G E U S

Report file no.

14944

GRO-3

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GEUS
Copenhagen
19-12-1997

DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 1997/151

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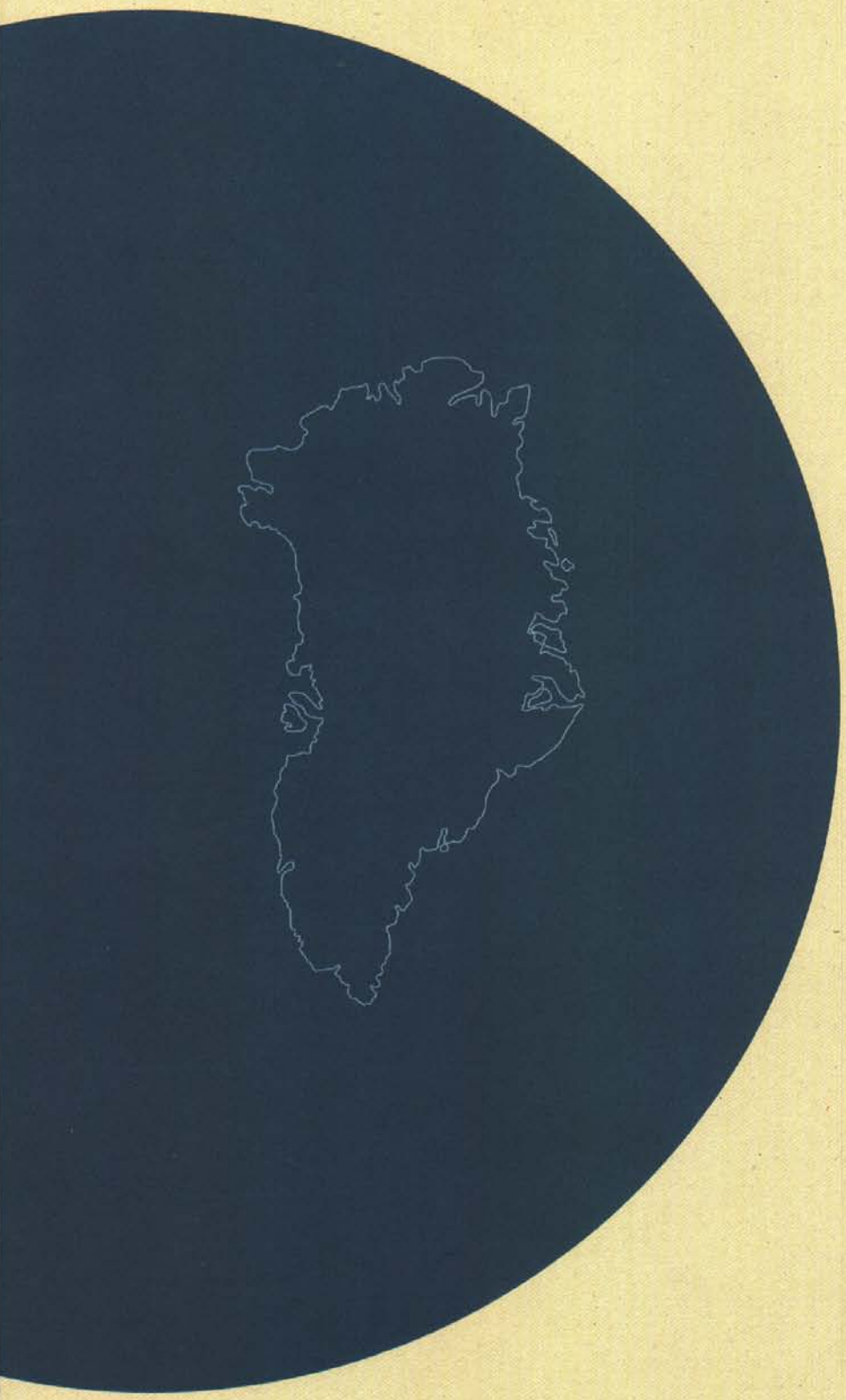

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
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Contents

Abstract

The dinoflagellate cyst assemblages from 50 samples from the well GRO#3 on Nuussuaq, West Greenland are described. GRO#3 are divided into seven informal dinoflagellate cyst intervals that can be correlated and dated as Selandian to ?Coniacian/ Santonian.

Introduction

In May 1995 grønArctic Energy Inc. and Platinova A/S were granted an exclusive exploration licence for an area covering western Nuussuaq (Fig. 1). grønArctic began their exploration programme in July 1995 by drilling the three slim-core holes (Fig. 1; GANE#1, GANK#1 and GANT#1). The Geological Survey of Denmark and Greenland (GEUS) carried out the well site geological description followed by a major sampling and analytical programme for grønArctic. A number of reports on the sedimentology, palynology and organic geochemistry of the sediments, oils and gases from these wells have been published by GEUS (e.g. Christiansen et al., 1996, Dam, 1996a; Dam, 1996b; Dam, 1996c; Nøhr-Hansen, 1997b). As part of their working obligations one or two exploration wells were to be drilled in 1996. The two wells (GRO#1 and GRO#2) were planned to be drilled in the vicinity of the GANK#1 and GANE#1 boreholes, respectively (Fig. 1). After the drilling equipment was unloaded on the beach southeast of the Kuussuaq River delta, mobilization of the drilling equipment to the first planned sites was suspended due to soft ground conditions and permafrost problems. An alternative well location along a major structural complex adjacent to the Kuussuaq River delta (~ 1 km form the landing site), identified as GRO#3 was then selected (Fig. 1). The well was spudded on August 3, 1996 and completed by October 6, 1996 and was drilled to a depth of 2996.2 m.

Technical details of the GRO#3 well are given in the confidential well termination report (grønArctic, 1997), but some of the released informations are summarized in (Christiansen *et al.*, 1997). GrønArctic reported a number of sand intervals containing hydrocarbons and eight zones were tested. The drill stem test was performed by Alpine testers Ltd. All tests were negative and the well was abandoned. Mud logging service was provided by Sperry-Sun Mud Logging Services and geophysical well services including a full suite of logs, and a VSP (vertical seismic profiling) were provided by Schlumberger.

The aim of the present report is to present a palynological biostratigraphy of the GRO#3 well and to correlate the well to nearby boreholes and exposures.

