

Danian dinoflagellate zonation, the C-T boundary and the stratigraphical position of the fish clay in southern Scandinavia

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ABSTRACT—Two Swedish borehole cores covering the Danian, and three Danish outcrop sections covering the Lower Danian, were analysed for dinoflagellates.

This study suggests that the Swedish sections, in contrast to previous investigations, are the most complete sections across the Cretaceous-Tertiary boundary in the Danish Embayment. As a consequence, the previously established biozonation can be modified to include one more basal Danian zonule.

A detailed study of the dinoflagellates of the Fish Clay in Denmark suggests that this layer was formed in a low salinity environment in eastern Denmark and in a stable marine environment in western Denmark. In addition, the Fish Clay is shown to be biostratigraphically older in eastern Denmark than in western Denmark.

INTRODUCTION

The Danish Embayment is a sedimentary basin containing Mesozoic and Cenozoic deposits. It is a part of the Danish-Polish Trough, which extends as a belt in a north-westerly to south-easterly direction from Denmark across Poland. The Danish Embayment was connected to the North Atlantic and Tethys through narrow sea passages (Posaryska, 1965). As a consequence of the regression that took place in the Late Maastrichtian (Vail *et al.*, 1977; Hancock & Kauffman, 1979; Möerner, 1980), the environment in the Lower Danian of Scandinavia was a shallow shelf environment (Hultberg & Malmgren, *In press* (a)).

Danian deposits are characterised by strongly undulating structures which have been interpreted as bioherms (Cheetham, 1971) or megaripples (N.A. Möerner, University of Stockholm, personal communication, 1984), formed under the influence of strong, unidirectional currents. These structures contrast strongly with the laminated structure of the Late Maastrichtian deposits. Danian deposits in Scandinavia consist of biogenic limestones, containing an average of about 75% CaCO₃ (Jørgensen, 1979). The most common constituent of the Danian limestones is bryozoan skeletons, but skeletal fragments of echinoderms, molluscs, nannoplankton, and foraminifera are also abundant.

The Cretaceous-Tertiary boundary is very distinct in Denmark, where it is marked by a change from Maastrichtian chalk facies to a thin clay layer. This clay, which can be seen at all known Danish C-T boundary sections, has been called "Fish Clay", because of its content of fish remains. This clay has been considered to be of lower-

most Danian age (Rosenkrantz, 1966). It is a formation of four thin clay layers, immediately overlying the Maastrichtian chalk. The lowermost layer is a 2–4 cm thick marl bed of a whitish grey colour. Overlying it is a 2–5 cm thick dark brown to black bed with abundant pyrite concretions of varying size, which is in turn overlain by a 3–5 cm thick dark grey marl bed, which gradually changes into a light grey marl horizon, about 7 cm thick.

Many hypotheses have been proposed about the biotic changes across the C-T transition. The rapid extinction of many plant and animal groups (for example the dinosaurs) have been explained by an instantaneous, global catastrophe. The most widespread theory is that of an extraterrestrial body impact, which drastically affected the earth's biosphere (Alvarez *et al.*, 1980; Alvarez *et al.*, 1983). The argument for this theory is the conspicuous peak of iridium found at various C-T boundary sections around the world (Alvarez, 1983), one of which is the Stevns Klint section in eastern Denmark.

The purpose of this study was to expand the existing Danian dinoflagellate stratigraphy of southern Scandinavia to include new zones at the bottom and the top of the Danian, to study the completeness of the lowermost Danian at various localities, and to investigate the time-relationships and depositional environment of the Fish Clay at various localities.

MATERIAL AND METHODS

Two borehole cores, D105 and D106, from the Limhamn area, southern Sweden, and three Danish outcrop sections, Stevns Klint, Dania, and Kjølby Gaard

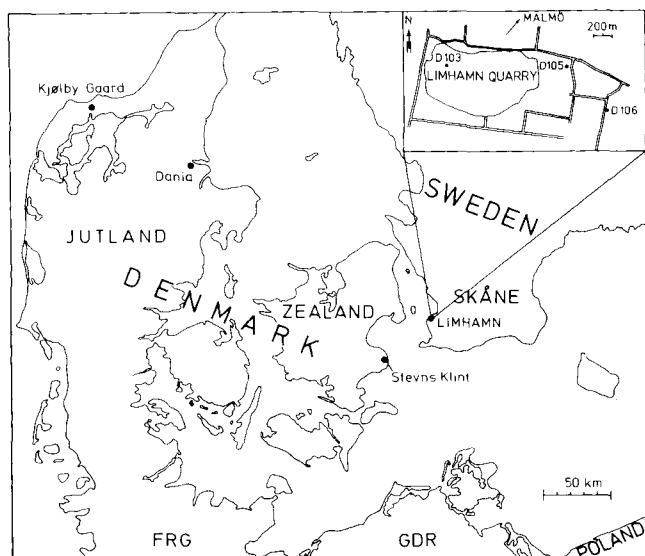


Fig. 1. Map of southern Scandinavia showing the sampling localities. Limhamn cores D105 and D106, and outcrop sections from Stevns Klint, Dania, and Kjølbj Gaard were used in this study.

