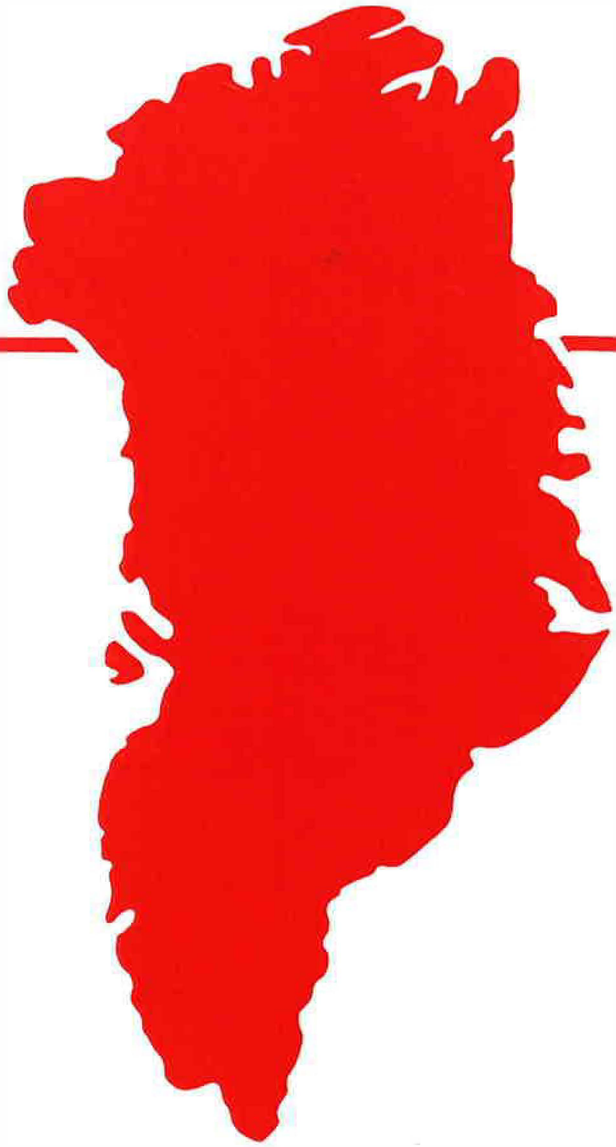
Dinoflagellate cyst biostratigraphy of the Upper Cretaceous black mudstones between Niaqornat and Ikorfat on the north coast of Nuussuaq, West Greenland



Henrik Nøhr-Hansen

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GRØNLANDS GEOLOGISKE UNDERSØGELSE
Ujarassiortut Kalaallit Nunaanni Misissuisoqarfiat
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Dinoflagellate cyst biostratigraphy of the Upper Cretaceous black mudstones between Niaqornat and Ikorfat on the north coast of Nuussuaq, West Greenland

Henrik Nøhr-Hansen

September 1994

Abstract

Stratigraphical ranges and geographical distribution of dinoflagellate cysts and selected pollen species are described on the basis of analysis of approximately 75 samples from 5 surface and 3 subsurface sections of Late Cretaceous age from the north coast of Nuussuaq, West Greenland. The sections make up an approximately 500 m thick black mudstone succession, previously dated as Late Campanian to Maastrichtian on the basis of scattered ammonite occurrences.

The dinoflagellate cysts and pollen date the majority of the studied samples to Late Campanian and Maastrichtian, whereas a few samples have been dated as Coniacian–Late Santonian and Early Paleocene.

It has been possible to divide the Late Campanian and Maastrichtian strata into three intervals based on three distinguishable palynomorph assemblages. The diversity of the studied dinoflagellate cysts is relatively low to very low; approximately 57 species were recorded.

New finds of ammonites and the new study of the palynomorphs move the Cretaceous–Tertiary boundary from the base of what was previously called the "basal Danian conglomerate" at Annertuneq to approximately 118 m above the top of this conglomerate.

CONTENTS

INTRODUCTION

The present study is part of the project 'Sequence stratigraphic analysis of the Cretaceous sediments in West Greenland', and aims to establish a palynostratigraphy for a key section for the sequence stratigraphical analysis for the Disko–Nuussuaq–Svartenhuk Halvø area in West Greenland (Christiansen *et al.*, 1992; Christiansen, 1993; Nøhr-Hansen, 1994a; 1994b). The project has been supported by funds from the Danish Ministry of Energy (Grant No. EFP 1313/91 0014).

The Upper Cretaceous–Lower Tertiary black mudstones on Nuussuaq and Svartenhuk Halvø constitute the only marine sediments of this age exposed in the entire Labrador Sea–Baffin Bay region, and studies of these are therefore essential for a detailed interpretation of not only onshore but also offshore geology in this region.

The stratigraphic correlation of the sediments in the region is problematic due to the interdigitating of Cretaceous fluviatile, deltaic and brackish to fully marine deposits which have been dated using very different types of fossils (Schiener, 1975; Pulvertaft, 1979, 1987; Pedersen & Pulvertaft, 1992).

Field work on the marine succession in the summers 1990 to 1992 was concentrated on detailed sedimentological studies, sampling for palynological and organic geochemical studies, and mapping and structural analysis (Christiansen *et al.*, 1992).

PREVIOUS PALYNOLOGICAL STUDIES IN THE SANTONIAN TO CAMPANIAN OF GREENLAND AND ELSEWHERE

West Greenland

Previous studies of Upper Cretaceous dinoflagellate cysts from West Greenland are few (Croxton, 1976, 1978, 1978a, 1980; Ehman *et al.*, 1976; Lentin & Williams, 1980).

The studies by Nøhr-Hansen (1994a, 1994b) confirm the observation by Lentin & Williams (1980, p. 20) that the Campanian assemblage from West Greenland contains elements of both the offshore eastern Canadian assemblages (also called the Williams suite) and the Mackenzie Delta assemblages from Arctic Canada (the McIntyre suite) described by McIntyre (1974, 1975).

Croxton (1978, 1978a, 1980) briefly described the palynomorph content from three localities between Niaqornat and Ikorfat (Fig. 1) on the north coast of Nuussuaq (M25, M27-28, Fig. 1). The palynomorphs from these three localities in the Kangilia and Annertuneq area indicate a Late Campanian to Maastrichtian age.

Hansen (1980) described the Paleocene dinoflagellate cyst content and proposed a zonation for the mudstone deposited above the so-called basal Danian conglomerate at the Kangilia/Annertuneq section (M25).

Piasecki *et al.* (1992) described mid-Paleocene dinoflagellate cyst assemblages from sediments intercalated in the Tertiary volcanic rocks on Disko and Nuussuaq.

Nøhr-Hansen (1993) described a low diversity dinoflagellate assemblage of Late Maastrichtian? to Early Paleocene age from the uppermost part of the more than two kilometre thick turbidite succession exposed immediately below the Tertiary pillow breccia on the south-east side of the Itilli valley in Nuussuaq, and compared the results with preliminary palynological studies of the Kangilia section.

Arctic Canada

Santonian to Maastrichtian Upper Cretaceous dinoflagellate cysts have been described from Arctic Canada by Manum (1963), Manum & Cookson (1964), Felix & Burbridge (1976), McIntyre (1974, 1975), Doerenkamp *et al.* (1976), Ioannides & McIntyre (1980) and Núnez-Betelu & Hills (1992). Ioannides (1986) studied the dinoflagellate cyst assemblages from the Santonian to Maastrichtian part of the Kanguk Formation and the Lower Paleocene Eureka Sound Formation on Bylot and Devon Islands. The dinoflagellate cyst assemblages described by Ioannides (1986) is very similar to the material from West Greenland; unfortunately, however, Ionnanides' stratigraphy is not very detailed due to poor outcrop and absence of macrofossils.

Western Canada, Western U.S.A.

Upper Cretaceous dinoflagellate cyst assemblages from western Canada and western U.S.A. have been described by Stanley (1965), Wall & Singh (1975), Harland (1973, 1977), Sweet & McIntyre (1988), Stone (1973) and Harker *et al.* (1990). Nichols & Sweet 1993 described the biostratigraphy of the Upper Cretaceous non-marine palynofloras in a north–south transect of the Western Interior Basin. The stratigraphical ranges given for the genera *Aquilapollenites* and *Wodehouseia* by Nichols & Sweet (1993) are very important for the dating the Upper Cretaceous sediment of northern Nuussuaq.

Offshore Eastern Canada, Eastern U.S.A. and the northern hemisphere

Burden & Langille (1991) described the palynology of the Cretaceous and Tertiary strata at Cape Dyer, east Baffin Island. These strata are the closest onshore Cretaceous to Tertiary deposits to West Greenland; unfortunately the exposures are dominated by terrestrial deposits of Aptian to Albian and Paleocene to Eocene ages.

Upper Cretaceous dinoflagellate cysts from offshore eastern Canada are described by Barss *et al.* (1979), Bujak & Williams (1978), Williams (1975), Williams & Brideaux (1975), Williams & Bujak (1977a, 1977b), Williams *et al.* (1974) and Williams *et al.* (1990).

The stratigraphical distribution of Mesozoic and Cenozoic dinoflagellate cysts has been described by Williams & Bujak (1985) for the world and by Williams *et al.* (1993) for the northern hemisphere.

Upper Cretaceous to Paleocene dinoflagellate cyst assemblages from eastern U.S.A. are described by Benson (1976), May (1980), Tocher (1987), Moshkovitz & Habib (1993), Aurisano & Habib (1977) who established a Campanian to lowermost Tertiary dinoflagellate cyst zonation, and by Aurisano (1989) who proposed a Cenomanian to Maastrichtian dinoflagellate cyst zonation for the Atlantic Coastal Plain of New Jersey and Delaware.