Geological setting

The West Greenland continental margin was formed in connection with the opening of the Labrador Sea in Late Mesozoic – Early Paleocene time. A complex of linked sedimentary basins stretching from the Labrador Sea to northern Baffin Bay (e.g. Chalmers *et al.*, 1993) extend onshore on Baffin Island and in West Greenland (Fig. 1). The onshore Cretaceous – Early Paleocene basins in West Greenland extend from Disko in the south to Svartenhuk Halvø in the north (Fig. 1). The sedimentary succession in West Greenland is in places 6 – 8 km thick (Christiansen *et al.*, 1995a) of which the uppermost 2.5 km lower Cretaceous (Albian) to Paleocene succession is exposed. The sediments are overlain by 3–5 km picritic

hyaloclastites and continental flood basalts (e.g. Pedersen, 1985). The outcrops are bounded to the east by a faulted contact to the basement which consists of Precambrian gneisses and metasediments (Rosenkrantz & Pulvertaft, 1969; Pedersen & Pulvertaft, 1992).

Palynology

Previous palynological studies on Nuussuaq

Ehman *et al.* (1976) studied the four sections Qilakitsoq (N10), Turritellakløft (N15), Qaarsutjægerdal (N16) and Nassaat (N17) central Nuussuaq (see Nøhr-Hansen, 1996, fig. 2). The ages given by Ehman *et al.* (1976) are Middle Cenomanian and early Danian for N10, Campanian or Maastrichtian to Paleocene for N15, Paleocene for N16 and N17.

Eight sections (M16-M23) from central Nuussuaq (see Nøhr-Hansen, 1996, fig. 2) were sampled by Hansen (1976); data on the palynological content from the two sections M16 and M17 from Tunoqqu have not been published.

Croxton (1978a, b) briefly described the palynomorph assemblages from seven localities (C4-C7, C21, M19, M22) on central Nuussuaq (see Nøhr-Hansen, 1996, fig. 2). The palynomorphs from Qilakitsoq (C4), Qaatunnat Ilorliit (C5), Ilugisssoq (C6) and Nallurarissat (C7) indicate a Late Cenomanian to Early Campanian age. A possible reworked Maastrichtian assemblage is recorded from the top of section C5, and dinoflagellate cysts from the topmost shale at C6 indicate a possible 'middle' Paleocene age (Croxton, 1978a). Sections C21 and M19 represent the 'Oyster-ammonite conglomerate' from Agatdalen; according to Croxton (1978b, 1980) palynomorphs from these sections may indicate reworked Maastrichtian floras. A few dinoflagellate cysts, probably indicating a Late Campanian age, were recorded by Croxton (1978a) from Scaphitesnæsen (M22).

Hansen (1980) described the Paleocene dinoflagellate cysts and proposed a zonation for the mudstones deposited above the so-called 'basal Danian conglomerate' in the Kangilia/ Annertuneq section (Fig. 1).

Hjortkjær (1991) described a middle Paleocene terrestrial flora assemblage from three localities around the valley Saqqaqdalen (Fig. 1) on south east Nuussuaq.

Piasecki *et al.* (1992) described mid-Paleocene dinoflagellate cyst assemblages from sediments interbedded with the Tertiary volcanic rocks on Disko and Nuussuaq and dated the sediments as NP 4 to NP 8.

Nøhr-Hansen (1993) described a low diversity dinoflagellate assemblage of Late Maastrichtian? to Early Paleocene age from the uppermost part of the thick turbidite succession exposed on the south-east side of the Itilli valley in Nuussuaq.

Nøhr-Hansen (1994b; 1996) described the palynomorph assemblages from 15 sections and four subsurface sections in the Agatdalen area and dated the marine succession as Late Santonian to Middle Campanian. One sample is dated as Paleocene.

Nøhr-Hansen (1994c; 1996), Dam & Nøhr-Hansen (1995) described the palynomorph assemblages from five sections and four subsurface sections on the north coast of Nuussuaq. The sections make up an at least 700 m thick dark mudstone succession. The dinoflagellate cysts and pollen date the majority of the samples as Late Campanian and Maastrichtian. A few samples were dated as Coniacian-Late Santonian and Early Paleocene. The section at Annertuneq includes the Cretaceous/Tertiary boundary and the palynomorph assemblage has been described by Nøhr-Hansen & Dam (1997).

Nøhr-Hansen in Christiansen *et al.* (1995b) described the dinoflagellate cyst assemblages from four samples from the GANW#1 well on the south coast of Nuussuaq (Fig. 1) and dated the samples as early Thanetian, now Selandian, Early Paleocene, according to Berggren *et al.*, 1995)

Nøhr-Hansen (1997b) described the palynomorph assemblages from the three holes GANE#1, GANK#1 and GANT#1. GANE#1 and GANK#1 were divided into two informal dinoflagellate cyst intervals dated as Selandian to ?Early Thanetian, Late Paleocene. GANT#1 was dated as Campanian (Late Cretaceous) to Danian (Early Paleocene) and divided into four informal dinoflagellate cyst intervals.

The upper Cretaceous spore and pollen assemblages from the Ataata Kuua section on south-western Nuussuaq have been studied by D. J. McIntyre, but data have not yet been published.

Samples and methods

At the well site, samples of cutting were collected and canned at approximately 10 metre intervals from 40 to 1200 m and at approximately 5 metre intervals from 1200 to 2996 m depth. A set of 70 chip-samples were processed for palynological studies.

Preparation

Palynological preparation and studies were carried out at GEUS. Palynomorphs were extracted from 20 g of sample by modified standard preparation techniques described by Poulsen *et al.* (1990). The organic residues were mounted in glycerol jelly.

Recording of material and analyses

The palynological slides were studied with transmitted light using a Leitz Dialux 22 microscope (512 742/057691). All the co-ordinates in the plate captions refer to this microscope. England finder index corners: Z 75 4 = 74.6-92.3; Z 1 3 = 1.9-92.2; A 1 1 = 1.9-116.7; A 65 2 = 64.6-116.6, centre: O 38 = 38.1-103.3.

The illustrated dinoflagellate cysts are marked with a sample number, slide number, microscope co-ordinates, laser-video-record number (LVR) and data base number (MicroImage; MI) for later identification. The illustrated dinoflagellate cysts are housed at the Geological Survey of Denmark and Greenland (Copenhagen).

Dinoflagellate cyst and acritarch species were recorded from the sieved, oxidised or gravitation-separated slides. Counting of specimens was done on the 50 samples that revealed dinoflagellate cysts (Enclosure 1), approximately 100 specimens were counted when possible.

The dinoflagellate cyst stratigraphy proposed here for the GRO#3 hole is based on the first and the last occurrences and the acme of stratigraphically important species.