(Fig. 1), have been analysed for dinoflagellate cysts. The Swedish cores cover 76 m (D105) and 75 m (D106), respectively, of Danian deposits and both penetrate the C-T boundary. The cores were sampled at average intervals of 4 m. Within 2 m from the C-T boundary, core D105 was sampled at intervals of 0.2 m. The Danish outcrop sections cover 11 m (Stevns Klint), 8 m (Dania), and 6 m (Kjølbj Gaard), respectively, of Lower Danian deposits. They all penetrate the C-T boundary. The Stevns Klint and Kjølbj Gaard sections were sampled at an average interval of 1 m, whereas the section ± 2 m from the boundary was sampled at approximately 0.3 m intervals. At Dania, only the interval ± 2 m from the boundary was sampled, again every 0.3 m. Fig. 2 shows stratigraphical ranges of the sections. A detailed sampling of the Fish Clay was made at Stevns Klint, where it is divided into four distinct horizons (Christensen *et al.*, 1973). Each of these was sampled separately for dinoflagellates; three different sections, about 150 m apart, were sampled from the cliff at Stevns Klint.

Dinoflagellate preparations were initiated with the removal of carbonates by treating the samples with HCl (Wilson, 1974b). The residues were centrifuged and submitted to a heavy-liquid separation with ZnCl_2 . The float fraction was decanted, washed through a sieve with a mesh size of $10\mu\text{m}$, and mounted on slides, using glycerol jelly as a mounting medium. The bottom fraction in the heavy-liquid separation was routinely scanned for dinoflagellates. Two slides were made from each sample, one of which was stained with fuchsin.

Relative abundances of dinoflagellates were generated by counts of at least 300 specimens per sample. The census counts included all species found in the slide.

SYSTEMATIC PALAEOONTOLOGY

This section includes all the species that have been used in the establishment of a modified dinoflagellate biostratigraphy for the Danian of Scandinavia and the species restricted to the Fish Clay in this area. In total, approximately 50 species were recognised.

Genus *Danea* Morgenroth, 1968, emend. Drugg, 1970
Danea californica Drugg, 1970, emend. Damassa, 1979
 (Plate 1, fig. 1)

Occurrence. *D. californica* is found in all sections studied here, from the C-T boundary upwards.

Remarks. Damassa (1979) considered *D. mutabilis* to be a synonym of *D. californica*, described by Drugg (1970) as *Palmnickia californica*. In this study, this interpretation of this species is followed.

Genus *Senoniasphaera* Clarke & Verdier, 1967
Senoniasphaera inornata Drugg, 1970
 (Plate 1, fig. 2)

Occurrence. This species is found from the Lower Danian *C. inornatum* Subzone (Hansen, 1977) up to the lower part of the *H. cryptovesiculata* Zonule.

Genus *Carpatella* Grigorovich, 1969
Carpatella cornuta Grigorovich, 1969
 (Plate 1, figs. 3, 4)

Occurrence. *C. cornuta* occurs in the Lower Danian *C. cornuta* Zonule at Limhamn and Kjølbj Gaard. This zonule is missing at Stevns Klint.

Genus *Hafniasphaera* Hansen, 1977
Hafniasphaera cryptovesiculata Hansen, 1977
 (Plate 1, fig. 5)

Occurrence. *H. cryptovesiculata* occurs in the Upper Danian *H. cryptovesiculata* Zone (Hansen, 1977) at Limhamn and Kjølbj Gaard. The *H. cryptovesiculata* Zone is missing at Stevns Klint.

Genus *Xenicodinium* Klement, 1960
Xenicodinium rugulatum Hansen, 1977
 (Plate 1, fig. 6)

Occurrence. *X. rugulatum* is found from the lower Danian *X. rugulatum* Zonule (Hansen, 1977) to the middle part of the *H. cryptovesiculata* Subzone (Hansen, 1977).

Xenodinium lubricum Morgenroth, 1968
 (Plate 1, fig. 7)

Occurrence. *X. lubricum* is present from the *X. lubricum* Zonule (Hansen, 1977) upwards.

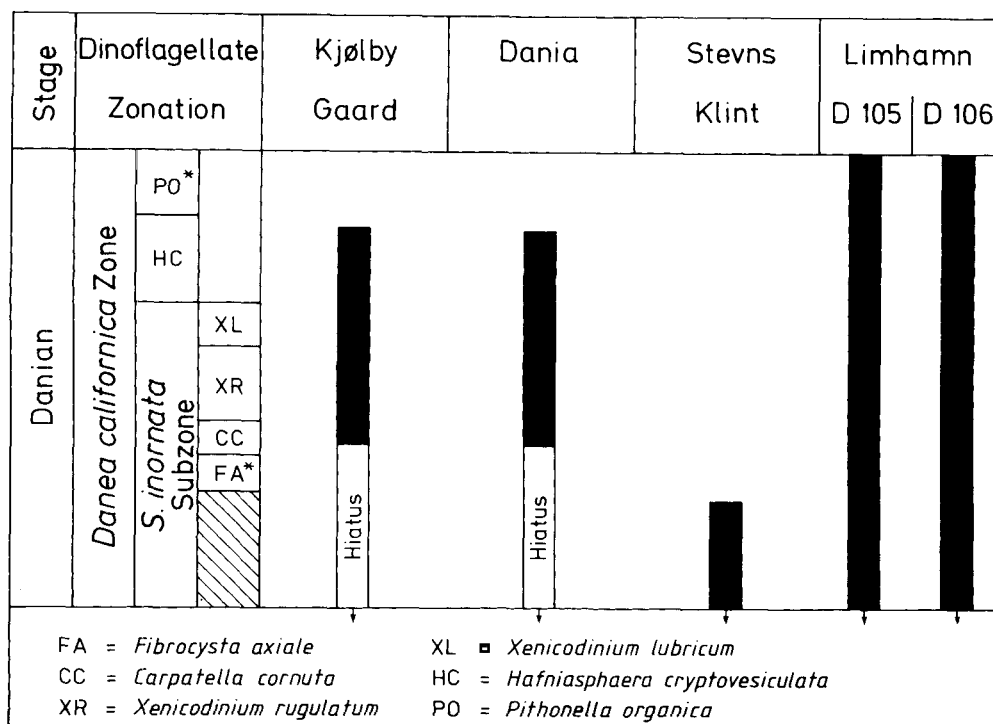


Fig. 2. Biostratigraphical ranges of the Limhamn core D105 and D106 and the Danish outcrop sections from Stevns Klint, Dania, and Kjølbj Gaard.