Northern North Sea, clastic deposits

According to Costa & Davey (1992, pp. 105–106) dinoflagellate cyst information has not been published from this region, apart from Costa (1985). However, an observation by Lucy I. Costa (reported in Costa & Davey, pp. 105–106) indicates assemblage affinities with the Upper Cretaceous arctic assemblages described by Vozzhennikova (1967) from Siberia, Manum & Cookson (1964) and Doerenkamp *et al.* (1976) from Arctic Canada, and McIntyre (1974) from the District of Mackenzie, Canada.

North-western Europe

The stratigraphical distribution of Upper Cretaceous dinoflagellate cysts in North-West Europe has been compiled by Foucher (1979) and Costa & Davey (1992). Foucher (1983) and Robaszynski *et al.* (1983) described the palynology of the Campanian to Maastrichtian in Belgium and the Netherlands. Hart *et al.* (1987) listed dinoflagellate cysts together with other microfossils from key Upper Cretaceous sections on the Isle of Wight. Marheinecke (1992) described the dinoflagellate cyst content and proposed a zonation for the Maastrichtian from Niedersachsen in northern Germany. Schiøler & Wilson (1993) proposed a dinoflagellate cyst zonation for the Dan Field in the Danish part of the North Sea.

Australia, Antarctica

There are numerous papers describing Cretaceous dinoflagellate cysts from Australia. Helby *et al.* (1987) established a palynological zonation covering the entire Mesozoic of Australia.

Askin (1988) described the Campanian to Eocene palynological succession of Seymour Island and adjacent islands, Antarctica.

Mohr & Gee (1992) and Mao & Mohr (1992) described the Cenomanian to Maastrichtian dinoflagellate cyst assemblages from the ODP leg 120 in the southern Indian Ocean.

The interesting point about the Upper Cretaceous palynomorphs recorded from Australia and around Antarctica is that they are very similar at generic level to the material recorded from West Greenland, whereas at species level there are small but distinguishable differences between superficially similar species from the two regions, which makes direct correlation difficult.

SAMPLES AND METHODS

Samples

This study covers samples from northern Nuussuaq obtained from five outcrop localities and three slim cores from shallow wells drilled by GGU in 1992 (Figs 1, 2). The sections are 20 to 470 metres thick and represent an approximately 500 m thick sandy shale succession.

Preparation

Palynological preparation and studies were carried out at GGU. Palynomorphs were extracted from 20 g of sample by modified standard preparation techniques. The bulk of the minerals were dissolved by hydrochloric and hydrofluoric acids. A first slide was made after this treatment. A second slide was made of the organic residue after sieving using a 20 micron nylon mesh. A third slide was made after oxidation (3 to 10 minutes) with fuming nitric acid, followed by washing with a weak potassium hydroxide solution. The oxidation was carried out in order to clean the sample of minor amorphous kerogen particles and pyrite. Finally, palynomorphs were separated from coal particles and woody material in most samples using the separation method described by Hansen & Gudmundsson (1978).

After each of the steps mentioned above the organic residues were mounted in a permanent medium (Eukitt R; produced by O. Kindler, Germany).

Recording of material and analyses

The palynological slides were studied with transmitted light using a Leitz Dialux 22 microscope (512 742/057691). All the coordinates in the plate captions refer to this microscope. England finder index corners: Z 75 4 = 74.6–92.3; Z 1 3 = 1.9–9220; 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 GGU number (sample number), slide number, microscope coordinates, laser-video-record number (LVR) and database number (MicroImage; MI) for later identification. The slides are housed at the Geological Survey of Greenland, Copenhagen where they are accessible for examination.

Composition of the organic material and maturation

The organic material is dominated by terrestrially derived black to brownish woody material and cuticles, whereas amorphous organic material, dinoflagellate cysts, spores and pollen constitute only a minor part.

A TAI (Thermal Alteration Index) evaluation was carried out on the sieved slide before oxidation. The study revealed TAI values between –2 and 3, which indicate that the organic material is thermally immature to mature with respect to oil generation. The TAI values agree with the chemical analyses of the organic material which yelled Tmax values between 404 and 456 °C.

DINOFLAGELLATE CYST STRATIGRAPHY AND ZONATION IN NORTHERN NUUSSUAQ

The dinoflagellate cyst and pollen stratigraphy that is proposed for the marine Upper Cretaceous deposits at northern Nuussuaq is based principally on a detailed study of material from five surface sections and three slim cores from shallow wells. Additional several spot samples from ten other surface sections have been studied in order to confirm that the detailed sections include the entire exposed Upper Cretaceous mudstone sequence situated between Niaqornat and Ikorfat on the northern coast of the peninsula (Figs 1, 2).

Marine palynomorphs were recorded from all the sections studied between Niaqornat and Ikorfat. Due to the very sparse macrofossil content and the monotonous lithology, the stratigraphical correlation of the five sections presented is based solely on the first and the last occurrences and acme of stratigraphically important dinoflagellate cysts and selected pollen species.

The present dating and stratigraphical correlation is based on limited observations as the dinoflagellate cyst diversity in the sections is low and the specimens are not always well preserved. Samples dominated by terrestrial material are common.

The mudstone succession between sea level and the conspicuous "basal Danian conglomerate" (approximately 280 m a.s.l.) of Rosenkrantz (1970) has been dated in the present study as Late Campanian, based on the presence of *Chatangiella* aff. *ditissima*, *Odontochitina striatoperforata* and the pollen genus *Aquilapollenites* (Fig. 3, Encl. 1), and on the absence of large *Isabelidinium* species.

Aquilapollenites has been recorded in the lower part of four of the studied sections. According to Traverse (1988) *Aquilapollenites* has a sporadic occurrence from Late Turonian to Late Santonian, whereas its occurrence becomes consistent in the latest Santonian and continues to the Early Paleocene. Nichols & Sweet (1993) described the first occurrence of the genus *Aquilapollenites* in the uppermost Santonian from Yukon in the Northwest Territories of Canada, whereas they first recorded the genus in the lower Campanian in New Mexico, USA. McIntyre (1974) did not record *Aquilapollenites* species in sediments older than middle to Upper Campanian in the District of Mackenzie, Arctic Canada. Croxton (1980, p. 16) concluded ''Although only a preliminary assessment has to date been made of the earliest occurrence of *Aquilapollenites* in West Greenland it is not thought to occur in strata older than Campanian in age''. The fact that Nøhr-Hansen (1994a, 1994b) did not record *Aquilapollenites* in the Coniacian to Upper Santonian sediments on Svartenhuk Halvø and central Nuussuaq suggests that the genus has a post-Late Santonian occurrence in West Greenland.

The absence of large *Isabelidinium* species such as *I. accumiantum* and *I. microarmum* in sediments on the north coast of Nuussuaq between Niaqornat and Ikorfat suggests that the lowermost exposed strata in the area are younger than the middle to ?Late Campanian strata described from the central Nuussuaq by Nøhr-Hansen (1994b).

According to Costa & Davey (1992) and Williams *et al.* (1993) *Chatangiella ditissima* has its last occurrence in the uppermost Campanian and *Odontochitina* species have their last occurrence in the lowermost Maastrichtian.

The "basal Danian conglomerate" is approximately 50 m thick at Annertuneq; no palynomorphs have been recorded from this interval (Fig. 3, Encl. 1, 6).

The Kangilia Formation, which has been defined as the "basal Danian conglomerate" and the overlying mudstone situated below the Lower Tertiary volcanic rocks at Kangilia, constitutes approximately 500 m of strata (Encl. 6). The Kangilia Formation has previously been dated as late Early Paleocene to late middle Paleocene by Hansen (1980, Encl. 6) on the basis of dinoflagellate cysts. Hansen (1980, fig. 49) correlated the interval with the nannoplankton zones NP3 to NP6.

During field work in the present study ammonites were found in a loose concretion at 50 m and *in situ* at 112 m above the top of the conglomerate at the Annertuneq section. These new finds and the last records of the pollen genera *Aquilapollenites* and *Wodehouseia* at 112 and at 118 m above the conglomerate (Fig. 3, Encl. 1) indicate that the Cretaceous–Tertiary boundary is situated at approximately 118 m above the top of the thick conglomerate at Annertuneq and not at the base of the conglomerate as previous stated by Rosenkrantz (1970) when he termed the conglomerate the "basal Danian conglomerate".

Hansen (1980, figs 14 & 15, p. 89) mentioned that he had no dinoflagellate cyst recovery from the lowermost 140 m of the Kangilia Formation but that it should not be excluded that these strata might represent the *Spiniferites cryptovesiculatus* Zonule (formerly *Hafniasphaera cryptovesiculata*) equivalent to parts of NP3 and NP4 or older strata.

Hansen (1980) recorded the genus *Aquilapollenites* consistently up to 160 m above the conglomerate (Encl. 6) and Croxton (1980) recorded the genera *Aquilapollenites* and *Wodehouseia* up to approximately 115 m above the conglomerate. Croxton (1980) wrote that no conclusive statement could be made on the current palynological evidence as to whether this interval (approximately 115 m) of strata above the conglomerate represents: 1) Paleocene strata, 2) Maastrichtian strata, or 3) Paleocene strata enclosing largely reworked palynomorph assemblages from different (? younger) Maastrichtian strata below the conglomerate. Neither Birkelund (1965), Croxton (1980) nor Hansen (1980) knew as we do today that ammonites exist *in situ* in the interval in question.

An extract of Hansen's (1980, fig. 15) range chart from the Annertuneq/Kangilia section (M25) is shown in Encl. 6; this shows Hansen's zonation and his proposed correlation to the nannoplankton zones.