Palynostratigraphy and thermal maturity of the bore-hole GRO#3

GRO#3 is situated close to the river Kuussuaq, about 10 km east of the outlet at the western end of the Aaffarsuaq valley (Fig. 1). The K.B elevation of GRO#3 is 22.5 m a.s.l., and the well was drilled to a total depth of 2996 m. The uppermost 300 m of the well consists of volcanics.

The organic geochemical analyses yielded Rock Eval T_{max} values between 431 and 577°C and vitrinite reflectance values (Ro) between 0,6 % and 2,6 % suggesting a considerable variation in thermal maturity from immature (just prior to generation) to post mature (dry gas zone) Bojesen-Koefoed *et al.* (1997).

Palynological intervals

The species recorded from GRO#3 are listed in the range chart (Enclosure 1).

Only a few morphologically characteristic and stratigraphically important species have been recognised, and based on their first and last occurrences it has been possible to distinguish seven dinoflagellate cysts intervals within the Paleocene to Cretaceous strata. The intervals are informally described, and a correlation is suggested to the Paleocene dinoflagellate cyst interval biozones described by Powell (1992) from the North Sea region (Fig. 2) and to the Upper Cretaceous intervals described by Nøhr-Hansen (1996, Fig. 3) from West Greenland.

Interval I, -320 m to -370 m

Age: Late Selandian (Late Paleocene).

This interval just below the volcanics is dominated by terrestrially derived black to brownish woody material, cuticles and few bisaccate pollen. Dinoflagellate cysts are common. The diversity of dinoflagellate cyst is low to moderate (6 to 12 species). The specimens are generally well preserved. Reworking of Late Cretaceous and Early Paleocene species is common at -360 m and -370 m (see Enclosure 1).

Interval I may be correlated with the Selandian *Palaeoperidinium pyrophorum* (Ppy) dinoflagellate cyst Interval Biozone (Fig. 2) described from the North Sea area by Powell (1992).

Characteristic species. The interval is characterised by the presence of *Alisocysta margarita* (rare), *Cerodinium diebelii*, *C. speciosum* (questionable), *C. striatum*. *Isabelidinium* aff. *viborgense*, *Palaeocystodinium bulliforme* and *Palaeoperidinium pyrophorum* (common). The reworked Danian species *Spongodinium delitiense* and *Trithyrodinium fragile* are present in the lowermost part of the interval (Enclosure 1).

Discussion. The first appearance datum (FAD) and last appearance datum (LAD) of *A. margarita* at the base of the interval suggest a Selandian age correlating with the *P. pyrophorum* (Ppy) or the younger early Thanetian *Alisocysta margarita* (Ama) dinoflagellate cyst Interval Biozones (Fig. 2) of Powell (1992). The common occurrence of *P. pyrophorum* and the presence of *C. speciosum* (questionable), *C. striatum*. *P. bulliforme* suggest correlation with the Ppy Interval Biozone since the species all have their LAD at the top of the Ppy Interval Biozone (Powell, 1992; Heilmann-Clausen 1994).

The species from Nuussuaq identified as *Isabelidinium* aff. *viborgense* is morphologically very similar to the stratigraphically important species *Isabelidinium viborgense* described from Denmark (Heilmann-Clausen, 1985). It differs, however, from the holotype of *I. viborgense* by the presence of a distinct pattern of longitudinal folds on the periphragm. *Isabelidinium viborgense* has its LAD in the lower part of the Ppy Interval Biozone and its FAD in the lower part of the older *Cerodinium speciosum* (Csp) Interval Biozone (Powell,1992).

Interval I corresponds to interval I described from the upper part of the GANE#1 and GANK#1 wells (Fig. 1; Nøhr-Hansen, 1997b)

Interval II, -370 m to -590 m

Age: Late Danian/Early Selandian (Early/Late Paleocene)

This interval is dominated by terrestrially derived black to brownish woody material, cuticles and few bisaccate pollen. Dinoflagellate cysts are common. The diversity of dinoflagellate cyst is moderate (8 to 11 species) in the upper part (-380 m to -450 m) and low (4 to 8 species) in the lower part (-450 m to -590 m). The specimens are generally well preserved. Reworking of latest Maastrichtian and earliest Danian species is very common (see Enclosure 1).

Interval II may be correlated with the late Danian to middle Selandian *Cerodinium striatum* (Cst), *Spinidinium densispinatum* (Sde) and *Cerodinium speciosum* (Csp) dinoflagellate cyst Interval Biozones (Fig. 2) described from the North Sea area by Powell (1992).

Characteristic species. The interval is characterised by the presence of *Cerodinium diebelii*, *C. speciosum*, *C. striatum* (questionable), *Isabelidinium* aff. *viborgense*, *Palaeocystodinium bulliforme* and *Palaeoperidinium pyrophorum* (common to dominant from -380 m to -430 m). The reworked Danian species *Cerodinium pannuceum*, *Spongodinium delitiense*, *Trithyrodinium fragile* are present to common in the interval and the uppermost Maastrichtian pollen species *Wodehouseia quadrispina* and *W. spinata* are present from -410 m to -430 m (Enclosure 1).

Discussion. Powell (1992) defined the base of his *Cerodinium striatum* (Cst) dinoflagellate cyst Interval Biozones by the FAD of *Palaeocystodinium australinum* and mentioned that *P. australinum* may be attributable to *P. bulliforme*. Later Heilmann-Clausen (1995) recorded *P.*

australinum from the upper part of the late Danian *Spiniferites cryptovesiculatus* (Scr) dinoflagellate cyst Interval Biozones described by Powell (1992) from the North Sea area (Fig. 2).

The presence of *Cerodinium striatum*, *Palaeocystodinium bulliforme* throughout the interval and the presence and a few questionable specimens of *Cerodinium speciosum* and *Isabelidinium* aff. *viborgense* at the top of interval II suggests a late Danian to early Selandian age.

Interval II corresponds to interval II described from the upper part of the GANE#1 and GANK#1 cores (Fig. 1; Nøhr-Hansen, 1997b)

Interval III, -590 m to -730 m

Age: ?latest Maastrichtian/early Danian (Late Cretaceous/Early Paleocene)

Only one sample from this sandy interval has been analysed. The sample is dominated by terrestrially derived black to brownish woody material, cuticles and few bisaccate pollen. Dinoflagellate cysts are rare and the diversity is very low (2 species).

The interval has been dated as ?latest Maastrichtian/early Danian based on the flora recorded above and below the interval.