Genus *Pithonella*

Pithonella organica Hultberg, 1985

(Plate 1, figs. 8, 9)

Occurrence. *P. organica* is found in the uppermost 8 m of Danian deposits in the Limhamn cores D105 and D106.

Genus *Manumiella* Bujak & Davies, 1983

Manumiella druggii Stover, 1974, emend.

Bujak & Davies, 1983

(Plate 2, figs. 1, 2)

Occurrence. This species is found in layers 2 and 3 from the Fish Clay of Stevns Klint. It is not found in any other samples from the study area.

Genus *Spongodinium* Deflandre, 1936, emend.

Stover & Evitt, 1978

Spongodinium reticulatum sp. nov.

(Plate 2, figs. 3, 4)

Holotype. Slide Sk 16-1, from Stevns Klint, Denmark. Coordinates x = 103.6, y = 23.8.

Diagnosis. Proximate cyst composed of one wall layer or two wall layers, closely appressed. Polyhedral in shape with prominent apical horn. Cyst wall is marked by vacuoles of different size, giving wall a reticulate appearance. These vacuoles are evenly distributed on cyst wall. No trace of paratabulation is present except the archeopyle. Paracingulum is marked by a slight depression in

cyst wall. Parasulcus is marked by a conspicuous area of vacuoles, much smaller than those at other locations. Archeopyle is precingular, type P, formed by the detachment of paraplate 3". Operculum is free. Archeopyle is very large and may be enlarged.

Occurrence. *S. reticulatum* is found at Stevns Klint in two samples, 10 and 11 m above the Fish Clay. This species has not been encountered in any of the other sections.

Remarks. This species can easily be distinguished from all other species of *Spongodinium* by its extremely vacuolate periphragm. The only other species with similar vacuoles is *S. delitiense*. However, *S. delitiense* has unevenly distributed vacuoles on a smooth periphragm.

Genus *Glaphyrocysta* Stover & Evitt, 1978

Glaphyrocysta perforata (Wilson 1974a) sp. nov.

(Plate 2, fig. 5)

Holotype. Slide D105-150.0-1, from the Limhamn area, southern Sweden (coordinates x/107.8, y/12.4).

Diagnosis. Shape of endophragm is subspherical to slightly lenticular. A slight antapical indentation is present in most specimens. Endophragm surface finely granulate on dorsal surface with coarser granulation at paraplate boundaries, thus faintly indicating para-

cingulum and paraplates 3", 4", and 5". Ventral surface smooth. Margin of endophragm bears a few solid, unevenly distributed processes of varying thickness, bases of which are isolated, but the processes gradually become confluent with the periphragm. Proximally, the processes fuse with a perforate periphragm, which distally changes into a homogeneous, almost non-perforate periphragm with no indication of the processes.Periphragm terminates with an irregular margin. Proximal part of processes pointed out laterally from endophragm, but are together with the periphragm turned in a ventral direction, terminating in front of ventral part of endophragm, and pointing towards center of endophragm. In apical view, processes and periphragm form a "wing-shaped" structure. Antapically, periphragm (in very well preserved specimens), shows a slight indentation. Archeopyle is apical, type tA, with a free operculum. Primary archeopyle suture zig-zag, indicating six precingular paraplates.

Genus *Fibrocysta* Stover & Evitt, 1978
Fibrocysta axialis Eisenack, 1965, emend.
 Stover & Evitt, 1978
 (Plate 2, fig. 6)

Occurrence. *F. axialis* is found from the C-T boundary up to the middle part of the *H. cryptovesiculata* Subzone.

DINOFLAGELLATE ZONATION

The Danian dinoflagellate flora in southern Scandinavia is characterised by well preserved dinoflagellate assemblages, marked by high abundances of *Spiniferites ramosus*, *Senoniasphaera inornata*, *Fibrocysta axialis* and *Areoligera coronata*. The species composition of the Danian assemblages is similar to that of the Maastrichtian floras. The C-T transition is not marked by pronounced extinctions and appearances of dinoflagellate species, but mostly by changes in the relative abundance of dinoflagellate taxa.

Hansen (1977) studied the dinoflagellate biostratigraphy of the uppermost Maastrichtian and the Lower Danian localities. He divided the Danian *Danea mutabilis* Zone (Hansen, 1977) into the *Senoniasphaera inornata* and the *Hafniasphaera cryptovesiculata* Subzones. The *S. inornata* Subzone was further subdivided into the *Carpatella cornuta*, *Xenicodinium rugulatum*, and *X. lubricum* Zonules. Kjellström & Hansen (1981) applied this zonation to the borehole cores D104, D105, and D106, from Limhamn, southern Sweden. They suggested a stratigraphical range of the Limhamn cores from slightly above the lower boundary of the *X. rugulatum* Zonule to slightly below the upper boundary of the *X. lubricum* Zonule.

