Triassic palynology and stratigraphy of some Danish North Sea boreholes

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Palynofloras ranging in age from Anisian to Rhaetian are described from the Danish North Sea sector. Anisian-Ladinian (Muschelkalk) assemblages were recovered from the basal part of the Dansk Nordsø A–2 borehole situated in the Central Graben. Rhaetian assemblages occur in the Dansk Nordsø F–1 and the Dansk Nordsø K–1 boreholes drilled in the northwestern part of the Danish Embayment. The Triassic red beds are generally non-palyniferous with rare poductive horizons.

Triassic palynological information from the North Sea offshore area has hitherto been limited to some profiles lying on an E–W directed line through the southern part of the North Sea Basin (Geiger & Hopping 1968). The present study intends to extend the published knowledge of the offshore Triassic deposits by giving the results of palynological investigations carried out within the Danish sector. Due to the rapidly developed palynological research on the British onshore Triassic (Warrington 1974) the stratigraphical "breakdown" of the offshore mainly non-marine deposits has to some degree been successful. However, the occurrence of vertically limited palyniferous sequences, which cause serious trouble in British onshore Triassic correlations seems to be repeated as a norm of the offshore area too.

The Danish offshore area comprises parts of four structurally determined deposition centre during the Triassic (Text-fig. 1): 1) To the north the northwesterly extension of the Danish Embayment, 2) to the west, part of the Central Graben, 3) to the south, a northern part of the North German Basin and 4) the Horn Graben connecting the Danish Embayment with the North German Basin (Childs & Reed 1975).

The Triassic deposits generally show a change from continental arenaceous red beds in the Early Triassic to a more pelitic red bed facies in the Middle-Late Triassic. During the Middle-Late Triassic, evaporitic carbonates, anhydrite and rock salt were also deposited. The climatic change

from arid to humid conditions at the beginning of Rhaetian time, which led to formation of extensive greyish arenaceous and pelitic deposits in northwestern Europe, is also traced in the offshore area (Larsen 1966, Childs & Reed 1975 a.o.).

The present investigation deals with the Triassic sequence of the Dansk Nordsø A–2 borehole situated in the Central Graben (Text-fig. 1), and the Dansk Nordsø F–1 and the Dansk Nordsø K–1 boreholes drilled in the western extension of the Danish Embayment (Text-fig. 1). The materials investigated are almost exclusively in the form of ditch sample cuttings. The profiles have therefore been analyzed and described in descending order to exclude contaminants from the results as far as possible.

Depths are given in feet below Kelly Bushing or in metres below the Mean Sea Level. If the depths have been corrected by means of Schlumberger logs these statements are printed in italics.

Dansk Nordsø A–2: 10050′ – 11143′ (3027 m – 3360 m)

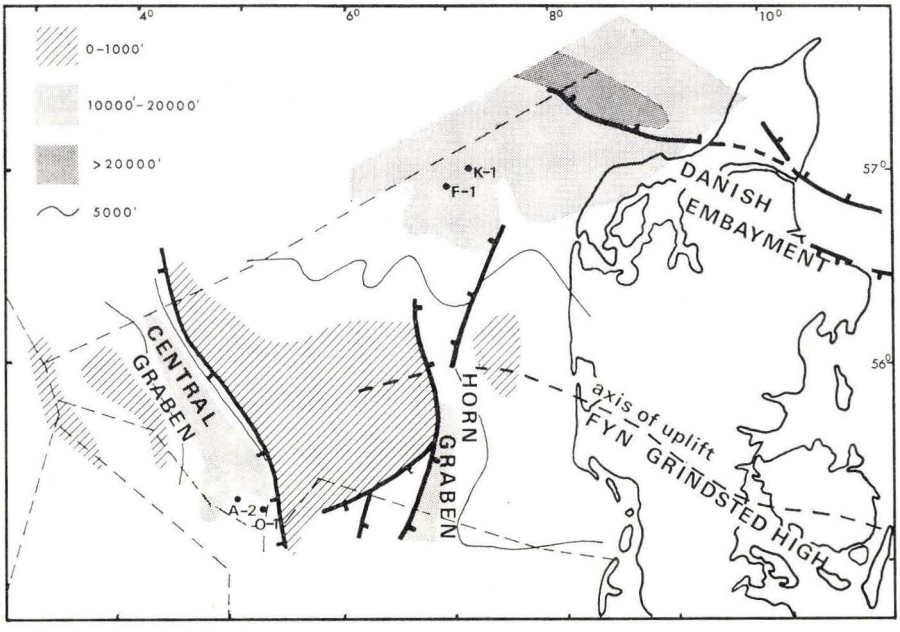
Geology

The geology of the Triassic section is in a shortened version given in Rasmussen (1974). The section is composed predominantly of redbrown continental claystones with anhydrite. Near the base of the section (base of borehole) a rock salt bed occurs. The Triassic sequence is abruptly overlain by Middle Jurassic sandstones and shales.