The present interval may correspond to interval I described from the uppermost part of GANT#1 (-58.2 m to -133.2 m) which Nøhr-Hansen (1997b) correlated with the early Danian flora described from Annertuneq on the north coast on Nuussuaq (Nøhr-Hansen and Dam,1997).

Interval IV, -730 m to -760 m

Age: Late Maastrichtian

The interval is dominated by terrestrially derived black to brownish woody material, cuticles and few bisaccate pollen and dinoflagellate cysts are rare. The diversity of dinoflagellate cyst is low (2-4 species), and the specimens are generally poorly preserved.

Interval IV is correlated with the Late Maastrichtian *Wodehouseia spinata* interval (Fig. 3) described from northern Nuussuaq (Nøhr-Hansen, 1996; Nøhr-Hansen & Dam 1997). The interval was defined as being from the FAD of *W. spinata* to its LAD.

Characteristic species. The interval is characterised by the presence of the dinoflagellate cyst species *Isabelidinium cretaceum* and the pollen species *W. spinata*.

Discussion. Previously *Isabelidinium cretaceum* has only been reported as reworked in Selandian deposits in the GANK#1 and GANT#1 holes (Nøhr-Hansen, 1997b) and the GRO#3 hole (see Enclosure 1), however, the author has also recorded the species in the uppermost four metres of Cretaceous sediments at Annertuneq on the north coast of Nuussuaq. These sediments have been dated as latest Maastrichtian (Nøhr-Hansen & Dam, 1997).

The occurrence of *I. cretaceum* and *W. spinata* in the present interval suggests a latest Maastrichtian age, and it also suggests that the K/T boundary may be situated just above the top of interval IV.

Interval V, -760 m to -980 m

Age: Early Maastrichtian

The interval is dominated by terrestrially derived black to brownish woody material, cuticles and few bisaccate pollen and dinoflagellate cysts are rare. The diversity of dinoflagellate cyst is low (2-3 species), and the specimens are poorly preserved.

Interval V is correlated with the Early Maastrichtian *Cerodinium diebelii* interval (Fig. 3) described from northern Nuussuaq (Nøhr-Hansen, 1996). The interval was defined as being from the FAD of *Cerodinium diebelii* to immediately below the FAD of *W. spinata*.

Characteristic species. The interval is characterised by the FAD of *C. diebelii* (820 m) and the FAD of *Hystrichosphaeridium tubiferum* (780 m). The presence of a few Paleocene species are considered as caved.

Discussion. The FAD of *C. diebelii* and the FAD of *Hystrichosphaeridium tubiferum* have previously been recorded from the Early Maastrichtian *Cerodinium diebelii* interval described from northern Nuussuaq (Nøhr-Hansen, 1996).

Interval VI, -980 m to -1400 m

Age: ?Early to Late Campanian.

The interval is dominated by terrestrially derived black to brownish woody material, cuticles and few bisaccate pollen and dinoflagellate cysts are rare. The diversity of dinoflagellate cyst is low (2-7 species), and the specimens are generally poorly preserved.

Interval VI can be correlated with the Late Campanian *Isabelidinium cooksoniae* interval (Fig. 3) previously described from the north coast of Nuussuaq (Nøhr-Hansen, 1996). The interval was defined by the abundance of *I. cooksoniae* and *Palaeoperidinium pyrophorum* and its upper boundary being immediately below the first occurrence of *Cerodinium diebelii.*

Characteristic species. Interval VI is characterised by the presence of *I. cooksoniae*, *I. belfastense* and the pollen genus *Aquilapollenites*, whereas *P. pyrophorum* is rare. The lower part of the interval is characterised by common *I. belfastense* and *I. cretaceum* aff. *oviforme* and the presence of some large but poorly preserved *Chatangiella* species including *Chatangiella* aff. *granulifera.*

Discussion. The LAD of *Isabelidinium* cf. *acuminatum* at -1250 m may suggest that the lower part of interval VI correlates with the early to middle Campanian *Aquilapollenites* interval described from central Nuussuaq (Nøhr-Hansen, 1996). The species *I. cretaceum oviforme* was described from the middle late Campanian from the southern Indian Ocean by Mao & Mohr (1992).

Interval VII, -1400 m to -1485 m

Age: ?Coniacian to ?Early Campanian.

The interval is dominated by terrestrially derived black to brownish woody material, cuticles and few bisaccate pollen and dinoflagellate cysts are rare. The diversity of dinoflagellate cysts is low (2-6 species), and the specimens are poorly preserved.

Interval VII may correlate with the Coniacian to Early Campanian floras recorded from central Nuussuaq and Svartenhuk Halvø by Nøhr-Hansen (1994a; 1996; 1997a).

Characteristic species. Interval VI is characterised by common *Ginginodinium* aff. *evittii* and by the presence of *Chatangiella* aff. *granulifera*, *Isabelidinium belfastense*, a single specimen of *Trigonopyxidia ginella*, few questionable specimens of *Trithyrodinium suspectum* and by the absence of the pollen genus *Aquilapollenites* (except from sample -1440 m).

Discussion. The LAD of *Trigonopyxidia ginella* at -1400 m and the LAD of questionable *Trithyrodinium suspectum* at -1440 may suggest a ?Coniacian/Santonian age according to Nøhr-Hansen (1996, 1997a), who recorded the LAD's of *T. ginella* and *T. suspectum* from the Coniacian/Santonian *Heterosphaeridium difficile* interval. The species *Ginginodinium evittii* was described from the Early Senomanian in Alberta, Canada, by Singh (1983).

Interval, - 1485 m to -2996m

Age: ?pre Coniacian/Santonian.

The interval is dominated by terrestrially derived black woody material, cuticles and few bisaccate pollen and very few (possibly caved) dinoflagellate cysts are present. The diversity of dinoflagellate cysts is low (2-6 species). The organic material is very degraded due to a post mature thermal maturity (Bojesen-Koefoed *et al.*, 1997).

Conclusions

The drilled sedimentary successions in the GRO#3 well have been dated as Selandian to ?pre Coniacian/Santonian. The Late Danian to Late Selandian Intervals I and II in GRO#3 correspond to intervals I and II described from the two holes GANE#1 and GANK#1 (Nøhr-Hansen, 1997b). The Early Danian/? latest Maastrichtian Interval III from GRO#3 may correlate with the interval I described from GANT#1 (Nøhr-Hansen, 1997b).