Hansen (1977) encountered the lowermost Danian *C. cornuta* Zonule at Kjølby Gaard and Dania, but not at Stevns Klint and Limhamn. Likewise, the uppermost Maastrichtian dinoflagellate zone, the *S. inornata*/*Palynodinium grallator*. Concurrent-Range-Zone, established by Hansen (1979), was encountered by him at Kjølby Gaard and Dania, but not at Stevns Klint and Limhamn. Therefore, he concluded that there had been a break in sedimentation, resulting in a hiatus, covering the uppermost Maastrichtian and lowermost Danian. This hiatus was considered to have an increasing stratigraphic extent eastwards (Kjellström & Hansen, 1981). Thus, among the localities studied by Kjellström and Hansen (1981), Limhamn was considered to be the most incomplete section and Kjølby Gaard the most complete across the C-T boundary.

The *S. inornata*/*P. grallator* Concurrent-Range-Zone (Hansen, 1979) was defined on the basis of the joint occurrence of these two species. Hultberg & Malmgren (1985b) noted that some of the specimens referred to *S. inornata* by Hansen (1979) were referable to *Glaphyrocysta perforata*. In the present study, it was found that *S. inornata*, in fact, first appears in the Danian. *Glaphyrocysta perforata* occurs throughout the Upper Maastrichtian and the lowermost Danian.

Explanation of Plate 1

Fig. 1. *Danea californica* Morgenroth, 1968, emend. Damassa, 1979.

Fig. 2. *Senoniasphaera inornata* Drugg, 1970.

Figs. 3-4. *Carpatella cornuta* Grigorovich, 1969.

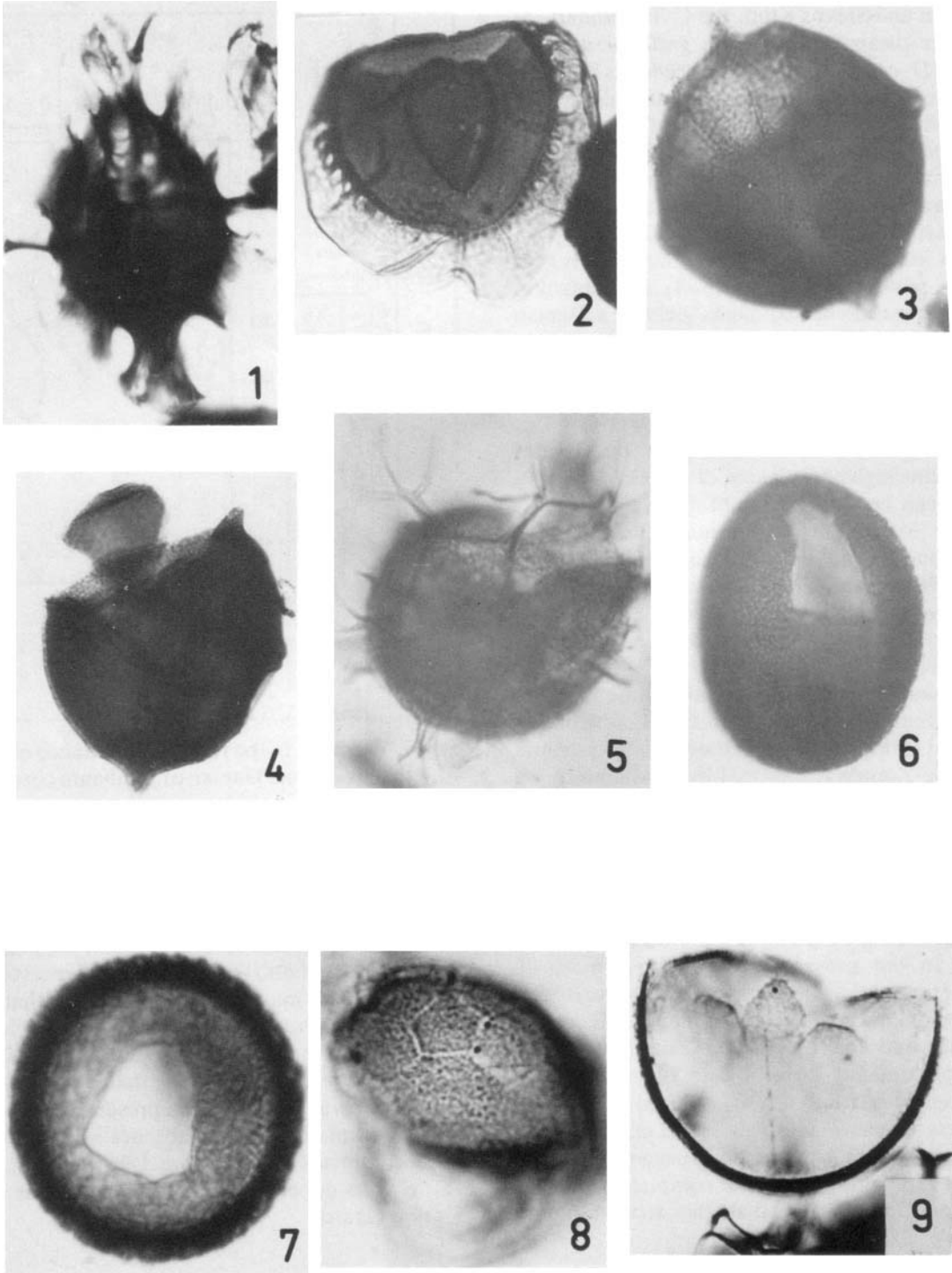
Fig. 5. *Hafniasphaera cryptovesiculata* Hansen, 1977.