Miospores are found to occur in the lower part of the sequence only and a more detailed lithological description of this palyniferous section is given below. The description is made by Michelsen (1967) and is based on a semiquantitative analysis of cuttings. Unfortunately, no electrical logs have been measured in this section.

10750′–10792′ Claystone, sticky, brown, slightly calcareous (see 10480′–10580′) dominates in 10750′–10770′. Anhydrite dominates in 10770′–10792′. Presumably there is an even transition. Claystone, light greenish grey, occurs subordinate with 20 %–30 %, increasing downwards.

10792′–11070′ Rock salt, clear, white, dominates with minor inclusions of anhydrite.
10792′–10830′ and 10850′–10870′: Anhydrite slightly



Text-fig. 1. Map showing Triassic-Lower Cretaceous offshore isopachs, main structural features and location of the discussed boreholes (after Childs & Reed 1975 a.o.).

increasing. Random occurrence of light greenish grey claystone.

10940′–11070′: Redbrown claystone increases downwards; random occurrence of anhydrite and light greenish grey claystone.

11070′–11110′ Claystone, redbrown, dominates with 40 %–50 %. Claystone, light greenish grey, increases to 25 %–30 %. Anhydrite somewhat increasing in proportion to the above section; rock salt decreases to ca 10 %. There is no distinct lithological boundary at 11070′.

Materials and methods

To reduce the content of Jurassic contaminants in the slides the following technique was found to give good results. Initially conc. HCl was added to the sample consisting of washed cuttings 0.1 mm–1 mm in size. The slightly calcareous palyniferous Triassic cuttings broke down immediately, whereas the rather hard Jurassic cuttings reacted more slowly. By decanting the suspension after some minutes the majority of the caved material was

retained in the beaker. The suspension was processed by standard methods without using oxidizing agents.

The following ditch samples (10' intervals) were investigated without HCl separation –10020′, –10080′, –10160′, –10280′, –10400′, –10520′, –10640', –10760′, –10880′ and –11080′. Having proved the presence of miospores in the latter sample only, the following samples were processed with use of the primary HCl separation: –10770′, –10780′, –10790′, –11070′, –11090′, –11100′ and –11110′. A test preparation of isolated cuttings of a redbrown claystone from sample –10760′ proved to be barren.

Results

Two distinct miospore assemblages have been recovered. The youngest one occurs in the sample interval 10760′–10790′ just above the rock salt bed. Single specimens from this assemblage are found in the sample interval 11070′–11090′ as contaminants. The oldest assemblage was recovered from the two deepest available samples of the borehole, sample interval 11090′–11110′.

The younger assemblage: 10760′–10790′ (3244 m–3253 m)

The following taxa were recovered:

Sample –10770′	Microspores	4
	Apiculatasporites plicatus Visscher, 1966 (3)	
	Porcellispora longdonensis (Clarke) Scheuring 1970 (1)	
	Bisaccate pollen grains	4
	Lunatisporites sp. (1)	
	Varia	3
	Total	11
Sample –10780′	Microspores	39
	Apiculatasporites plicatus Visscher, 1966 (14)	
	Porcellispora longdonensis (Clarke) Scheuring, 1970 (11)	
	Aratrisporites saturni (Thiergart) Maedler, 1964 (5)	
	Bisaccate pollen grains	40
	Illinites chitonoides Klaus, 1964 (1)	
	Triadispora spp. (8)	

	Caytonipollenites pallidus (Reissinger) Couper, 1958 (3)	
	Sulcatisporites kraeuseli Maedler, 1964 (1)	
	Umbrososaccus keuperianus Maedler, 1964 (3)	
	Protodiploxypinus spp. (1)	
	Varia	3
	Total	82
Sample –10790′	Microspores	6
	Porcellispora longdonensis (Clarke) Scheuring, 1970 (2)	
	Bisaccate pollen grains	28
	Illinites chitonoides Klaus, 1964 (3 or 4)	
	Striatobietites aytugii Visscher, 1966 (1)	
	Triadispora spp. (3)	
	Alisporites spp. (2)	
	Umbrososaccus keuperianus Maedler, 1964 (1)	
	Total	34