The find of ammonites *in situ* at Annertuneq confirm that the lower part of Hansen's (1980) *Cerodinium striatum* (formerly *Deflandrea striata*) Zonule (samples 210433-210447, Encl. 6) in profile M25 is of latest Maastrichtian age and that the Cretaceous–Tertiary boundary may be situated in an interval between 118 and 135 m above the conglomerate.

Hansen's (1980, p. 123, fig. 49) correlation between dinoflagellate cyst zonation and nannoplankton zones disagrees with the occurrence of nannoplankton characteristic of NP3 recorded by Jürgensen & Mikkelsen (1974) from samples collected just below the volcanic rocks at Annertuneq. An explanation of this disagreement is beyond the scope of the present report; renewed studies of Hansen's samples may solve the correlation problem or simply end up with the conclusion that some stratigraphically important dinoflagellate cyst species have an earlier first occurrence in West Greenland than other places such as the North Sea.

The species list on the cumulative range chart (Encl. 1) illustrates that the assemblages are of very low diversity. Approximately 67 dinoflagellate cyst, pollen and acritarch species were recorded. Based on the first and last occurrence, presence or absence of a few morphologically characteristic and stratigraphically important species, it has been possible to distinguish three intervals with characteristic dinoflagellate and pollen content from the cumulative Annertuneq section (Encl. 1).

Two minor sections (HNH 920824/2 and FGC 900813/7) have been studied from the area around Ikorfat (Fig. 1). Section HNH 920824/2 (Encl. 5) revealed the species *Heterosphaeridium difficile*, *Surculospheridium? longifurcatum* and questionable specimens of *Arvalidinium* aff. *scheii* and *Laciniadinium arcticum* which according to Costa & Davey (1992) and Nøhr-Hansen (1994a, 1994b) indicate a Coniacian to Late Santonian age. The two lower samples from the other section FGC 900813/7 (Encl. 4) correlate with the Upper Maastrichtian strata of Annertuneq; ammonites have been sampled from the same level as the uppermost sample (366623). The record of the Tertiary dinoflagellate species *Senegalinium? dilwynense* in the lowermost Tertiary sample (366624, Encl. 4) situated 15 m above the uppermost Maastrichtian sample (366623) indicate a hiatus, *S? dilwynense* has its first occurrence at approximately 180 m above the last ammonite in the Annertuneq section (Encl. 6).

Isabelidinium cooksoniae interval

The sparse dinoflagellate cyst assemblage recorded from the *I. cooksoniae* interval (Encl. 1, 2, 3) indicates the presence of the oldest recorded marine influenced depositional environment between Niaqornat and Ikorfat on the north coast of Nuussuaq.

Age. The age of the interval is most likely Late Campanian.

Definition. The interval is defined by the abundance of the species *Isabelidinium cooksoniae* and *Palaeoperidinium pyrophorum*, the upper limit being immediately below the first occurrence of *Cerodinium diebelii.*

Thickness and distribution. Approximately 280 m of composite strata in the subsurface wells GGU 400705, 400706, 400707 (Fig. 2) and sediments below the conspicuous conglomerate at the north coast of Nuussuaq (Encl. 1, 2, 3) are described as the *I. cooksoniae* interval.

Characteristic species. The interval is characterised by the abundance of *Isabelidinium cooksoniae* and *Palaeoperidinium pyrophorum*, and by the presence of *Chatangiella* aff. *ditissima*, *Odontochitina striatoperforata*, *Laciniadinium arcticum* and the pollen genus *Aquilapollenites*. Only a few specimens of the genera *Xenascus* and *Hystrichodinium* have been recorded. The species *Fibrocysta?* sp. cf. *F. vectensis* of Ioannides (1986) has only been recorded from the uppermost part of the interval at Annertuneq (Encl. 1), and the informal species *"Isabelidinium bujakii"* of Marheineche's (1992) has its first occurrence in the same interval.

Discussion. The presence of the pollen genus *Aquilapollenites* indicates an age not older than latest Santonian or earliest Campanian (see discussion above). According to Costa & Davey (1992) and Williams *et al.* (1993) the presence of the species *Chatangiella* aff. *ditissima*, *Odontochitina striatoperforata* and *Xenascus* indicates an age no younger than Early Maastrichtian. The absence of the large *Isabelidinium* species such as *I. acuminatum* and *I. microarmum* in the interval indicates an assemblage younger than the middle to ?Late Campanian assemblages described from the central Nuussuaq by Nøhr-Hansen (1994b).

***Cerodinium diebelii* interval**

Age. ?Early Maastrichtian

Definition. The interval is defined as being from the first occurrence of *Cerodinium diebelii* to immediately below the first occurrence of the pollen species *Wodehouseia spinata*.

Thickness and distribution. The interval is represented in the Annertuneq sections (Encl. 1) by approximately 46 m, in the Kangilia section (Encl. 2) by one sample, in section FGC 900813/7 (Encl. 4) by one sample and in section HNH 910718/1 (Encl. 3) by more than 30 m.

Characteristic species. The interval is characterised by the first occurrence of the species *Cerodinium diebelii, Paleocystodinium golzowense, Impagidinium* cf. *dispertitum*, the informal subspecies *"Hystrichosphaeridium proprium proprium"* of Marheinecke (1992) and by the presence of the informal species *"Isabelidinium bujakii"* of Marheinecke (1992) and representatives of the pollen genus *Aquilapollenites*. The lowermost sample (366589) at Annertuneq (Encl. 1) is dominated by *"H. p. proprium"* and *Chatangiella* aff. *granulifera* of which the latter may be reworked. The species *Chatangiella* aff. *ditissima*, *Isabelidinium cooksoniae*, *Laciniadinium arcticum* and *Odontochitina striatoperforata* are, when they occur, only recorded from the lowermost part of the interval.

Discussion. The first occurrence of *Cerodinium diebelii* has previously been reported from Early Maastrichtian in Arctic Canada (McIntyre, 1975) and from the Atlantic Coastal Plain of U.S.A. (Aurisano, 1989), whereas Williams, *et al.* (1993) reported a Late Santonian first occurrence for *C. diebelii* in the Northern Hemisphere and Costa & Davey (1992) reported a Late Campanian first occurrence from the North Sea area.

The informal species *"Isabelidinium bujakii"* was described and reported only from the latest Early Maastrichtian in Germany by Marheineche (1992). According to Costa & Davey (1992) and Williams *et al.* (1993) *Chatangiella ditissima* has its last occurrence in the uppermost Campanian and *Odontochitina* species have their last occurrence in the lowermost Maastrichtian.

The first occurrence of *C. diebelii* and the last occurrence of *C.* aff. *ditissima*, *O. striatoperforata* in the lowermost part of the interval, and the presence of *"I.* cf. *bujakii"* throughout the interval, suggest an Early Maastrichtian age.

Wodehouseia spinata interval

Age. Late Maastrichtian

Definition. The interval is defined as being from the first occurrence of the pollen species *Wodehouseia spinata* to the last occurrence of the *Wodehouseia spinata*.

Thickness and distribution. The interval is represented by approximately 80 m in the Annertuneq section (Encl. 1), by approximately 70 m in the Kangilia section (Encl. 2), and by approximately 25 m in section FGC 900813/7 at Ikorfat.

Characteristic species. The interval is characterised by the pollen species *Wodehouseia spinata*. The following dinoflagellate cyst species have their first occurrences in the interval: *Deflandrea galeata*, *"Hystrichosphaeridium proprium brevispinum"* informal subspecies of Marheineche (1992), *Phelodinium kozlowskii* and *Deflandrea* aff. *galeata*. The species *Cerodinium diebelii*, *"Hystrichosphaeridium p. proprium"* and *Paleocystodinium golzowense* are present throughout the interval.

The species *Spinidinium clavus* is abundant in the lowermost sample of the interval in the Annertuneq section. The pollen genera *Pseudointegricorpus*, *Scollardia* and the species *Wodehouseia* cf. *fimbriata* and *W. quadrispina* are rare but have only been recorded from this interval in this study.

Discussion. According to Nichols & Sweet (1993, fig. 3a, table. 1) *Wodehouseia spinata* has its lowest occurrence in their assemblage 9 (lower part of Late Maastrichtian) from the Western Interior, and *W.. spinata* has a stratigraphical range from the Upper Maastrichtian to the Cretaceous–Tertiary boundary in the Yukon area in the Northwest Territories of Canada and in New Mexico, USA, whereas the species seems to cross this boundary in the northern part of the Western Interior Basin (Nichols & Sweet, 1993, p. 551). McIntyre (1974) recorded *W. spinata* in sediments of Maastrichtian age in the District of Mackenzie, Arctic Canada.

The presence of a few specimens of *Wodehouseia* cf. *quadrispina* in the uppermost part of the present *W. spinata* interval indicates, according to Nichols & Sweet (1993), a late Maastrichtian age.

Recording of the pollen *Wodehouseia* cf. *fimbriata* in the concretion surrounding the ammonite sample 408892 (Encl. 1) is remarkable. Sweet *et al.* (1989, p. 98) wrote that the occurrence of *Wodehouseia fimbriata* started at a horizon about 22 m above the Cretaceous-Tertiary boundary at Police Island in Northwest Territories of Canada, and the same first occurrence for *W. fimbriata* was illustrated by Nichols & Sweet (1993, fig. 5).

However, under discussion, A. R. Sweet (1994) confirmed that specimens similar to the *Wodehouseia* cf. *fimbriata* species from West Greenland have been recorded from the latest Maastrichtian in Western Interior, and that the pollen content of the samples 408886 and 408892 suggest a latest Maastrichtian age.

