains come very close to certain species of *Gunneraceae* – Fig. 13, Tricolporate pollen with faintly reticulate structure, 23 μ (cf. *Rhoipites* p. 268 in Srivastava, 1972) – Fig. 14, Triporate pollen, about 20 μ, cf. *Triporopollenites rugatus* (Pl. 1, Fig. F, Norton & Hall) – Fig. 15, *Liquidambarpollenites stigmosus (Periporopollenites stigmosus* Pl. 8, Figs. 1–8, Krutzsch, 1966) 28 μ – Fig. 16, Tricolporate grain, 28 μ. The faint striate pattern corresponds with that of *Tricolpopollenites striatus* (Pl. 20, Figs. 11, 12, Manum 1962).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An identification of the fossils further than to a generic level, was considered of little importance for our purpose, which was a dating of the embedding clayey deposit. The rock fragment came from a formation of sedimentary rocks yet unknown. No material for comparison is available from this area.

The flora as indicated by the fossils (selected grains are pictured in Plate 1) was one dominated by two groups of plants, the conifers and the angiosperms. Pteridophytic spores and older types of gymnosperm pollen are rare. However, it seems unjustifiable to judge from negative evidence in such a sparse assemblage.

Only a few works, mainly those of Groot & Groot (1962), Manum (1962), Martin & Rouse (1966), Norton & Hall (1967), Piel (1971) and Srivastava (1972) were consulted for comparisons.

Two-winged coniferous grains are sparse, three taxa belonging to the *Podocarpacea* and *Pinaceae* (Figs. 1 and 2). The most frequent pollen grains are of taxodiaceous affinities and might be assigned to the following taxa: *Glyptostrobus* (Fig. 5), *Metasequoia/Sequoia* (Figs. 3 and 4), *Sciadopitys* (Figs. 6 and 7), and *Taxodium* (Fig. 8).

The angiospermous pollen is such as may be assigned to the *Betulaceae* or *Myricaceae* (Figs. 9 and 10), to *Hamamelidaceae* (Fig. 15), and *Juglandaceae*. There is also some tricolporate pollen (Figs. 13 and 14).

The assemblage seems to be related to the Arctotertiary floras, and a Danian age is proposed for this rock, which also indicates the maximum age of the deposit where the rocks was embedded.

Remarks on the material

Certain dinoflagellate cysts characteristic of some clay samples could not be recovered in any of the rock fragments. To detect a possible source of such fossils, erratics from grab- and dredge-samples from other areas near Frøyabanken were searched for sedimentary rocks. A coarse micaceous sandstone yielded by maceration an assemblage which also included such cysts. It may therefore be supposed that the material from which the core deposit was formed, also included rocks which have not been discovered by this investigation.

The core deposit clearly demonstrates what has been found earlier by other workers (Owens 1972): that one has to work very carefully when handling material from an area where redeposition may have taken place. If the material of our core had been completely disintegrated during the formation of this deposit, we should have had no possibilities of estimating the age of the rebedded rock material, in relation to the last formed deposit. In that case the lower part of the cores 324 and 325 would have been taken as material of Lower Cretaceous age, as the younger rocks form the minor part of the rebedded material.

Discussion and conclusions

In Fig. 6 and Fig. 7 is shown an assembly of sedimentological data of cores 324 and 325. The upper and lower parts of the two cores differ with respect to the following factors:

1. The colour is visually different.
2. The content of organic matter is negligible in the upper part, and about 3% in the lower part.
3. The grain size distribution of the upper part shows grading from fine to coarse material upwards, while the lower part has a more homogeneous composition with little variance throughout the section.
4. Rock fragments of fragile, sedimentary rocks are usual in the lower part, while the content of such rock fragments is negligible in the upper.
5. The clay mineral composition changes abruptly while passing the boundary between the two parts of the cores.
6. Shells and foraminifera are present in the upper part of the core, but not in the lower.
7. Distinct assemblages of plant fossils, dating from Middle Jurassic to Early Tertiary, are found in the rock fragments as well as in the finer material in the lower part of the cores.

THE UPPER PART OF THE CORES

The upper part of the cores consists of material which seems to be a rather usual surface deposit formed after the retreat of the ice from the area. The material in the basal parts could be expected to have been derived partly from the meltwater suspension of the retreating ice. According to Haldorsen (1973), however, material from the melting shelf ice has no strong influence on the composition of the core sediments. The presence of surface till deposits in the area around the sample sites suggests a washing out of fine material by waves and currents. The coarsening of the deposit upwards towards the surface, which seems to be a general phenomenom of similar sediments over a wide area, is of interest here, and may indicate a gradual shoaling of the sea due to a glacial-isostatic rebound of the crust, which counteracts the eustatic influence. Further work is needed to solve these questions.

THE LOWER PART OF THE CORES

The lower part of the cores has a very different origin from that of the upper part. Grain size, as well as lithological studies, show the sediment to be a mixture of rock types of various kinds and a matrix consisting to a great extent of silt and clay. From studies of the clay mineral composition it is shown that the mineralogical assemblage of the matrix is very similar to that of the rock fragments. As mentioned, the colloid fraction of the sediment is nearly identical to the composition of the black, fine-grained claystones and is probably composed through a disintegration of this black rock. It is reasonable that the matrix of the core material is derived from those rock types which are now present in the sediment as gravels and stones.

The fossil assemblage of the matrix is composed of members of the fossil assemblages recovered from the rock fragments, and was undpubtedly derived from them. The polymorphy of the lithology is also shown up clearly in the age-variety of the fossils, ranging from Middle Jurassic to early Tertiary.

The mixture of different rock types without any stratigraphical order, and the palaeontological evidence, show the deposit to consist of rebedded material derived from various sources. The final deposition must be younger than the youngest fossils found, i.e. Lower Tertiary, and it must be older than the upper section of the core, which is presumably Late Weichsel.

A sediment of this type was scarcely formed during the Tertiary. It rather represents a glacial till deposited by the inland ice during a stage of the Pleistocene, probably the Weichsel. From the seismic data and geomorphological studies (Figs. 3 and 4) it was shown that the site of cores 324 and 325 coincides with an area of very thin Quaternary cover, and has a position in a depression to the northwest of a very marked ridge, also with a presumably thin till-cover. The only till cover of greater thickness is found on the northwestern slope of the ridge and in the area northwest of the sampling site. The depression is obviously a result of selective glacial erosion of comparatively weak rocks, while the ridge to the south presumably consists of more resistant rocks.

It is therefore reasonable to assume that the material of the lower parts of the cores studied consists of material derived from the bedrock surface near the sampling site in the area to the southeast. With a westerly to northwesterly movement of the ice, rocks of Middle Jurassic to Lower Tertiary age, which are supposed to outcrop in the area, were picked up and redeposited. Because of the very fragile nature of most of the rock fragments, the transport is thought to have been short.

During this transportt very little material with an origin from the mainland has been introduced in the sediment, and no fossils of Quaternary age have been found.

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