The assemblage shows an interesting co-existence of typical Neotriassic taxa such as *P. longdonensis* and *A. saturni* (cf. Mädler 1964, Geiger & Hopping 1968 and Scheuring 1970) and a Palaeo-Mesotriassic form, *Apiculatasporites plicatus* (Visscher 1966, Visscher & Commissaris 1968, Warrington 1974). Important also is the absence of *Ovalipollis ovalis* Krutzsch, 1955, which is a very frequently recorded and common species in the Middle and Upper Keuper deposits of Northwest Europe. This species has also been recovered from another borehole in the Central Graben, the Dansk Nordsø 0–1 borehole (Text-fig. 1) where together with *P. longdonensis* it forms a typical Carnian "Gipskeuper" assemblage, both taxa being abundant. *O. ovalis* is therefore present regionally and would be expected to occur in the samples in question if the assemblage is younger than Late Anisian/Ladinian, which seems to be the most reasonable stratigraphical designation on the basis of the above given information. The bisaccate pollen grains, of which only a minor portion has been identified, have so far not been found to be stratigraphically indicative.

The older assemblage: 11090′–11110′ (3344 m–3350 m)

The following taxa were recovered:

Sample –11100′ Microspores 28
Apiculatasporites plicatus Visscher, 1966 (7)
Bisaccate pollen grains 77
Illinites chitonoides Klaus, 1964 (1)
I. kosankei Klaus, 1964 (2)
Striatobietites aytugii Visscher, 1966 (1)
S. balmei Klaus, 1964 (1)
Lunatisporites spp. (9)
Triadispora spp. (10)
Alisporites spp. (5)
Protodiploxypinus potoniei (Maedler) Scheuring, 1970 (1)
P. sittleri (Klaus) Scheuring, 1970 (3)
Granosaccus cf. *sulcatus* Maedler 1964 (9)

Total.... 118

Sample –11110′ Microspores 10
Cyclotriletes granulatus Maedler, 1964 (2)
Apiculatasporites plicatus Visscher, 1966 (7)
cf. *Aequitriradites minor* Maedler, 1964
Bisaccate pollen grains 17
Illinites kosankei Klaus, 1964 (1)
Angustisulcites klausii Freudenthal, 1964 (1)
Striatobietites balmei Klaus, 1964 (1)
Triadispora spp. (2)
Protodiploxypinus fastidioides (Jansonius) Warrington, 1974 (1)
P. sittleri (Klaus) Scheuring, 1970 (1)
Granosaccus cf. sulcatus Maedler, 1964 (1)

Total.... 27

The older assemblage is seen to be composed of 65 %–75 % bisaccate pollen taxa. Stratigraphically important is the occurrence of such taxa as *Striatobietites balmei* and *Protodiploxypinus sittleri,* which according to Geiger & Hopping (1968) are reported from deposits referred to Upper Buntsandstein and Lower-Middle Muschelkalk. Thus, referring to *S. balmei,* they state (p. 30): "Its 'top occurrence' has been taken in operational petroleum geology as marking the top of the Middle Muschelkalk".

Among the various palynofloras described from Upper Buntsandstein and Muschelkalk successions within the North Sea Basin, special attention

is paid to the assemblages of the West Lancashire Kirkham Mudstones recently described by Warrington (1974). It is seen, that all of the above listed species, with the exception of *Cyclotriletes granulatus,* are recorded within the range zone of *Aequitriradites minor.* Most of these taxa are long-ranging, but noteworthy however is the range of the morphologically distinctive species *Granosaccus* cf. *sulcatus.* This species appears within the range zone of *A. minor* and persists above the upper range limit of the latter, and it has been proven identical with the Danish specimens (Pl. 1) attributed to this taxon (Warrington in correspondance). Warrington does not discuss the correlation of the section to the European standard zonation. However, the range of *A. minor* still seems at present to be known to be restricted to Muschelkalk equivalents (Taugourdeau-Lantz 1974) and the assemblage recovered in the Dansk Nordsø A–2 borehole is therefore most probably not older than these Muschelkalk assemblages. As the major lower and middle parts of the Northwesteuropean Muschelkalk sediments are traditionally referred to the Anisian stage, the older assemblage is tentatively referred to the Anisian.

Concluding remarks on the studied interval of the Dansk Nordsø A–2 borehole

It seems reasonable on the basis of the palynological results obtained to compare the salt bed member and the surrounding miosporebearing beds with the halitic Muschelkalk sequences published from the southern North Sea area by Geiger & Hopping (1968).

There is a good correlation, both lithologically and palynologically, with the sequences referred to the Middle Muschelkalk in the Leman Field and "North Holland" (composite profile).