According to Schøiler & Wilson (1993, p. 343) the dinoflagellate cyst species *Deflandra galeata* has a first occurrence in the middle part of the Late Maastrichtian *Isabelidinium cooksoniae* Interval Zone in the Danish part of the North Sea. Schøiler & Wilson show that *D. galeata* and *I. cooksoniae* occur together in their interval zone, and that *I. cooksoniae* was abundant until its extinction.

COMPARISON WITH PREVIOUSLY REPORTED MACROFOSSIL AGES

Santonian, Campanian and Maastrichtian ammonites between Niaqornat and Ikorfat on the north coast Nuussuaq (Fig. 4) were recorded by Birkelund (1965; table 1, plate 48) in her monograph on Upper Cretaceous ammonites from West Greenland. The ammonite record was correlated with other macrofossil records by Rosenkrantz & Pulvertaft (1969) in their review of Cretaceous–Tertiary stratigraphy and tectonics in West Greenland.

Birkelund (1965) recorded ammonites indicating the presence of Santonian deposits at the Tupersuartaa locality (Fig. 1); unfortunately all studied organic material from this area is thermally overmature. Birkelund's (1965) records of Upper Campanian and Maastrichtian ammonites between Scaphiteskløften and Skifer–peridotitnæsen at Kuuk Anemiik (Figs 1, 4) correlates with the present study of palynomorphs from the Annertuneq section (Encl. 1), the Kangilia section (Encl. 2) and the section HNH

910718/1-3 (Encl. 3). Birkelund's (1965, Table 1) recording of Upper Campanian ammonites from 550 to 665 m above sea level from Brudkløft at Ikorfat, is not in conflict with the present record of Coniacian or Santonian dinoflagellate cysts from the locality HNH 920824/2 (Encl. 5) situated at 350 to 375 m above sea level at Brudkløft.

The ammonites recorded from Ikorfatnæsen and Ikorfat pass (Fig. 1) indicate a Maastrichtian age (Birkelund, 1965). The dinoflagellate cyst assemblage from the section FGC 900813/7 (Encl. 4), which is very close to these two sections, also suggests a Maastrichtian age.

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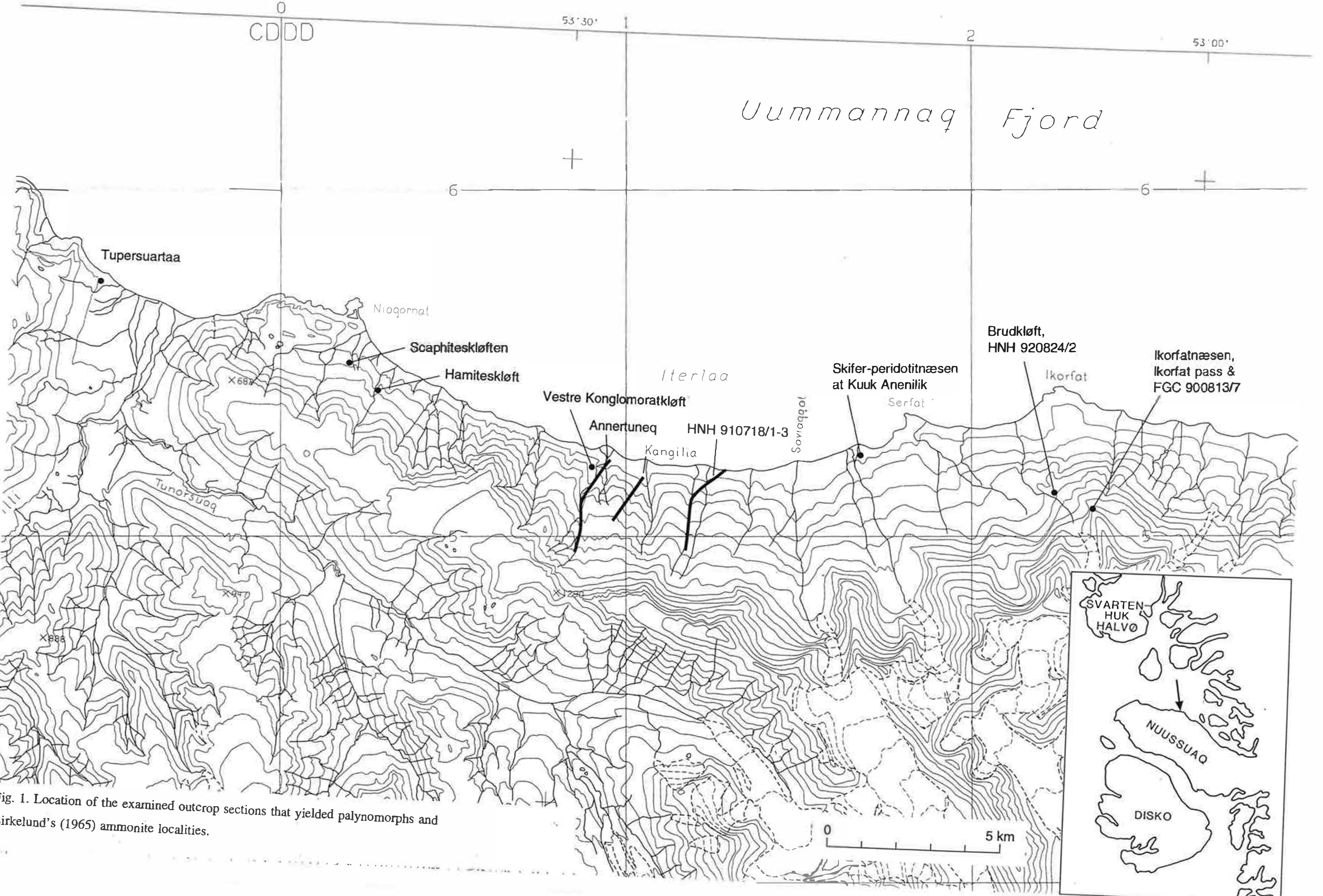


ig. 1. Location of the examined outcrop sections that yielded palynomorphs and irkelund's (1965) ammonite localities.

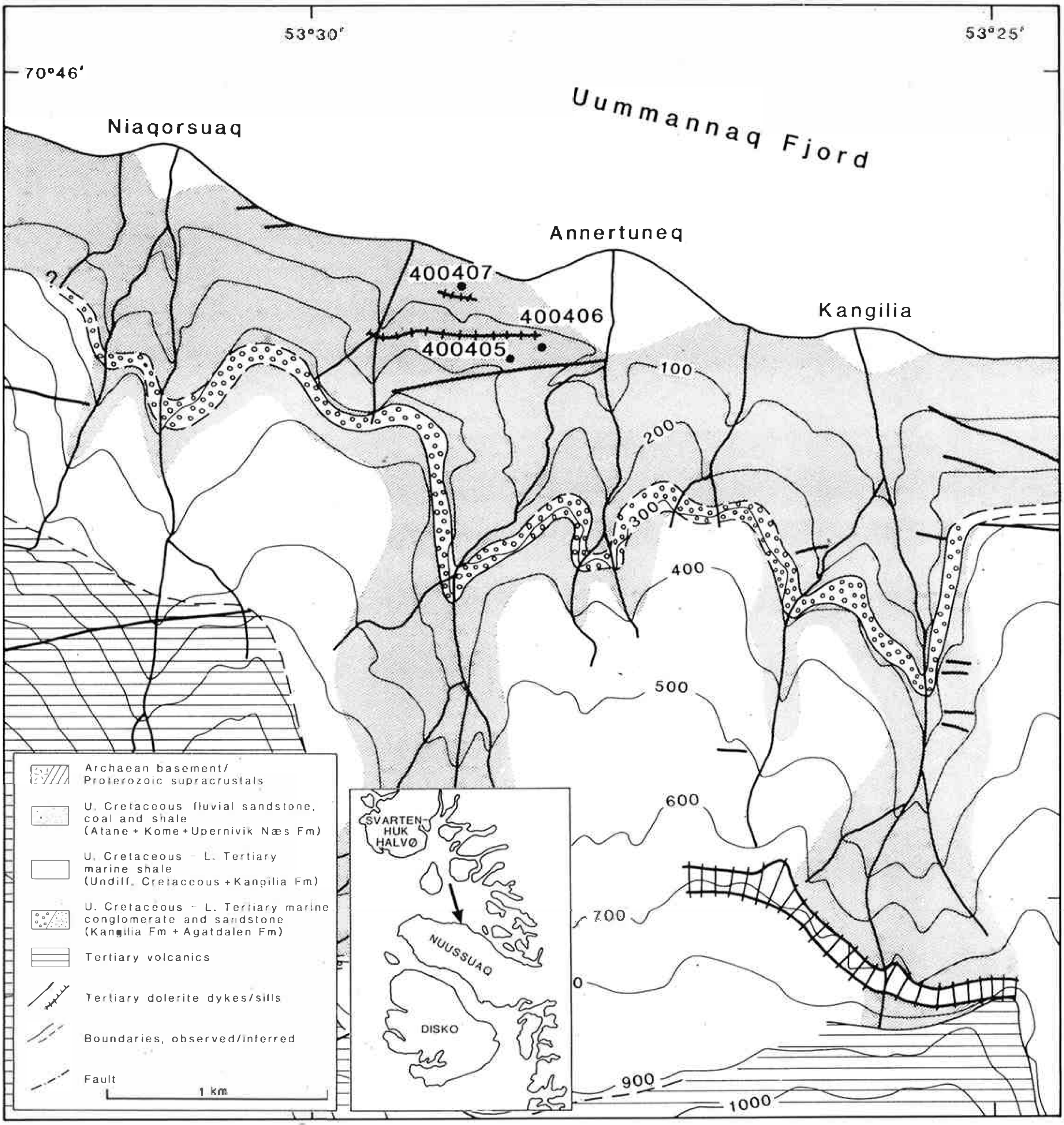


Fig. 2. Location of the examined outcrops and subsurface sections in the Annertuneq area that yielded palynomorphs.