Fig. 6. *Xenicodinium rugulatum* Hansen, 1977.

Fig. 7. *Xenocodinium lubricum* Morgenroth, 1968.

Fig. 8. *Pithonella organica* Hultberg, 1985, dorsal view.

Fig. 9. *Pithonella organica* Hultberg, 1985, ventral view.



At Limhamn and Stevns Klint, the C-T boundary, as marked by the disappearance of *P. grallator* and the appearance of *D. californica* and *S. inornata*, is followed by an interval of low dinoflagellate content. This interval is 13 m thick at Limhamn and 9 m thick at Stevns Klint. No such interval is present at Dania and Kjølby Gaard. Also, in approximately the same interval, abundances of planktonic foraminifera and calcareous nannoplankton decrease drastically (B. Malmgren, University of Uppsala, pers. comm., 1983, 1984; G. Gard, University of Stockholm, pers. comm., 1983, 1984). At Limhamn, this interval is overlain by sediments yielding a Danian dinoflagellate assemblage. At Stevns Klint, the barren interval is followed by an interval of "mass occurrence" of the dinoflagellate *Spongodinium reticulatum* (40,000 cysts/g; average in the Danian is 400 cysts/g).

At Limhamn, the interval overlying the barren interval, contains high abundances of *F. axiale* (Fig. 3). This interval can be used to establish a basal Danian Acme-Zonule within the *S. inornata* Subzone. This zonule is defined by a series of samples exhibiting relative abundance of *F. axiale* greater than 10%. The average relative abundance of this species in this zone is approximately 19% and the average value in the Danian is approximately 6%.

The *C. cornuta* Zonule, suggested by Hansen (1977) to be basal Danian, was not found at Limhamn by Kjellström and Hansen (1981). In the present study, the *F. axiale* Acme-Zonule is followed by Limhamn by an interval containing abundant specimens of *C. cornuta* (40% of the assemblage). This interval is 6 m thick in core D105 and 6.5 m thick in core D106. The *C. cornuta* Zonule was found by Hansen (1977) to be approximately 0.2 m thick at Kjølby Gaard and 0.3 m thick at Dania. At Stevns Klint, the Fish Clay was considered to belong to this zonule. In the present study, no specimens of *C. cornuta* were found in any of the Fish Clay horizons.

The interval of low dinoflagellate content, the *F. axiale* Acme-Zonule, and the *C. cornuta* Zonule together comprise approximately 26 m of Danian sediments at Limhamn (Fig. 4). At Kjølby Gaard and Dania, the total thickness of these intervals is 0.1 m and 0.2 m respectively. In contrast to previous suggestions, this indicates that Limhamn is the most complete sequence in the Lower Danian and that the stratigraphical

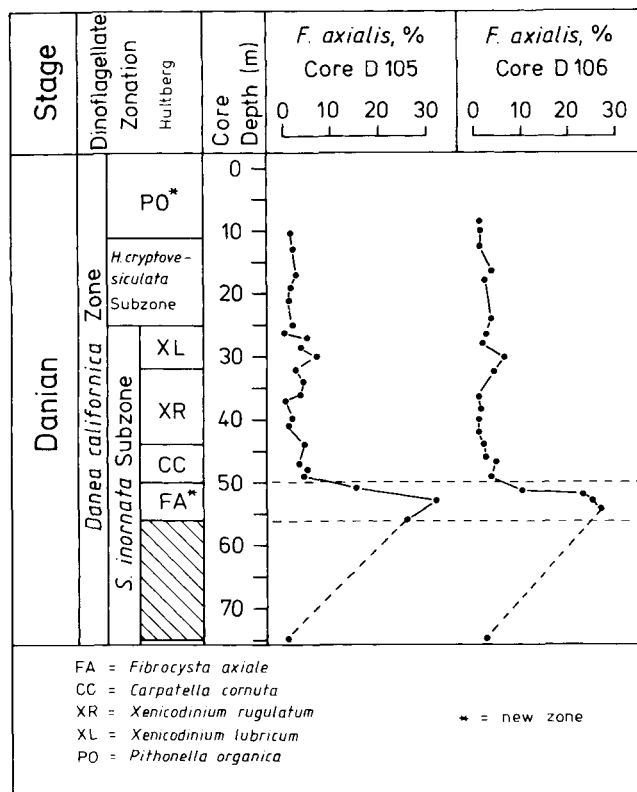


Fig. 3. Variation in the relative abundance of *F. axiale* in the lowermost Danian of Limhamn cores D105 and D106.

extension of the hiatus increases westwards instead of eastwards (Fig. 5). The fact that no specimens of *C. cornuta* were found at Stevns Klint suggests that the interval of low dinoflagellate content here is correlatable with the similar interval at Limhamn, and that sediments belonging to the *F. axiale* Acme-Zonule and the *C. cornuta* Zonule have been eroded at Stevns Klint.

The *C. cornuta* Zonule is overlain by the *X. rugulatum* Zonule, characterised by the presence of *X. rugulatum* and *X. reticulatum* and the absence of *X. lubricum*. This zone comprises 12 m in core D105 and 11 m in core D106. The uppermost part of this zone is missing at Kjølby Gaard.