The Late Maastrichtian interval IV from the GRO#3 well can be correlated with the *Wodehouseia spinata* interval described from northern Nuussuaq (Nøhr-Hansen, 1996). The Early Maastrichtian interval V from GRO#3 can be correlated with the *Cerodinium diebelii* interval described from northern Nuussuaq (Nøhr-Hansen, 1996). The ?Early to Late Campanian interval VI from GRO#3 can be correlated with the *Isabelidinium cooksonoae* interval described from northern Nuussuaq (Nøhr-Hansen, 1996). The lower part of interval VI may correlate with the Early to Middle Campanian *Aquilapollenites* interval described from central Nuussuaq (Nøhr-Hansen, 1996).

The flora from the ?Coniacian/Santonian/?Early Campanian interval VII from GRO#3 may correlate with similar floras described from central Nuussuaq and Svartenhuk Halvø (Nøhr-Hansen, 1996, 1997a).

Acknowledgements

The exploration drilling was carried out by the Canadian company grønArctic Energy Inc. The study was economically supported by the Governments of Greenland, Minerals Office, the Danish State through the Mineral Administration for Greenland and the EFP project 1313/960010 'Reservoirmodellering af det vestlige Nuussuaq'. The sample processing was carried out by Yvonne Desezar and Kim Villadsen, the figures were produced by Jette Halskov and reviewing was done by Gregers Dam, all staff at GEUS.

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Figure captions

Fig. 1. Map of Nuussuaq showing the drilling locations.

Fig. 2. Dinoflagellate cyst interval biozones by Powell (1992) from the North Sea region. The position of the Selandian/Thanetian boundary is according to Powell *et al.* (1996) situated at the base of the *Alisocysta margarita* (Ama) dinoflagellate cyst Interval Biozones (Powell, 1992) from the North Sea region. The Selandian/Thanetian boundary is now correlated with the middle part of NP 6 (Berggren *et al.*, 1995).

Fig. 3. Cretaceous palyno-interval onshore West Greenland by Nøhr-Hansen (1996).

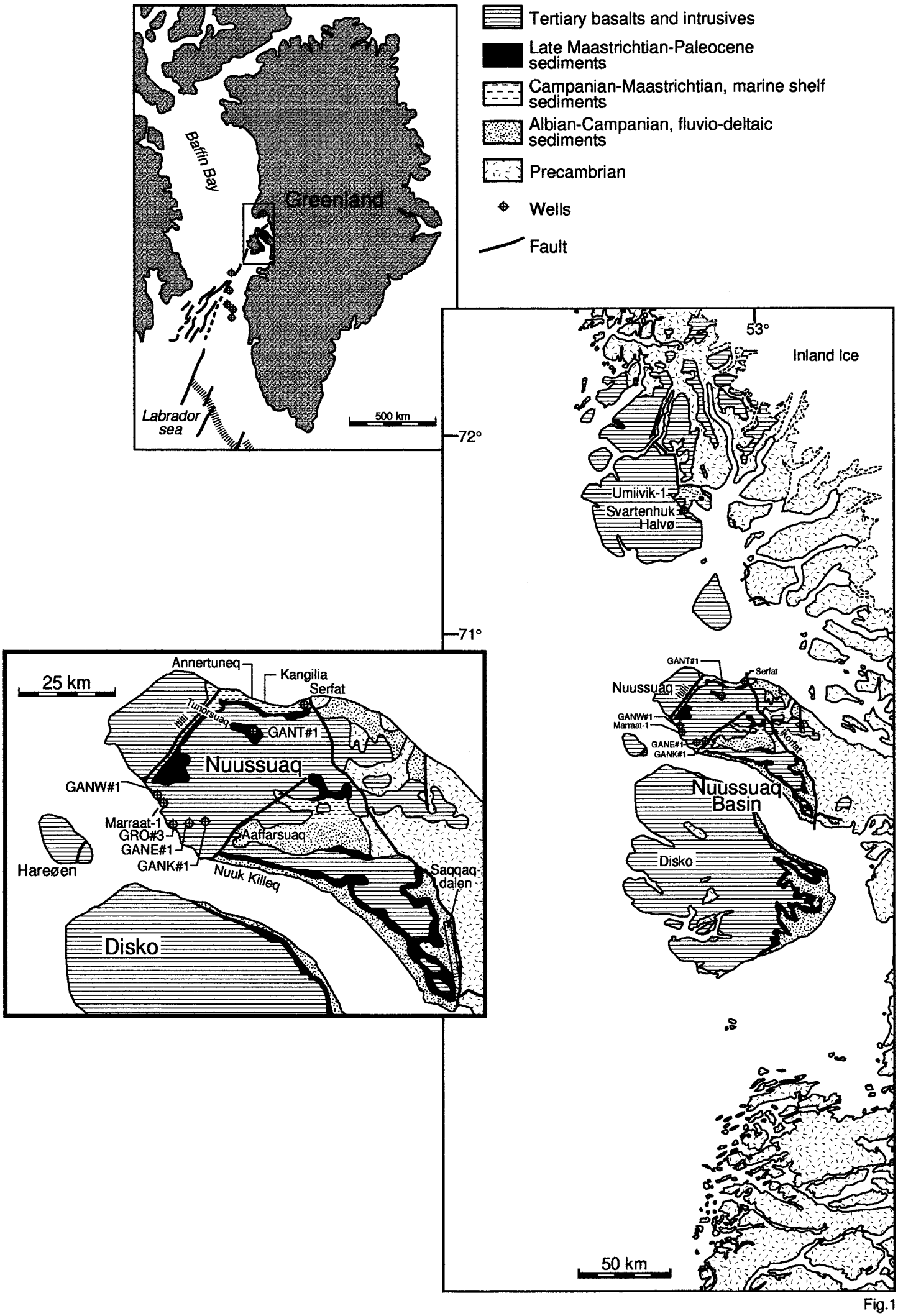

Tertiary basalts and intrusives
Late Maastrichtian-Paleocene sediments
Campanian-Maastrichtian, marine shelf sediments
Albian-Campanian, fluvio-deltaic sediments
Precambrian
Wells
Fault
Baffin Bay
Greenland
Labrador sea
500 km
53°
72°
71°
Inland Ice
Umiivik-1
Svartenhuk Halvø
GANT#1
Serfat
Nuussuaq
GANW#1
Marraat-1
GANE#1
GANK#1
Kangilia
Nuussuaq Basin
Disko
50 km
25 km
Annertuneq
Tunorsuaq
Aaffarsuaq
GRO#3
Hareøen
Nuuk Killeq
Saqqaq dalen