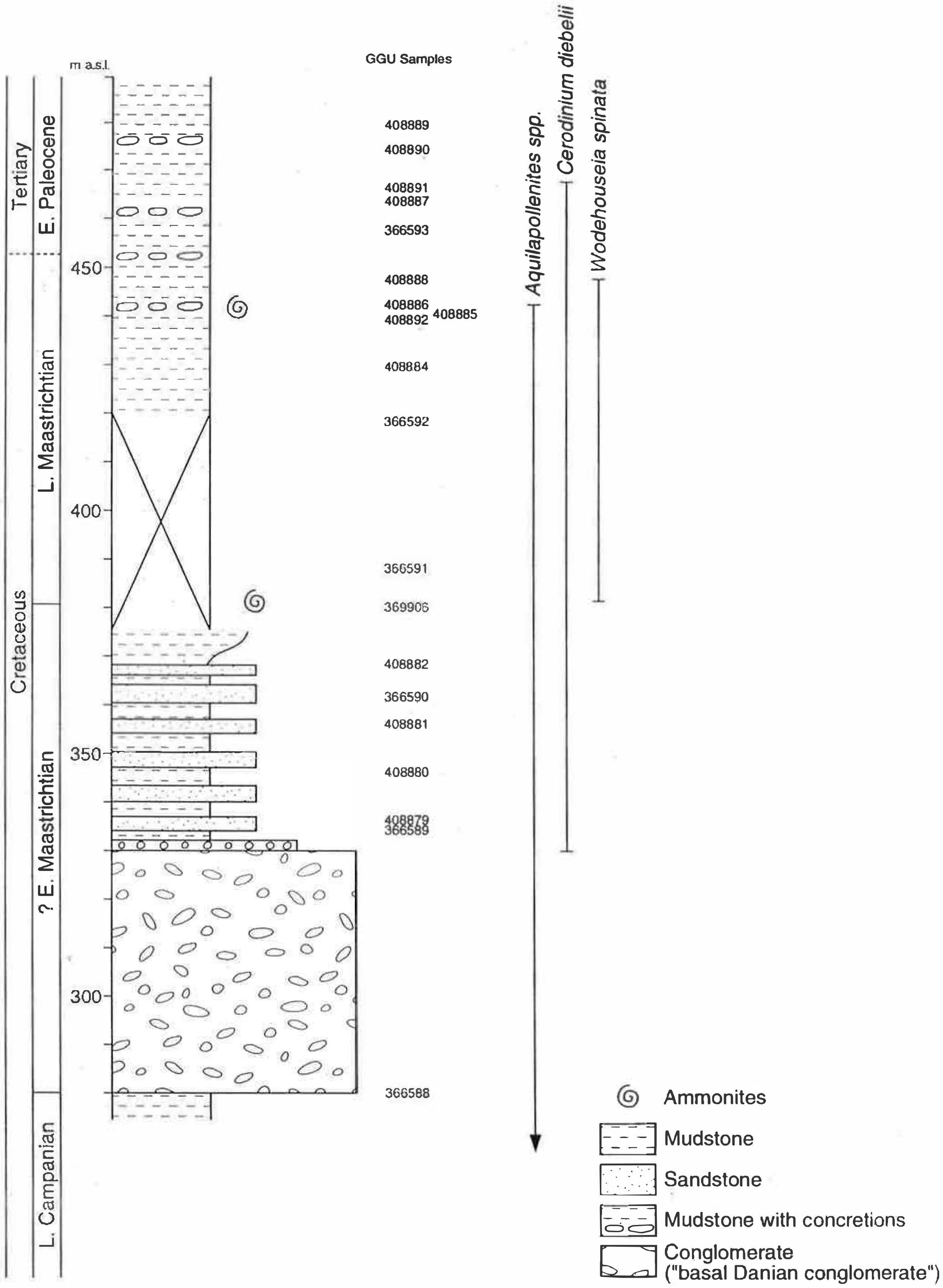


Fig. 3. Stratigraphic log, sample position and range of important stratigraphical palynomorphs from the base of the basal Danian conglomerate to the Cretaceous–Tertiary boundary at the Annertuneq section on northern Nuussuaq.

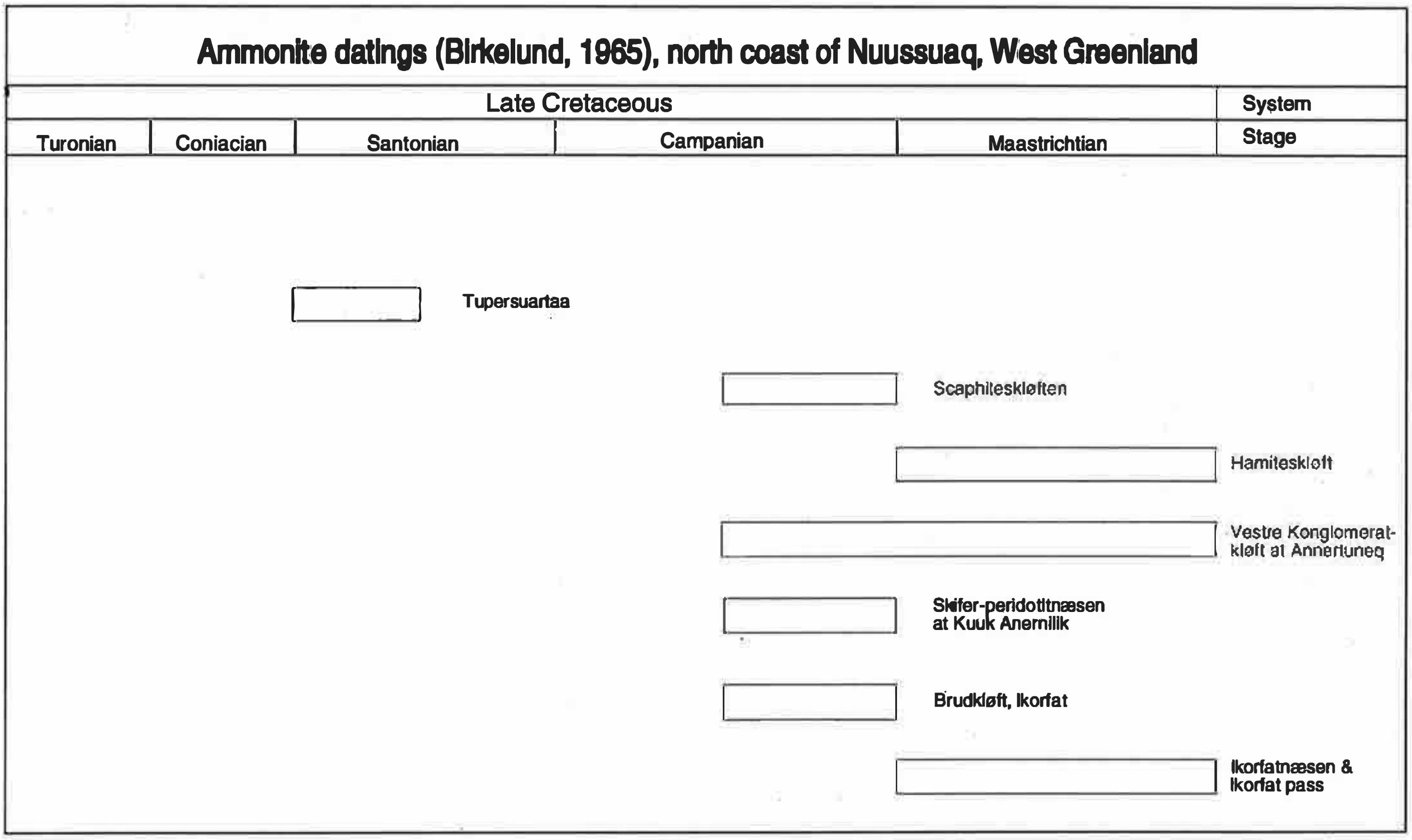
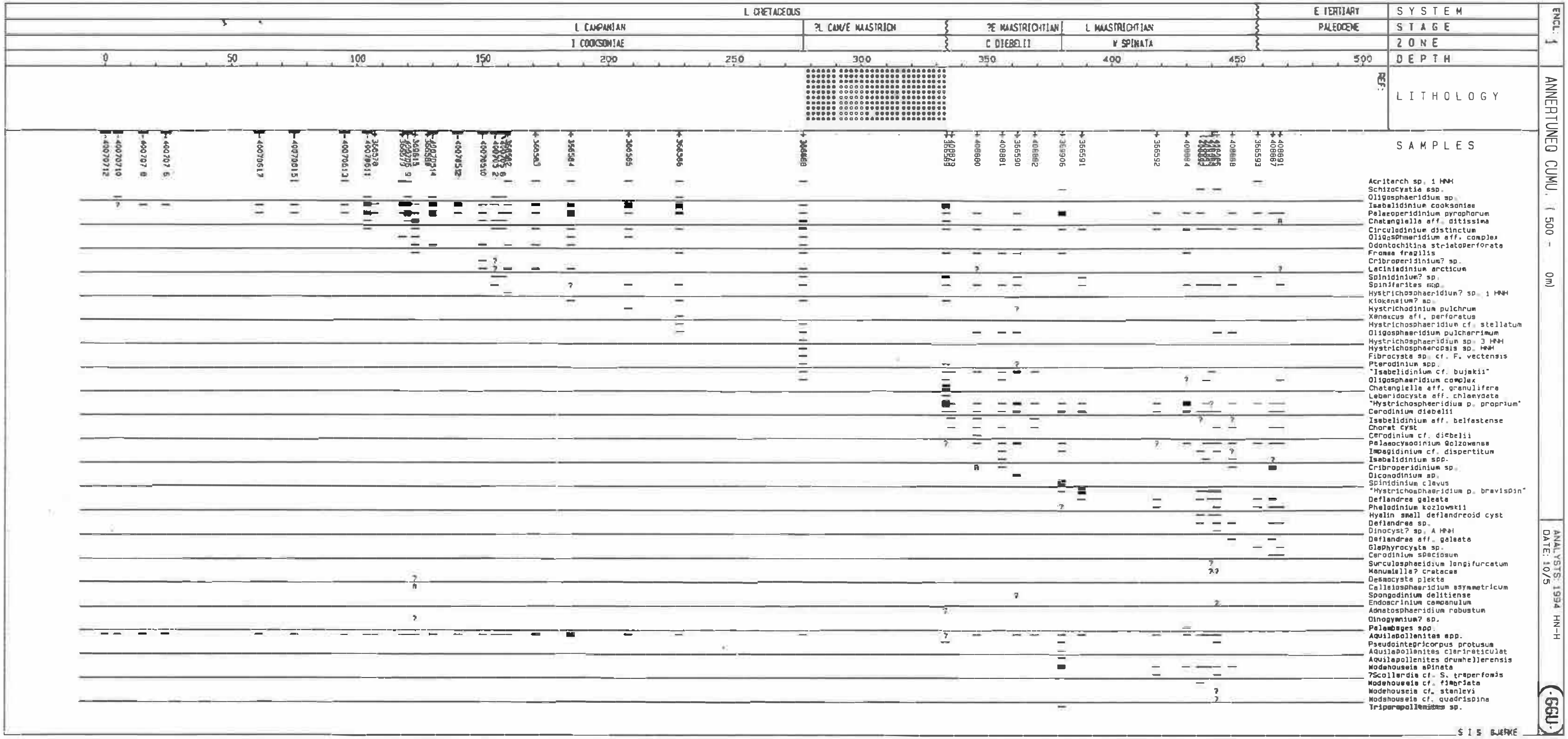