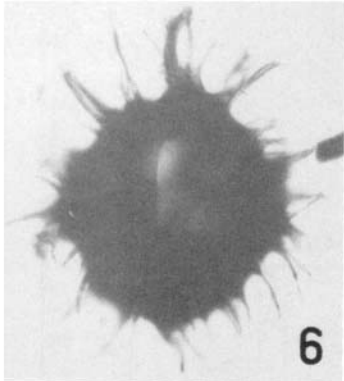
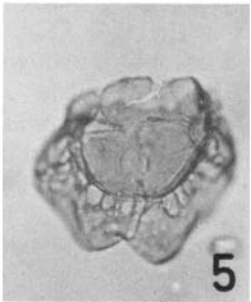
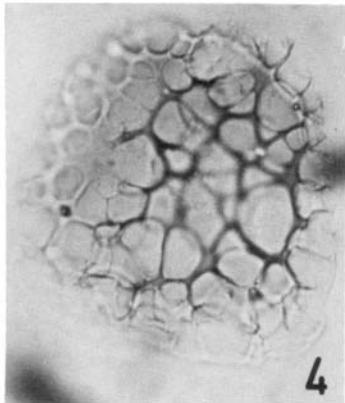
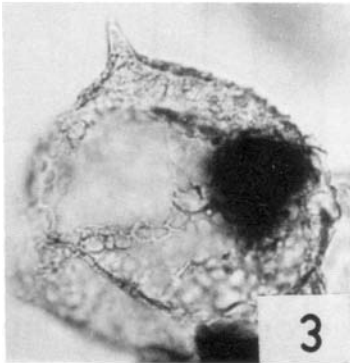
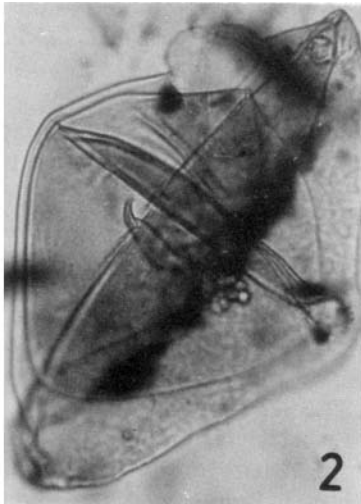
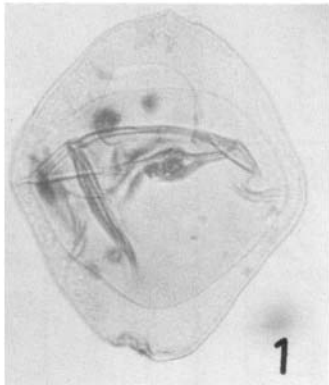
Explanation of Plate 2

Figs. 1, 2. *Isabelidinium cretaceum* Cookson, 1956, emend. Lentin & Williams, 1977.

Figs. 3, 4. *Spongodinium reticulatum* Hultberg sp. nov.: figs. 3, dorsal view; fig. 4, single 3" operculum.

Fig. 5. *Glaphyrocysta perforata* Hultberg & Malmgren, 1985b.

Fig. 6. *Fibrocysta axialialis* Eisenack, 1965, emend. Stover & Evitt, 1978.



The *X. rugulatum* Zonule is overlain by the *X. lubricum* Zonule, defined by the presence of *X. lubricum* (Fig. 5). This zone is 7 m thick in core D105 and 7 m thick in core D106.

The *H. cryptovesiculata* Subzone is here found for the first time in Swedish deposits. It is defined by the first occurrence of *H. cryptovesiculata*. This zone was described by Hansen (1977) as uppermost Danian. However, the uppermost part of the Limhamn cores is marked by the first appearance of *Pithonella organica*, which can be used to establish a new, uppermost Danian subzone, defined by the first appearance of this species. The *H. cryptovesiculata* Subzone is 14 m thick in both core D105 and core D106. The *P. organica* Subzone is 14 m and 13 m thick, respectively, in cores D105 and D106. Fig. 5 shows a range chart for all stratigraphical index species. Fig. 6 shows a comparison between the dinoflagellate zonation established by Hansen (1977, 1979), and the modified dinoflagellate zonation established in this paper.

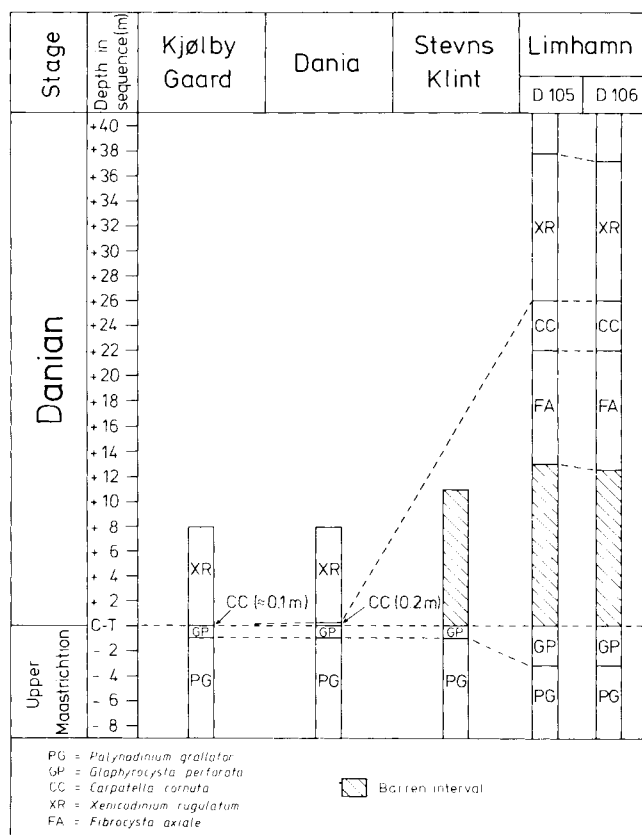


Fig. 4. Correlation between Limhamn cores D105 and D106, and the Danish outcrop sections from Stevns Klint, Dania, and Kjølbby Gaard based on dinoflagellate stratigraphy.