Fig.1

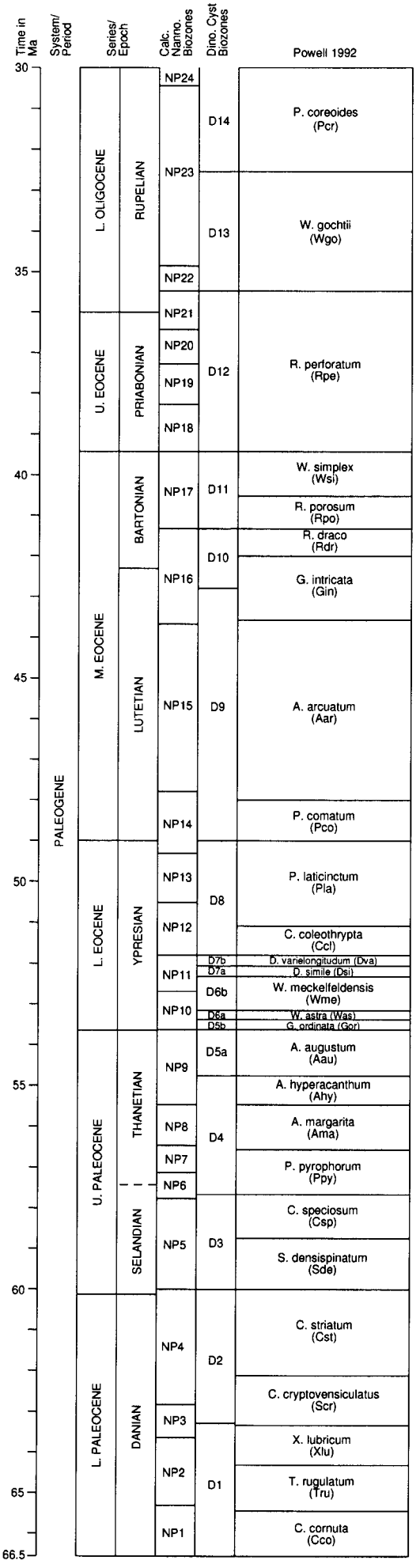

Time in Ma
System/ Period
Series/ Epoch
Calc. Nanno. Biozones
Dino. Cyst Biozones
Powell 1992
30
35
40
45
50
55
60
65
66.5
PALEOGENE
L. OLIGOCENE
RUPELIAN
U. EOCENE
PRIABONIAN
M. EOCENE
BARTONIAN
LUTETIAN
L. EOCENE
YPRESIAN
U. PALEOCENE
THANETIAN
SELANDIAN
L. PALEOCENE
DANIAN
NP24
NP23
NP22
NP21
NP20
NP19
NP18
NP17
NP16
NP15
NP14
NP13
NP12
NP11
NP10
NP9
NP8
NP7
NP6
NP5
NP4
NP3
NP2
NP1
D14
D13
D12
D11
D10
D9
D8
D7b
D7a
D6b
D6a
D5b
D5a
D4
D3
D2
D1
P. coreoides (Pcr)
W. gochtii (Wgo)
R. perforatum (Rpe)
W. simplex (Wsi)
R. porosum (Rpo)
R. draco (Rdr)
G. intricata (Gin)
A. arcuatum (Aar)
P. comatum (Pco)
P. laticinctum (Pla)
C. coleothrypta (Ccl)
D. varielongitudum (Dva)
D. simile (Dsi)
W. meckelfeldensis (Wme)
W. astra (Was)
G. ordinata (Gor)
A. augustum (Aau)
A. hyperacanthum (Ahy)
A. margarita (Ama)
P. pyrophorum (Ppy)
C. speciosum (Csp)
S. densispinatum (Sde)
C. striatum (Cst)
C. cryptovensiculatus (Scr)
X. lubricum (Xlu)
T. rugulatum (Tru)
C. cornuta (Cco)