Fig. 4. Previous ammonite datings obtained from Birkelund (1965).



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DEPTH
REF:
LITHOLOGY
SAMPLES
Acritarch sp. 1 HNH
Schizocystia ssp.
Oligosphaeridium sp.
Isabelidinium cooksoniae
Palaeoperidinium pyrophorum
Chatangiella aff. ditissima
Circulodinium distinctum
Oligosphaeridium aff. complex
Odontochitina striatoperforata
Fromea fragilis
Cribroperidinium? sp.
Laciniadinium arcticum
Spinidinium? sp.
Spiniferites spp.
Hystrichosphaeridium? sp. 1 HNH
Kiokansium? sp.
Hystrichodinium pulchrum
Xenascus aff. perforatus
Hystrichosphaeridium cf. stellatum
Oligosphaeridium pulcherrimum
Hystrichosphaeridium sp. 3 HNH
Hystrichosphaeropsis sp. HNH
Fibrocysta sp. cf. F. vectensis
Pterodinium spp.
"Isabelidinium cf. bujakii"
Oligosphaeridium complex
Chatangiella aff. granulifera
Leberidocysta aff. chlamydata
"Hystrichosphaeridium p. proprium"
Cerodinium diebelii
Isabelidinium aff. belfastense
Chorat cyst
Cerodinium cf. diebelii
Palaeocystodinium golzowense
Impagidinium cf. dispertitum
Isabelidinium spp.
Cribroperidinium sp.
Diconodinium sp.
Spinidinium clavus
"Hystrichosphaeridium p. brevispin"
Deflandrea galeata
Phelodinium kozlowskii
Hyalin small deflandreoid cyst
Deflandrea sp.
Dinocyst? sp. A HNH
Deflandrea aff. galeata
Glaphyrocysta sp.
Cerodinium speciosum
Surculosphaeridium longifurcatum
Manumiella? cretacea
Desmocysta plekta
Callaiosphaeridium asymmetricum
Spongodinium delitiense
Endoscrinium campanulum
Adnatosphaeridium robustum
Dinogymnium? sp.
Palambages spp.
Aquilapollenites spp.
Pseudointegricorpus protusum
Aquilapollenites clarireticulat
Aquilapollenites drumhellerensis
Wodehouseia spinata
?Scollardia cf. S. trapaformis
Wodehouseia cf. fimbriata
Wodehouseia cf. stanleyi
Wodehouseia cf. quadrispina
Triporopollenites sp.
ENCL. 1
ANNERTUNEQ CUMU. (500 - 0m)
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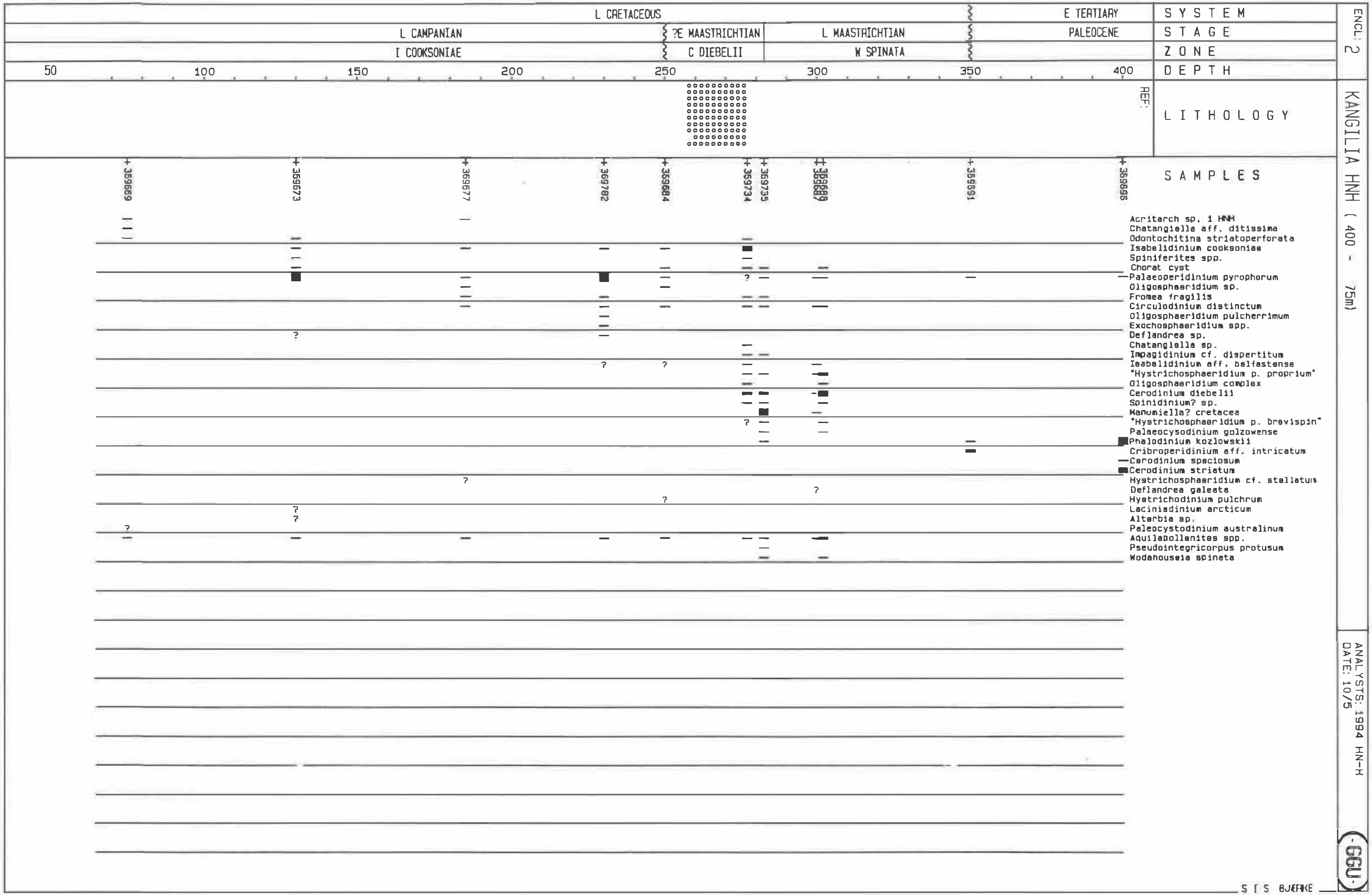
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DEPTH
REF:
LITHOLOGY
359669
359673
359677
369782
359684
359734
359735
359689
359691
359696
SAMPLES
Acritarch sp. 1 HNH
Chatangiella aff. ditissima
Odontochitina striatoperforata
Isabelidinium cooksoniae
Spiniferites spp.
Chorat cyst
Palaeoperidinium pyrophorum