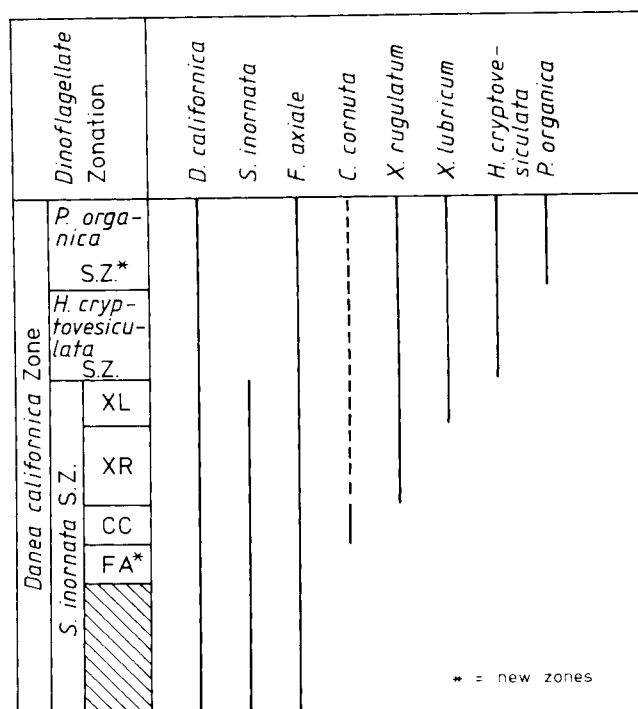


Fig. 5. Ranges of stratigraphical index species in the dinoflagellate stratigraphy. Dotted line indicates that relative abundance is below 1%.

PALAEOECOLOGY AND BIOSTRATIGRAPHY OF THE FISH CLAY

In this study, the four different beds of the Fish Clay (Christensen *et al.*, 1973) were analysed separately for dinoflagellates. The uppermost metre of Maastrichtian chalk, immediately below the Fish Clay, displays low abundances of dinoflagellates, which indicates that the assemblages in the Fish Clay are not reworked, but primary. The lowermost bed contains a well-developed Maastrichtian dinoflagellate assemblage, containing abundant specimens of *P. grallator*. In this assemblage, no dinoflagellates indicative of the Danian were found.

The second bed is marked by a monospecific occurrence of *M. druggii*.

The third bed is marked by an assemblage consisting of 70% *M. druggii*.

The uppermost bed of the Fish Clay does not contain any dinoflagellates.

The gonyaulacacean ratio was established by Harland (1973) as a measure of relative salinity; this is the ratio between gonyaulacacean and peridiniacean dinoflagellate cysts. Harland (1973) compared this ratio between core top samples in the Caribbean (high salinity) and the nearshore waters of Woods Hole, Massachusetts (lower salinity). In the samples from Woods Hole, the abundance of peridiniacean cysts was higher. Thus, the value of the gonyaulacacean ratio was lower in the


Stage	Dinoflagellate Zonation Hansen (1977, 1979) Kjellström & Hansen (1981)			Dinoflagellate Zonation Hultberg, (1985)			
Danian	<i>Danea mutabilis</i> Zone	<i>H. cryptove-siculata</i> Subzone		<i>Danea californica</i> Zone	PO*		
		<i>C. inornatum</i> Subzone	XL		<i>S. inornata</i> Subzone	<i>H. cryptove-siculata</i> Subzone	
			XR			XL	XR
			CC			CC	CC
						FA*	FA*
							
<div>FA = <i>Fibrocysta axiale</i> CC = <i>Carpateella cornuta</i> XR = <i>Xenicodinium rugulatum</i> XL = <i>Xenicodinium lubricum</i> PO = <i>Pithonella organica</i> * = new zone</div>							

Fig. 6. Comparison between the dinoflagellate zonation established by Hansen (1977, 1979) and the zonation established by the present study.

samples with lower salinity. This ratio is usually high in the Maastrichtian and Danian (Fig. 7), which indicates open marine conditions.

In the second bed of the Fish Clay, the gonyaulacacean ratio has a value close to zero (Fig. 7). It is difficult to draw statistical conclusions from a monospecific assemblage, but this may indicate low salinity or even brackish conditions during the deposition of this bed (average value in the Danian is 150).

The gonyaulacacean ratio in this bed has a value of 6.4 which, again, indicates a low salinity environment (Fig. 7).

More than 100,000 dinoflagellate specimens have been recorded in the Fish Clay from Stevns Klint. *P. grallator* was found in beds one and three, but no

dinoflagellates indicative of the Danian occur in any of the beds. The specimens of *P. grallator* in the Fish Clay are considered to be *in situ*. If they were reworked, *P. grallator* would also be present in bed two. Thus, according to dinoflagellate stratigraphy, the Fish Clay at Stevns Klint should be placed in the uppermost Maastrichtian, not in the lowermost Danian.