Fig.2

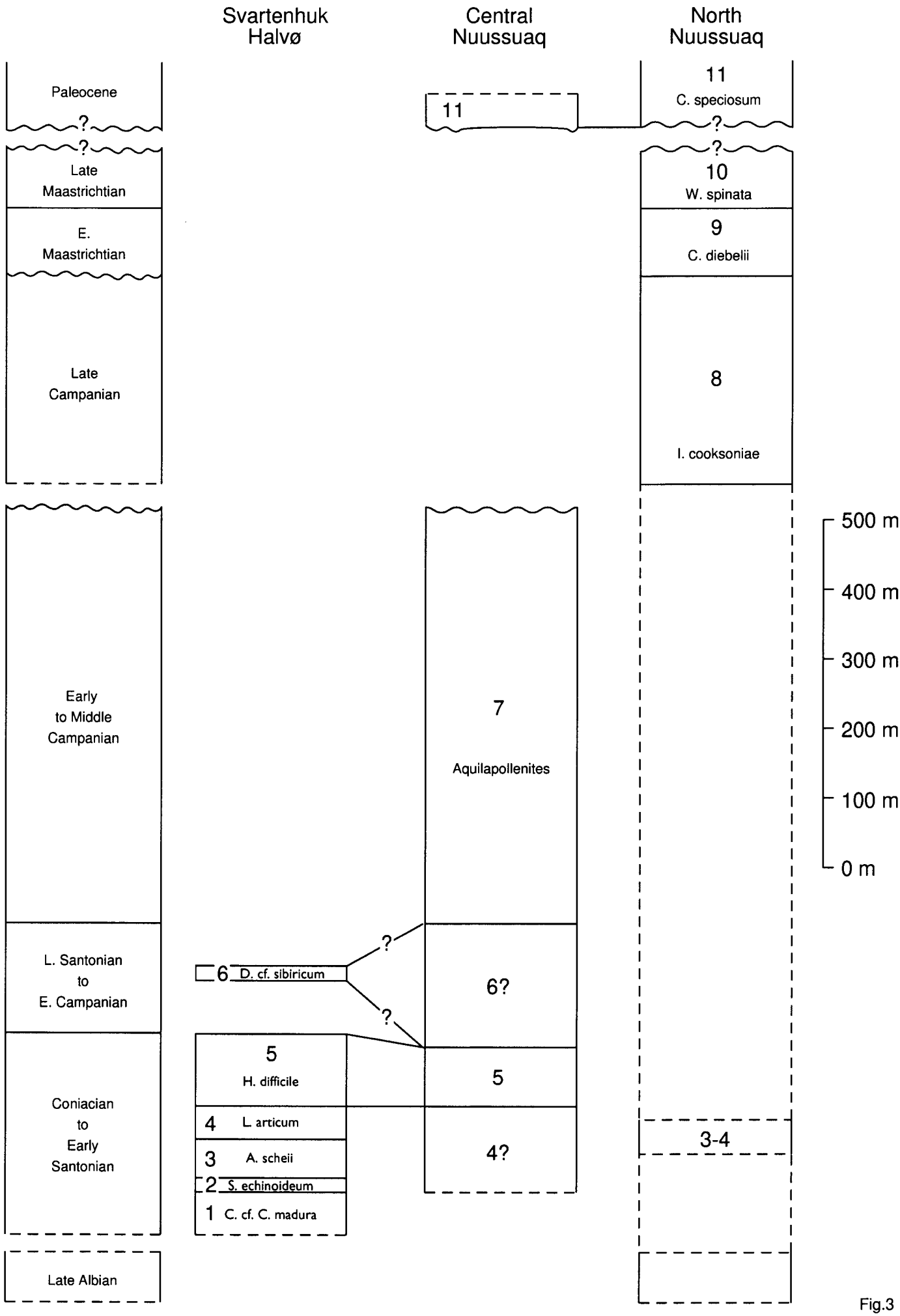
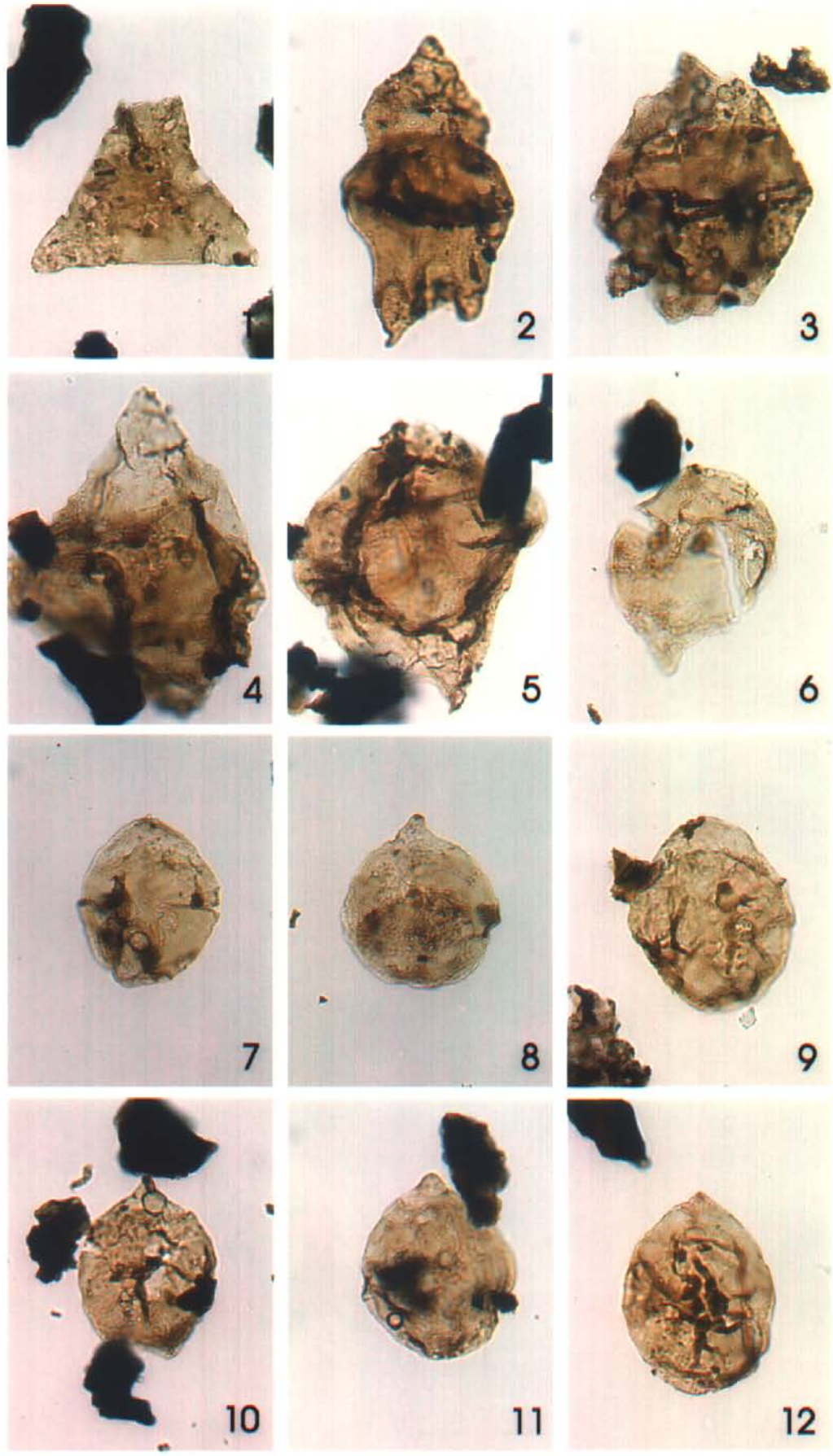

Svartenhuk Halvø
Central Nuussuaq
North Nuussuaq
Paleocene
Late Maastrichtian
E. Maastrichtian
Late Campanian
Early to Middle Campanian
L. Santonian to E. Campanian
Coniacian to Early Santonian
Late Albian
11
C. speciosum
10
W. spinata
9
C. diebelii
8
I. cooksoniae
7
Aquilapollenites
6?
5
4?
3-4
6 D. cf. sibiricum
5 H. difficile
4 L. articum
3 A. scheii
2 S. echinoideum
1 C. cf. C. madura
500 m
400 m
300 m
200 m
100 m
0 m

Fig.3

Plate 1, GRO#3.