Oligosphaeridium sp.
Fromea fragilis
Circulodinium distinctum
Oligosphaeridium pulcherrimum
Exochosphaeridium spp.
Deflandrea sp.
Chatangiella sp.
Impagidinium cf. dispertitum
Isabelidinium aff. belfastense
"Hystrichosphaeridium p. proprium"
Oligosphaeridium complex
Cerodinium diebelii
Spinidinium? sp.
Manumiella? cretacea
"Hystrichosphaeridium p. brevispin"
Palaeocysodinium golzowense
Phalodinium kozlowskii
Cribroperidinium aff. intricatum
Cerodinium speciosum
Cerodinium striatum
Hystrichosphaeridium cf. stellatum
Deflandrea galeata
Hystrichodinium pulchrum
Laciniadinium arcticum
Alterbia sp.
Paleocystodinium australinum
Aquilapollenites spp.
Pseudointegricorpus protusum
Wodehouseia spinata
ENCL: 2
KANGILIA HNH (400 - 75m)
ANALYSTS: 1994 HN-H
DATE: 10/5
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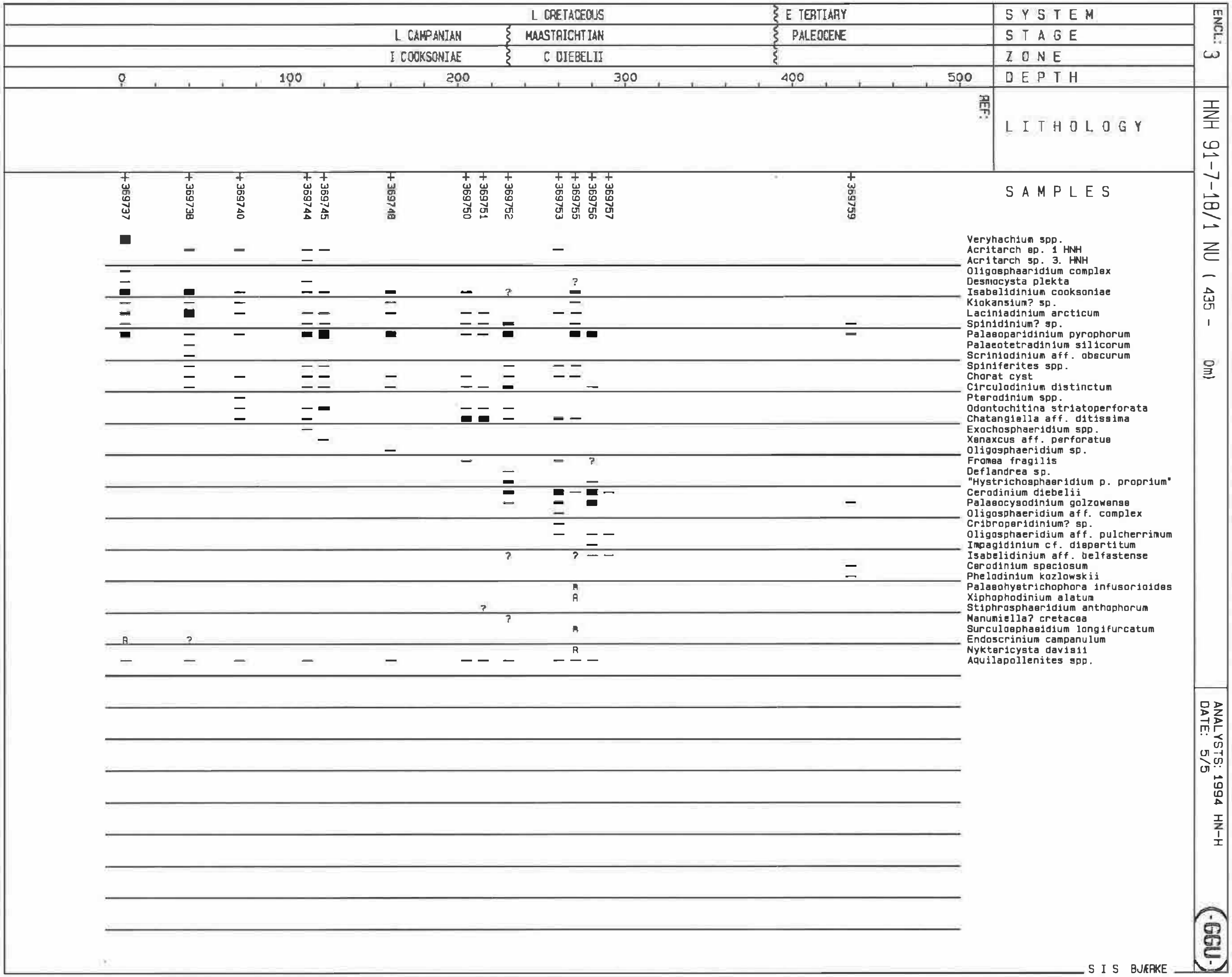
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REF:
LITHOLOGY
369737
369738
369740
369744
369745
369748
369750
369751
369752
369753
369755
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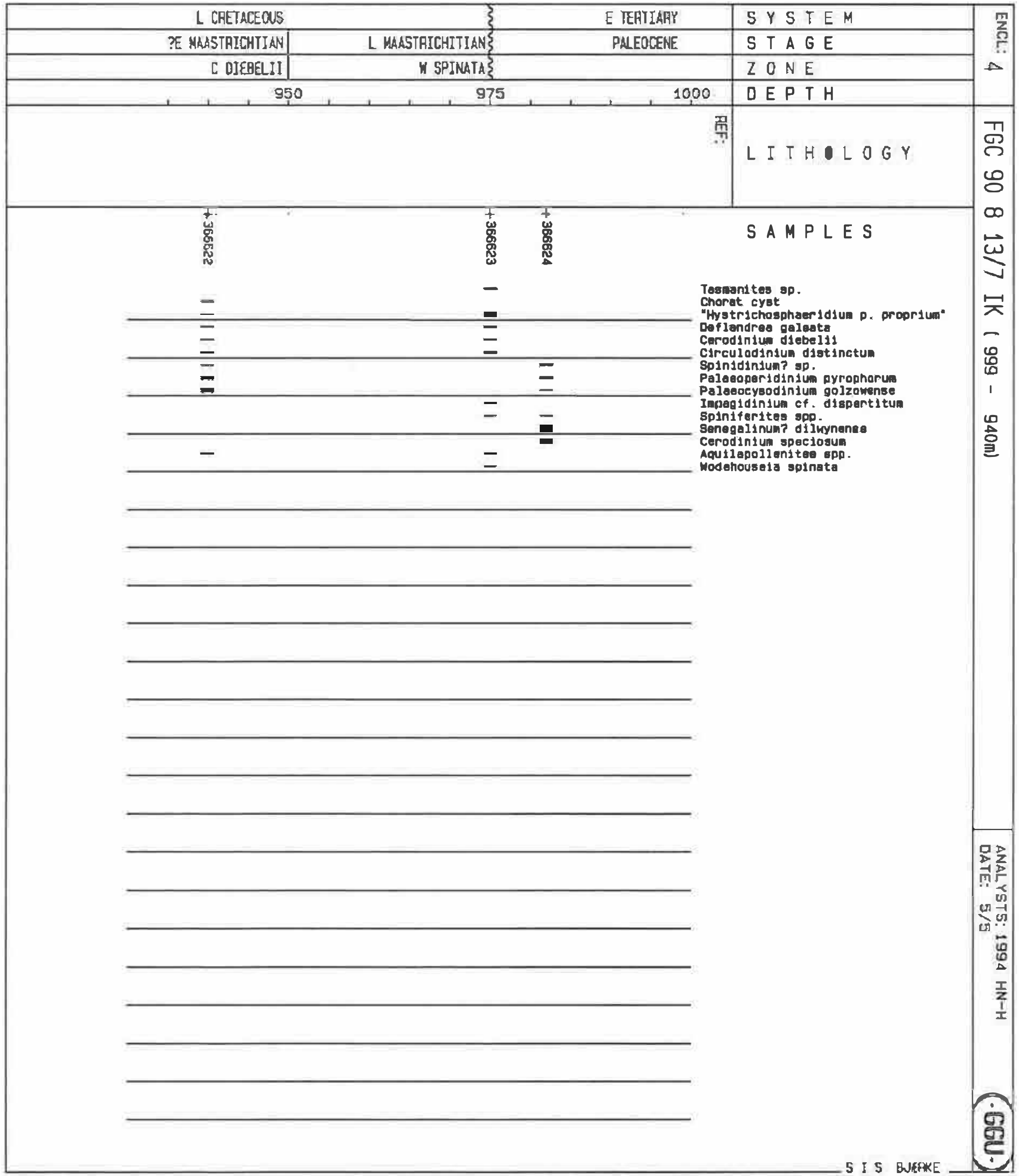
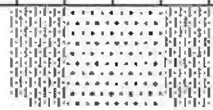
369759
SAMPLES
Veryhachium spp.
Acritarch sp. 1 HNH
Acritarch sp. 3. HNH
Oligosphaeridium complex
Desmocysta plekta
Isabelidinium cooksoniae
Kiokansium? sp.
Laciniadinium arcticum
Spinidinium? sp.
Palaeoperidinium pyrophorum
Palaeotetradinium silicorum
Scriniodinium aff. obscurum
Spiniferites spp.
Chorat cyst
Circulodinium distinctum
Pterodinium spp.
Odontochitina striatoperforata
Chatangiella aff. ditissima
Exochosphaeridium spp.
Xenaxcus aff. perforatus
Oligosphaeridium sp.
Fromea fragilis
Deflandrea sp.
"Hystrichosphaeridium p. proprium"
Cerodinium diebelii
Palaeocysodinium golzowense
Oligosphaeridium aff. complex
Cribroperidinium? sp.
Oligosphaeridium aff. pulcherrimum
Impagidinium cf. dispertitum
Isabelidinium aff. belfastense
Cerodinium speciosum
Phelodinium kozlowskii
Palaeohystrichophora infusorioides
Xiphophodinium alatum
Stiphrosphaeridium anthophorum
Manumiella? cretacea
Surculosphaeridium longifurcatum
Endoscrinium campanulum
Nyktericysta davisii
Aquilapollenites spp.
ENCL: 3
HNH 91-7-18/1 NU (435 - 0m)
ANALYSTS: 1994 HN-H
DATE: 5/5
GGU
SIS BJÆRKE