The prevailing red bed facies in the three profiles indicate corresponding marginal environments in the three areas during the Mesotriassic. The facial development of the Dansk Nordsø A–2 sequence is therefore in accordance with the idea of a restricted Muschelkalk transgression from S–SE into the North German Basin as expressed by Sorgenfrei (1969) a.o. The profiles from the southern part of Jutland (Sorgenfrei & Buch 1964) show that the sequences here referred to the Muschelkalk are developed as grey claystones, marls and limestones without rock salt, i.e. in a more "Muschelkalk-like" facies, and that they are not comparable lithologically with the Dansk Nordsø A–2 profile.

The grey shales and sands etc. which abruptly overlay the studied red beds are of Middle Jurassic age, and Rhaetic elements have at least not been traced. There seems, therefore, to be an important hiatus between the

studied section, of which the uppermost barren part for lithological reasons is compared with the German Lower or Middle Keuper, and the Jurassic series. However, this hiatus is most certainly to be regarded as a local erosion phenomenon, which may be explained by local halokinetic movements in the structure. In this connection it may be added that the presence of Rhaetic and Liassic shales has been demonstrated in other boreholes in the Danish part of the Central Graben.

Dansk Nordsø F–1: *6820′ – 7945′* (*2042* m – *2384* m)

Geology

The pre-Jurassic sequence of the Dansk Nordsø F–1 borehole was originally referred to the Upper Triassic in internal reports by Stenestad (1969) and Michelsen (1969). This assumption was based on lithostratigraphical reflections alone, as marine Rhaetic deposits were not proved in this borehole (Christensen 1969), contrary to expectations. The "Triassic" sequence is overlain by marine Lower Jurassic shales with L. Sinemurian ostracod faunas (Michelsen 1975).

The sequence, which is briefly described lithologically in Rasmussen (Danm. geol. Unders., III. række, 44. – In preparation) is built up mainly of alternating argillaceous and arenaceous red beds. Only the uppermost 250′ show a different ('Rhaetic') lithological character. As part of the latter beds proved palyniferous, a full lithological description of these beds (Stenestad 1969) is cited below.

6820′ – 6845′ *2042* m – *2049* m	Sandstone, fine-grained, light grey, with glauconite, pyrite and calcitic matrix. Beds of limestone, fine-grained, light grey, with glauconite and mica, probably occur.
6845′ – 6940′ *2049* m – *2078* m	Shale, blackgrey, micro-micaceous, non-calcareous. Siltstone, grey, micro-micaceous, non-calcareous. Siltstone, purple, rich in mica, slightly calcareous to non-calcareous.
6940′ – 7070′ *2078* m – *2118* m	Sandstone, coarse-grained, light grey, quartzitic, with subordinate beds of claystone and siltstone, greybrown, with lignite and mica, slightly calcareous.

Materials and methods

Cuttings (0.1–1 mm) of the following ditch samples were processed by standard methods:

6800′–6820′, 6820′–6840′, 6880′–6900′, 6940′–6955′, 6980′–7000′, 7040′–7060′, 7090′–7110′, 7130–7160′, 7260′–7275′, 7310′–7340′, 7360′–7380′, 7420′–7440′, 7480′–7490′, 7540′–7550′, 7600′–7610′, 7630′–7640′, 7680′–7690′, 7720′–7750′, and 7790′–7810′. In addition, two side wall cores were available for preparaton: 7855′ and 7905′.

Results

Two assemblages have been recovered. The youngest one occurs in the sandstone bed *6940′–7070′,* and the oldest one is recovered from the ditch sample 7680′–7690′. All samples are highly contaminated by Jurassic caved material.

The younger assemblage: *6940′–7070′* (*2078* m–*2118* m)

It is not possible to prove the Triassic by means of palynomorphs in the three uppermost samples, –6820′, –6840′ and –6900′. The uppermost record of Triassic miospores is in sample –6955′, i.e. within the uppermost part of the lower of the above described sandstone beds (*6940′–7070′*). The assemblage is characterized by abundant *Ricciisporites tuberculatus* Lundblad, 1954, and accessory rare taxa such as *Densosporites foveocingulatus* Schulz, 1967, *Aratrisporites* spp. and *Rhaetipollis germanicus* Schulz, 1967.

Elements of this assemblage are traced in all of the subsequent samples. It is, however, a general experience that the Triassic (and other) red beds in the North Sea Basin are commonly non-palyniferous and the occurrence of the assemblage below the lower grey sandstone is therefore considered secondary. The available side wall cores were in fact barren too.