Fig. 1. *Trigonopyxidia ginella*, GGU 439401-1400-4, 45.6–108.7; LVR 1.9246; MI 6670
Fig. 2. *Isabelidinium belfastense*, GGU 439401-1200-4, 33.0–112.2; LVR 1.9247; MI 6671.
Fig. 3. *Chatangiella* aff. *granulifera*, GGU 439401-1400-4, 22.3–106.0; LVR 1.9245; MI 6669.
Fig. 4. *Chatangiella* sp. large, GGU 439401-1320-4, 21.9–102.5; LVR 1.9244; MI 6668.
Fig. 5. *Chatangiella* sp. large, GGU 439401-1320-5, 43.6–107.1; LVR 1.9243; MI 6667.
Fig. 6. *Isabelidinium* aff. *acuminatum*, GGU 439401-1250-6, 23.7–93.6; LVR 1.9242 MI 6665.
Fig. 7. *Isabelidinium cretaceum* aff. *oviforme*, GGU 439401-1230-5, 17.7–111.2; LVR 1.9239; MI 6663.
Fig. 8. ?*Isabelidinium cretaceum* aff. *oviforme*, GGU 439401-1230-5, 21.0–94.2; LVR 1.9240; MI 6664.
Fig. 9. *Isabelidinium cretaceum* aff. *oviforme*, GGU 439401-1230-5, 44.9–96.9; LVR 1.9241 MI 6666.
Fig. 10. *Ginginodinium* aff. *evittii*, GGU 439401-1440-4, 45.8–106.0; LVR 1.9248; MI 6672.
Fig. 11. *Ginginodinium* aff. *evittii*, GGU 439401-1440-6, 21.2–102.1; LVR 1.9249; MI 6673.
Fig. 12. *Ginginodinium* aff. *evittii*, GGU 439401-1440-4, 47.6–96.9; LVR 1.9250; MI 6674.


20 µm
1
2
3
4
5
6
7
8
9
10
11
12

ENCLOSURE 1 | SHEET: 1 | SCALE: 1: 4000 | Groups: A D S P E | Complete spp. set

GEUS

439401 GRO#3 (300 - 2950m)

SYSTEM: TERTIARY | U CRETACEOUS

STAGE: L MAASTRICHTIAN | ?U MAASTR/L DANIAN | U DANIAN/L SELAND. | U SELANDIAN

PALYNO. ZONES: V | VI | III | IV | II | I

?CONIA TO ?L CAMP | VII

DEPTH

SIGNATURES

1 *Pterospermella spp.*
2 *Schizocystia spp.*
3 *Acritarch spp*
4 *C.speciosum cf.glabrum*
5 *Isabelidinium aff.viborgense*
6 *Palaeocystodinium bulliforme*
7 *Hystrichosphaeridium tubiferum*
8 *Cerodinium diebelii*
9 *Circulodinium distinctum*
10 *Spinidinium spp.*
11 *Palaeocystodinium golzowense*
12 *Glaphyrocysta spp.*
13 *Cerodinium spp.*
14 *Palaeoperidinium pyrophorum*
15 *Alisocysta margarita*
16 *Alisocysta circumtabulata*
17 *Alisocysta spp.*
18 *Cerodinium striatum*
19 *Spiniferites spp.*
20 *Exochosphaeridium spp.*
21 *Areoligera spp.*
22 *Isabelidinium cretaceum*
23 *Isabelidinium spp.*
24 *Isabelidinium cooksoniae*
25 *Isabelidinium belfastense*
26 *Laciniadinium arcticum*
27 *Chatangiella spp.*
28 *Oligosphaeridium spp.*
29 *Oligosphaeridium pulcherrimum*
30 *Chatangiella aff.granulifera*
31 *Odontochitina operculata*
32 *Chatangiella sp large*
33 *Chatangiella ditissima*
34 *I.creta. aff.oviforme*
35 *Isabelidinium cf.acuminatum*
36 *Laciniadinium cf.arcticum*
37 *Trigonopyxidia ginella*
38 *Ginginodinium aff.evittii*
39 *Achomosphaera spp*
40 *Trithyrodinium fragile*
41 *Senegalinium spp.*
42 *Isabelidinium majae*
43 *Fromea fragilis*
44 *Chatangiella aff.ditissima*
45 *Cerodinium pannuceum*
46 *Deflandrea galeata*
47 *Spongodinium delitiense*
48 *Thalassiphora pelagica*
49 *Senoniasphaera inornata*
50 *Tanyosphaeridium magdalinum*
51 *Palynodinium grallator*
52 *Disphaerogena carposphaeropsis*
53 *Cerodinium speciosum*
54 *Trithyrodinium suspectum*
55 *Heterosphaeridium difficile*
56 *Wodehouseia spinata*
57 *Aquilapollenites spp.*
58 *Pseudointegricorpus protrusum*
59 *Aquilapollenit. aff.clarireticulatu*
60 *Aquilapollenites cf.magnus*
61 *Aquilapollenites reductus*
62 *Wodehouseia quadrispina*
63 *Wodehouseia stanleyi*
64 *Striatacorpus spp.*

ALPHABETICAL SPECIES LIST

39 Achomosphaera spp.
3 Acritarch spp
16 Alisocysta circumtabulata
15 Alisocysta margarita
17 Alisocysta spp.
59 Aquilapollenit. aff clarireticulatu
60 Aquilapollenites cf.magnus
61 Aquilapollenites reductus
57 Aquilapollenites spp.
21 Areoligera spp.
4 C.speciosum cf.glabrum
8 Cerodinium diebelii
45 Cerodinium pannuceum
53 Cerodinium speciosum
13 Cerodinium spp.
18 Cerodinium striatum
44 Chatangiella aff.ditissima
30 Chatangiella aff.granulifera
33 Chatangiella ditissima
32 Chatangiella sp large
27 Chatangiella spp.
9 Circulodinium distinctum
46 Deflandrea galeata
52 Disphaerogena carposphaeropsis
20 Exochosphaeridium spp.
43 Fromea fragilis
38 Ginginodinium aff.evittii
12 Glaphyrocysta spp.
55 Heterosphaeridium difficile
7 Hystrichosphaeridium tubiferum
34 I.creta. aff.oviforme
5 Isabelidinium aff.viborgense
25 Isabelidinium belfastense
35 Isabelidinium cf.acuminatum
24 Isabelidinium cooksoniae
22 Isabelidinium cretaceum
42 Isabelidinium majae
23 Isabelidinium spp.
26 Laciniadinium arcticum
36 Laciniadinium cf.arcticum
31 Odontochitina operculata
29 Oligosphaeridium pulcherrimum
28 Oligosphaeridium spp.
6 Palaeocystodinium bulliforme
11 Palaeocystodinium golzowense
14 Palaeoperidinium pyrophorum
51 Palynodinium grallator
58 Pseudointegricorpus protrusum
1 Pterospermella spp.
2 Schizocystia spp.
41 Senegalinium spp.
49 Senoniasphaera inornata
10 Spinidinium spp.
19 Spiniferites spp.
47 Spongodinium delitiense
64 Striatacorpus spp.
50 Tanyosphaeridium magdalinum
48 Thalassiphora pelagica
37 Trigonopyxidia ginella
40 Trithyrodinium fragile
54 Trithyrodinium suspectum
62 Wodehouseia quadrispina
56 Wodehouseia spinata
63 Wodehouseia stanleyi