Unfortunately, the Fish Clay contains very little information on other microfossil groups, such as planktonic foraminifera and nannofossils. No stratigraphically useful planktonic foraminifera are encountered in any of the Fish Clay samples. Nannofossils are present in low numbers in the Fish Clay, however, they are severely dissolved and appear to represent a reworked Maastrichtian flora. All Fish Clay samples, except those from bed two, contain a moderately well preserved fauna of benthic foraminifera. The samples contain abundant Maastrichtian representatives, such as *Arenobulimina obesa*, *Gavelinella pertusa*, and *Stensioina pomerana*. No representatives of the Danian *Eoglobigerina danica* assemblage were found. This means that there is no evidence from other microfossil groups contradicting the Maastrichtian age of the Fish Clay at Stevns Klint.

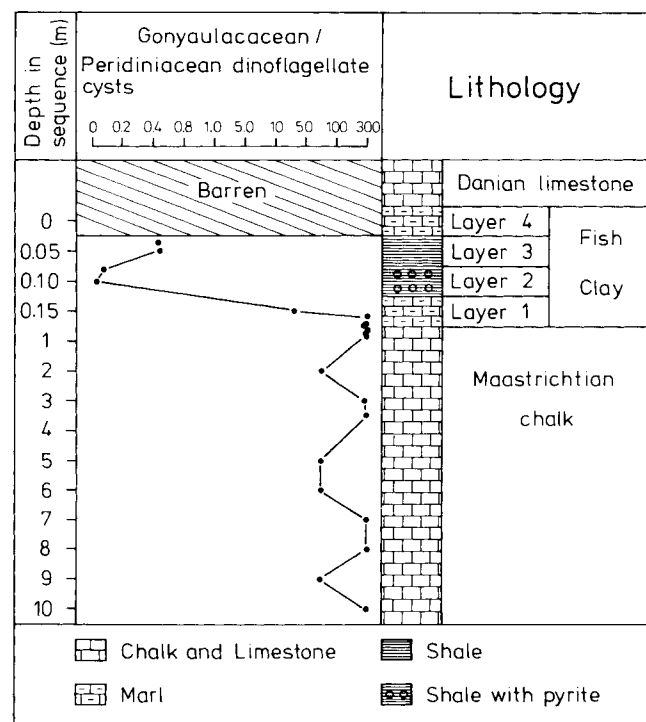


Fig. 7. Variation in the gonyaulacacean ratio (ratio between gonyaulacacean and peridiniacean dinoflagellate cysts) across the C-T boundary at Stevns Klint.

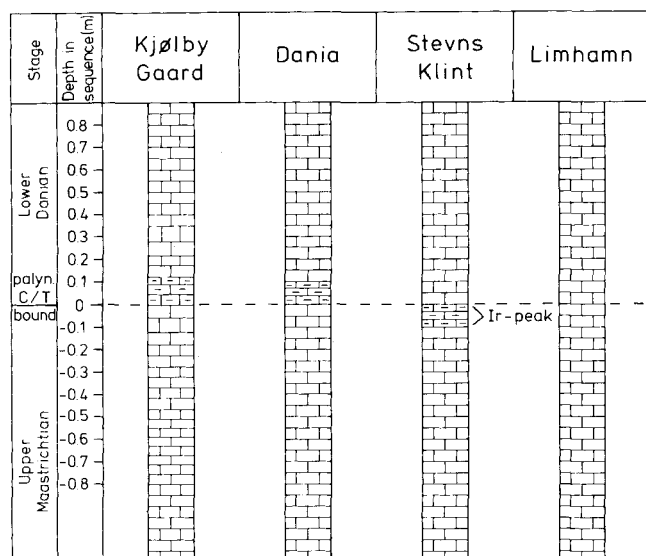


Fig. 8. Stratigraphical position in the uppermost Maastrichtian and the lowermost Danian of the Fish City at Stevns Klint, Dania, and Kjølby Gaard. No Fish Clay is present in the Limhamn area.

At Dania and Kjølby Gaard, the Fish Clay, which is totally homogeneous at these localities, contains a well developed Danian assemblage. Only a few specimens of *M. druggii* were found. At these localities, the gonyaulacacean ratio in the Fish Clay (approximately 130) is close to the average value in the Maastrichtian and Danian chalk in general (average = 150). This indicates stable marine conditions during the deposition of the Fish Clay in western Denmark.

These results strongly point to the fact that the Fish Clay was deposited diachronously, and that it is of younger age in the western parts of Denmark than in the eastern parts (Fig. 8).

The Fish Clay of Denmark has been one of the examples of iridium peaks, suggesting an extraterrestrial body impact at the C-T boundary (Alvarez *et al.*, 1980, 1983). Still very little is known about the properties of the noble metals of the platinum group. Therefore, the iridium peaks cannot be used independently to interpret the stratigraphy, and deal with the problems of synchronism/diachronism. The interpretation of the iridium peaks is totally dependent on a well studied biostratigraphy at the C-T boundary. In the case of the Fish Clay, the only fossils that are of biostratigraphical value are dinoflagellates and benthic foraminifera. Since the impact hypothesis assumes global synchronicity between the different C-T boundary layers containing iridium peaks, these microfossil groups suggest that it is necessary to restudy the hypothesis of an extraterrestrial body impact as the source of iridium in the Danish Fish Clay.

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