In Britain, equivalent assemblages characterized, among other things, by an acme of *Ricciisporites tuberculatus* are reported from the Westbury Beds of the Rhaetic Formation. They constitute the upper part of the *Rhaetipollis* Zone of Orbell (1973). In the underlying Grey Marls member the *Rhaetipollis* Zone assemblages show acmes of genera of the Circumpolles group: *Corollina, Classopollis* and *Granuloperculatipollis.*

Identical vertical changes in composition of the palynofloras, from dominance of Circumpolles taxa (especially *Granuloperculatipollis rudis* Venkatachala & Góczán, 1964) to dominance of *R. tuberculatus* have recently been found by the present author in boreholes in the central part of the Danish Embayment in East Jutland. The boundary of the floral change approximates the Lower/Middle Rhaetic boundary (*sensu germanica*) in these sections, partly dated by means of ostracods. Due to the parallelism

thus demonstrated in the uppermost Triassic microfloral development in the British Midlands and in the northern part of Jutland it seems reasonable to refer the recovered assemblage to the upper part of the *Rhaetipollis* Zone as found in the Westbury Beds.

In recent investigations, Morbey & Neves (1974) attempt a correlation of the British Rhaetic Formation with a proposed stratotype section for the Rhaetian stage in the Kendelbachgraben of Austria by means of palynostratigraphy. Their correlation implies that the Westbury Beds (Member) assemblages of the Bunny Hill borehole are of Late Rhaetian to Early Hettangian age. A survey by the present author of the distribution of the zonal index species of Morbey & Neves in the range diagrams of Orbell makes it clear that most of these species are rare and rather randomly distributed within the Westbury Beds. They are therefore not readily suitable for correlative purposes. Important however, is the information in Morbey & Neves (1974, p. 170) that *Heliosporites reissingeri* (Harris) Chaloner, 1969 is abundant at the base of the FG Subzone, which in the section of Kendelbachgraben embraces the boundary between the Rhaetian stage *sensu lato* (Morbey & Neves) and the Hettangian stage. A study of the diagrams of Orbell shows that *H. reissingeri* is rare in the Westbury Beds, but abundant in the overlying White Lias. This may indicate that the Westbury palynofloras as a rule are of Late Rhaetian age, if a rather diachroneous nature of this member is accepted.

The age of the recovered microflora is therefore indirectly correlated to the Upper Rhaetian.

The older assemblage: 7680′–7690′

Sample 7680′–7690′ which coincides with an extreme maximum peak of the gamma ray curve (Text-fig. 2) is unexpectedly rich in plant materials (and ? mica), and seems to contain a primary palynoflora. *Ovalipollis* spp. dominate, but rare *Triadispora* spp. are also observed. *Ovalipollis* is a typical and common genus in Neotriassic deposits but range up into the Jurassic, whereas *Triadispora* spp. as far as is known are restricted to the Triassic, preferably to the pre-Rhaetic. The assemblage is presumed to be of Carnian or Norian age on the basis of the known distribution pattern of the two genera (Geiger & Hopping 1968, Scheuring 1970). However, a Ladinian age cannot be excluded, which could imply that an equivalent to the German Lettenkohlensandstein may occur in this borehole.

No stratigraphically indicative or believed primary specimens were observed below 7690′.

Dansk Nordsø K–1: *6514′ – 7525′* (*1948* m – *2256* m)

Geology

The sequence of the Dansk Nordsø K–1 borehole compares well with that of the Dansk Nordsø F–1 borehole discussed above. As in the latter borehole, the upper beds are developed in a "Rhaetic" facies distinctly different in colour from the subsequent red beds. The Dansk Nordsø K–1 profile differs however from the Dansk Nordsø F–1 profile by the presence of ca. 40′ of marly, greybrown limestones on top of the red bed section. Miospores regarded as originating from the sequence have only been recovered from the upper grey coloured beds and the lithological description given below (Bertelsen *et al.* 1970) is therefore restricted to comprise these beds only. A shortened lithological description of the total profile of the borehole is given in Rasmussen (Danm. geol. Unders., III. række, 44. – In preparation). The sequence studied is overlain by grey shales with Hettangian ostracod faunas (Michelsen 1975).

6514′ – 6738′ / *1948* m – *2017* m: Sandstone, with gravel, unconsolidated, uncoloured to slightly yellowish or greyish, consisting of subangular quarts grains and some feldspar grains. Two further types of sandstone occur in the interval: 1) sst., fine grained, silty, white to greywhite with matrix of illite-like mineral and 2) sst., middle-grained, greyish, well consolidated. At ca. 6660′ occur one or more coalbeds, blackbrown, slightly glistening.

6738′ – 6822′ / *2017* m – *2042* m: Claystone, silty, slightly calcareous to non-calcareous, dark grey, slightly darker than above, with minor beds of sandstone, greyish-brown and coal, blackbrown, slightly glistening.

Materials and methods

The following ditch samples (taken out at 30′ intervals) were processed by standard methods: –6530′, –6560′, –6590′, –6620′, – 6650′, –6680′, –6770′, –6830′ and –7120′. Due to the meagre results obtained in the Dansk Nordsø F–1 red beds, only two samples from these beds were processed.

Results

The samples -6530′, –6560′, –6620′, and –6650′ yielded limited numbers of Jurassic palynomorphs and the upper part of the sandstone interval

6514'–6738' is most probably non-palyniferous, the Jurassic miospores being considered to be contaminants.

In the samples –6680', –6770', –6830' and –7120' was recovered an assemblage identical with the younger assemblage of the Dansk Nordsø F–1 borehole. In addition to the dominant *Ricciisporites tuberculatus, Limbosporites lundbladii* Nilsson, 1958 and *Rhaetipollis germanicus* were found. Especially the uppermost sample is rich in lignite and the top occurrence of the microflora is believed to coincide with the top of the coal beds at ca 6660'.

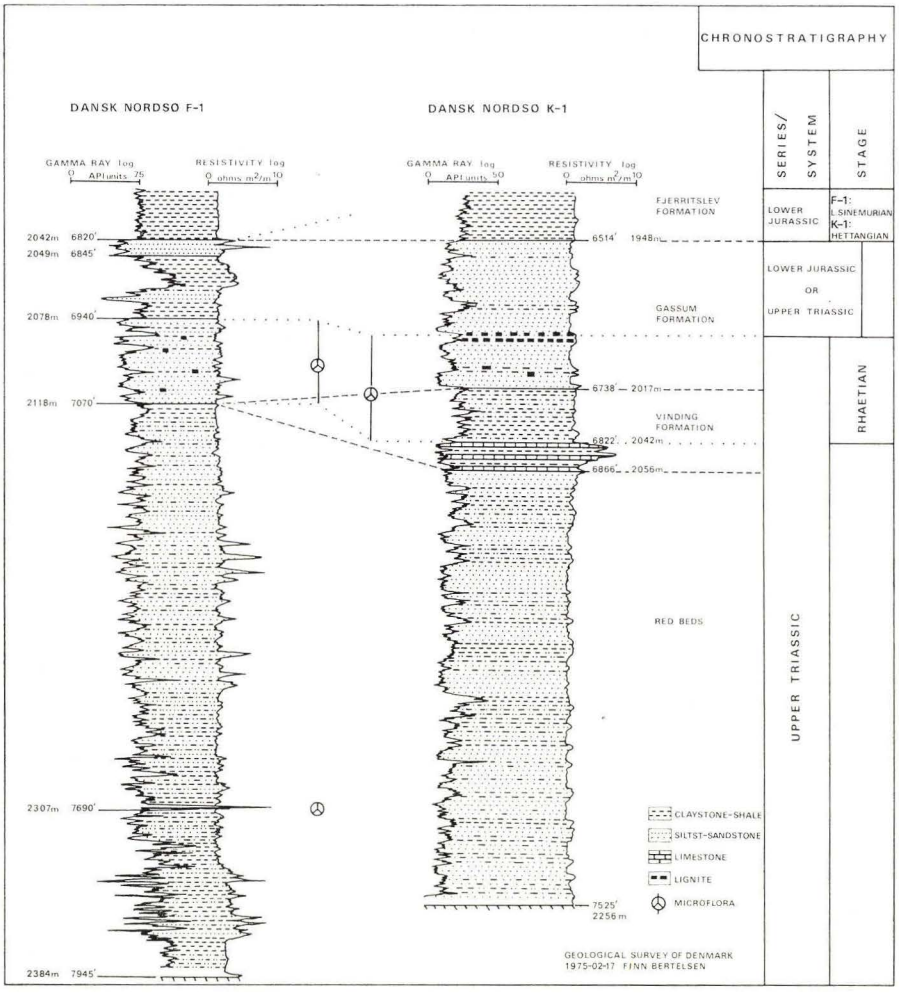
The samples –6770' and –6830' contain several specimens of the dinoflagellate cyst *Rhaetogonyaulax rhaetica* (Sarjeant) Loeblich & Loeblich, 1968. The presence of this species thus indicates a marine influence during this part of the sequence. In Britain *R. rhaetica* is reported from the Grey Marls, the Westbury Beds and the Cotham Beds (Orbell 1973, Warrington 1974), and was originally described from the Cotham Beds (Sarjeant 1963). According to Morbey & Neves (1974), *R. rhaetica* seems to be restricted to the Rhaetian stage *sensu lato* (Morbey & Neves), at least with respect to the extension of its lower range.

The microflora occurring in the sample –7120' is considered to be due to contamination. Isolated cuttings of the dominant rock type of the sample, a light greyish claystone, were found to be non-productive. Regarding the recovery of the sample –6830' it has not yet been clarified whether this (limestone-bearing) part of the sequence is palyniferous.

Concluding remarks on the studied sections in the Dansk Nordsø F–1 and the Dansk Nordsø K–1 boreholes

The present investigation has proved a Triassic age for at least the upper parts of the studied sections. It has also demonstrated that uniform Rhaetian palynofloras occur in the two borings, and that these palynofloras compare closely with the assemblages from the British Westbury Beds. In the central part of the Danish Embayment in East Jutland identical assemblages referred to the Middle Rhaetic *sensu germanica* have been proven too. Furthermore, in the Dansk Nordsø F–1 borehole an older, monotoneous *Ovalipollis* assemblage of possible Ladinian to Norian age was recorded within the generally barren red beds.

In both boreholes the uppermost arenaceous beds of the sections referred to the Triassic seem to be non-palyniferous. In the above-mentioned sections of eastern Jutland (which are still subject to clauses of confidentiality) a corresponding sterility is observed in the uppermost arenaceous beds of the Gassum Formation, which is generally referred to the Rhaetic (cf. Larsen



Text-fig. 2. The chronostratigraphical division of the Triassic sequences of the Dansk Nordsø F–1 and Dansk Nordsø K–1 boreholes and their correlation. The presumed primary ranges of the recovered microfloras are also shown.

1966). These latter beds are overlain by shales of the Fjerritslev Formation with well-defined Hettangian ostracod faunas (O. Michelsen, personal communication) and their stratigraphical position is therefore restricted to the Rhaetian/Hettangian transition.

The studied sections in the two North Sea boreholes are, as described earlier, overlain by Lower Jurassic shales, which are included in the Fjerritslev Formation by Michelsen (1975) (see also Text-fig. 2). In the Dansk Nordsø K–1 borehole these shales basally contain a Hettangian ostracod

fauna, whereas the basal shales of the Dansk Nordsø F–1 borehole are slightly younger according to Michelsen, being characterized by a Lower Sinemurian fauna. Chronostratigraphically the probably barren beds are therefore to be referred to the Upper Triassic/Lower Jurassic transition, and they are for that reason found to be more or less isochronous with the uppermost beds of the Gassum Formation in the mentioned boreholes in East Jutland.

Lithostratigraphically the sandstone interval *1948* m–*2017* m (*6514′–6738′*) of the Dansk Nordsø K–1 section is referable to the Gassum Formation. The underlying mainly dark grey, partly marine claystones of the interval *2017* m–*2042* m (*6738′–6822′*) and the subsequent, limestone bearing interval *2042* m–*2056* m (*6822′–6866′*) are considered to belong to the Vinding Formation defined in Larsen (1966).

In the Dansk Nordsø F–1 section the interval *2042* m–*2118* m (*6820′–7070′*) is referred to the Gassum Formation and the Vinding Formation is found not to be present in this borehole. It must be stressed, however, that an alternative correlation is possible, since interval *2042* m–*2078* m (*6820′–6940′*) may also be regarded as part of the Fjerritslev Formation. Due to the traces of purple siltstones described from the shaly section *2049* m–*2078* m (*6845′–6940′*), which is merely a "Triassic feature", the latter correlation seems less reliable.

As regards the red bed sequences, only one sample in the Dansk Nordsø F–1 profile (–7690′) proved productive. This sample of Ladinian-Norian age indicates that at least the major part of the red beds in this borehole are of Upper Triassic age. The proximity of the Dansk Nordsø K–1 borehole may justify the assumption that the corresponding beds in that borehole are also from the Upper Triassic.

In the lowermost part of the Dansk Nordsø F–1 profile, the resistivity log seems to indicate the presence of limestones, but such rocks are not mentioned in the description. The claystones, however, are described as being calcareous and the presence of Muschelkalk equivalents is therefore a possibility, although not very likely. All red beds are for that reason referred to the Upper Triassic, as seen in Text-fig. 2.

Dansk sammendrag

I artiklen redegøres for resultaterne af palynologiske undersøgelser foretaget i de triassiske afsnit i de tre danske Nordsø-boringer: Dansk Nordsø A–2, Dansk Nordsø F–1 og Dansk Nordsø K–1.

I boringen Dansk Nordsø A–2 beliggende i *the Central Graben,* er trias-afsnittet, 3027 m–3360 m (10050′–11143′) udviklet som kontinentale "red beds" indeholdende en basal stensaltforekomst. I lagene umiddelbart over og under saltlagene påvistes

mikrofloraer af sandsynlig Anisien-Ladinien alder. Det sporeførende, halitiske afsnit er som helhed sammenlignet med saltførende lagserier i den sydlige del af Nordsøen, der kan korreleres til mellem Muschelkalk i Tyskland.

I boringerne Dansk Nordsø F–1 og Dansk Nordsø K–1 med position i den vestlige del af Det danske Sænkningsområde forekommer mikrofloraer af rhætisk alder i lagserier, der lithologisk må henføres til Gassum Formationen. I boringen Dansk Nordsø K–1 påvistes tillige tilstedeværelsen af marint rhæt i en lagserie, der kan refereres til Vinding Formationen. De underliggende "red beds" fandtes generelt at være golde, men i en enkelt prøve i F–1 profilet lykkedes det dog at påvise en mikroflora af øvre triassisk alder. Med forbehold er de gennemborede "red beds" derfor som helhed henregnet til øvre trias. Undersøgelsesresultaterne fra de to sidstnævnte boringer er sammenstillet i tekstfigur 2.

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Plate 1

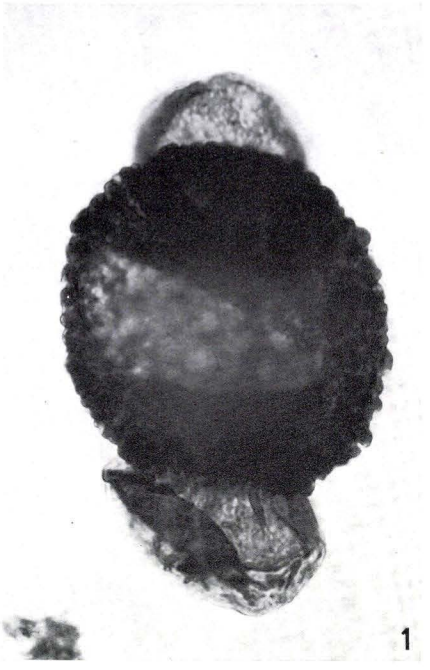
D.G.U.
Catalogue No.

Figs. 1–2. *Granosaccus* cf. *sulcatus* Maedler 1964 ..... 1975–FB–01
Dansk Nordsø A–2 borehole, 11,090′–11,100′.
S1 321 PM: 42.0–100.4.

Fig. 3. *Granosaccus* cf. *sulcatus* Maedler 1964..... 1975–FB–02
Dansk Nordsø A–2 borehole, 11,090′–11,100′.
S1 321 PM: 50.8–104.9.

Fig. 4. *Granosaccus* cf. *sulcatus* Maedler 1964..... 1975–FB–03
Dansk Nordsø A–2 borehole, 11,090′–11,100′.
S1 321 PM: 47.6–97.5.

The plate shows examples of the variation of ornamentation within specimens identified as *G.* cf. *sulcatus*. Magnification × 1000.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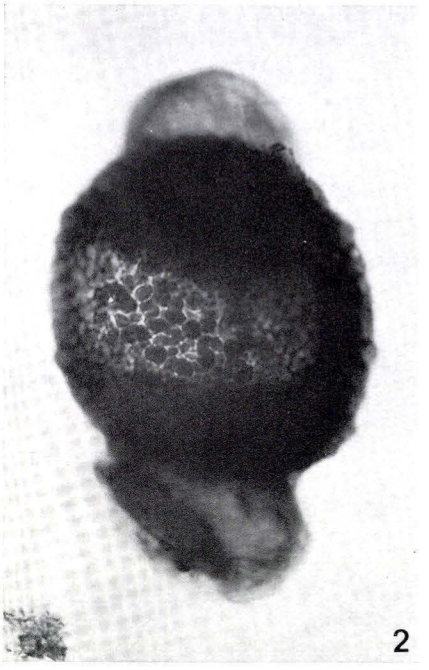
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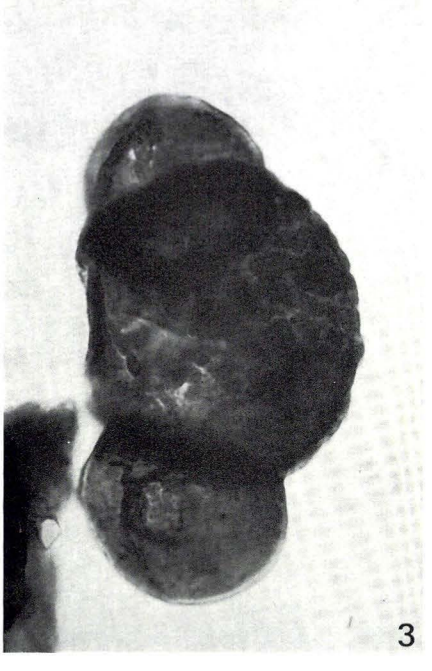
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