L CRETACEOUS
E TERTIARY
SYSTEM
?E MAASTRICHTIAN
L MAASTRICHTIAN
PALEOCENE
STAGE
C DIEBELII
W SPINATA
ZONE
950
975
1000
DEPTH
REF:
LITHOLOGY
366622
366623
366624
SAMPLES
Tasmanites sp.
Chorat cyst
"Hystrichosphaeridium p. proprium"
Deflandrea galeata
Cerodinium diebelii
Circulodinium distinctum
Spinidinium? sp.
Palaeoperidinium pyrophorum
Palaeocystodinium golzowense
Impagidinium cf. dispertitum
Spiniferites spp.
Senegalinum? dilwynense
Cerodinium speciosum
Aquilapollenites spp.
Wodehouseia spinata
SIS BJERKE
ENCL: 4
FGC 90 8 13/7 IK (999 - 940m)
ANALYSTS: 1994 HN-H
DATE: 5/5
GGU

L CRETACEOUS	SYSTEM
CONIAC / L SANTON	STAGE
A AFF SCHEII/L ARC{ L ARCTICUM/H DIF	ZONE
350 375	DEPTH
 REF:	LITHOLOGY
402682 402685	SAMPLES

Acritarch sp. 1 HNH
Schizocystia ssp.
Surculosphaeidium longifurcatum
Oligosphaeridium complex
Spiniferites spp.
Stiphrosphaeridium anthophorum
Florentinia aff. deanei
Chatangiella aff. ditissima
Cribroperidinium? sp.
Chatangiella granulifera
Chatangiella sp.
Circulodinium distinctum
Heterosphaeridium difficile
Chorat cyst
Exochosphaeridium spp.
Isabelidinium spp.
Trithyrodinium suspectum
Xenaxcus aff. perforatus
Palaeohystrichophora infusorioides
Palaeoperidinium pyrophorum
Chlamydophorella spp.
Isabelidinium aff. acuminatum
Florentinia spp.
Odontochitina striatoperforata
Arvalidinium aff. scheii
? Laciniadinium arcticum

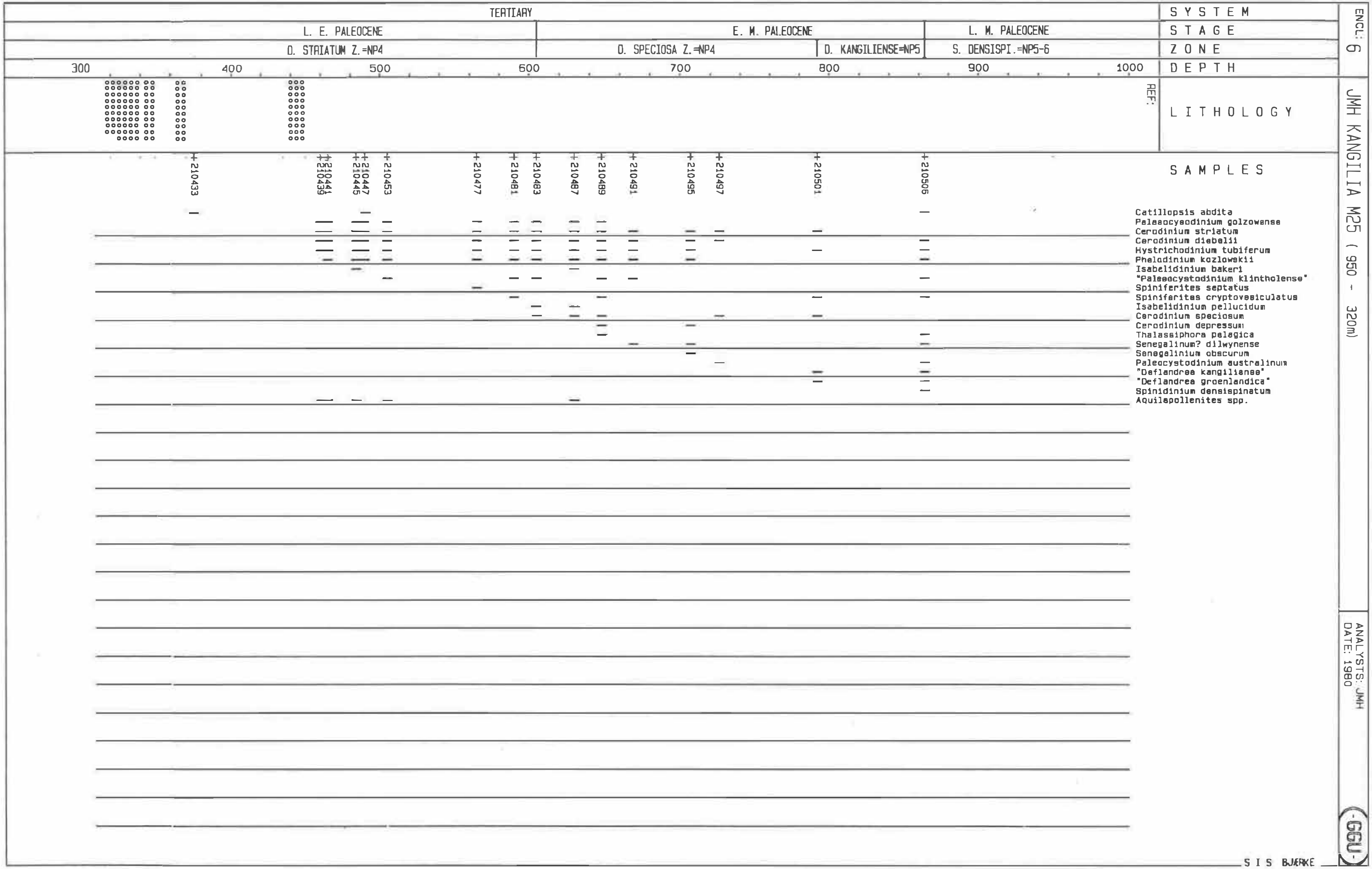
ENCL: 5

HNH 92 8 24/2 IK (375 - 355m)

ANALYSTS: 1994 HN-H
DATE: 10/5

GGU

S I S BJÆRKE



TERTIARY
SYSTEM
L. E. PALEOCENE
E. M. PALEOCENE
L. M. PALEOCENE
STAGE
D. STRIATUM Z.=NP4
D. SPECIOSA Z.=NP4
D. KANGILIENSE=NP5
S. DENSISPI.=NP5-6
ZONE
300
400
500
600
700
800
900
1000
DEPTH
REF:
LITHOLOGY
210433
210439
210441
210445
210447
210453
210477
210481
210483
210487
210489
210491
210495
210497
210501
210506
SAMPLES
Catillopsis abdita
Palaeocystodinium golzowense
Cerodinium striatum
Cerodinium diebelii
Hystrichodinium tubiferum
Pheladinium kozlowskii
Isabelidinium bakeri
"Palaeocystodinium klintholense"
Spiniferites septatus
Spiniferites cryptovesiculatus
Isabelidinium pellucidum
Cerodinium speciosum
Cerodinium depressum
Thalassiphora pelagica
Senegalinum? dilwynense
Senegalinium obscurum
Paleocystodinium australinum
"Deflandrea kangiliense"
"Deflandrea groenlandica"
Spinidinium densispinatum
Aquilapollenites spp.
ENCL: 6
JMH KANGILIA M25 (950 - 320m)
ANALYSTS: JMH
DATE: 1980
GGU
SIS BJERKE

Index of figured species

Plate 1. Northern Nuussuaq

Fig. 1. *Cerodinium diebelii*, GGU 366589-3, Annertuneq, 26.6-103.0; LVR 1.553; MI 256. 40x

Fig. 2. *Cerodinium diebelii*, GGU 366906-10, Annertuneq, 48.6-103.9; LVR 1.597; MI 294. 40x

Fig. 3. *Cerodinium diebelii*, GGU 408888-8, Annertuneq, 31.0-109.6; LVR 1.4050; MI 3008. 40x

Fig. 4. *Cerodinium* aff. *diebelii*, GGU 408880-4, Annertuneq, 28.0-99.4; LVR 1.4000; MI 2969. 40x

Fig. 5. *Cerodinium* aff. *diebelii*, GGU 408880-4, Annertuneq, 35.0-109.3; LVR 1.4001; MI 2970. 40x

Fig. 6. *Cerodinium* aff. *diebelii*, GGU 408881-4, Annertuneq, 44.1-108.4; LVR 1.4007; MI 2975. 40x

Fig. 7. *Cerodinium speciosum*, GGU 408887-7, Annertuneq, 32.5-106.2; LVR 1.4066; MI 3022

Fig. 8. *Cerodinium speciosum*, GGU 408887-4, Annertuneq, 23.7-101.6; LVR 1.4068; MI 3024

Fig. 9. *Cerodinium speciosum*, GGU 366624-4, FGC 900813/7, Ikorfat, 23.5-100.4; LVR 1.4081; MI 3035

Fig. 10. *Cerodinium speciosum*, GGU 408887-4, Annertuneq, 46.0-96.7; LVR 1.4067; MI 3023

Fig. 11. *Phelodinium* cf. *kozlowskii*, GGU 366593-4, Annertuneq, 53.7-102.8; LVR 1.663; MI 347

Fig. 12. *Phelodinium kozlowskii*, GGU 366593-3, Annertuneq, 46.1-102.3; LVR 1.657; MI 342

NORTH COAST OF NUUSSUAQ

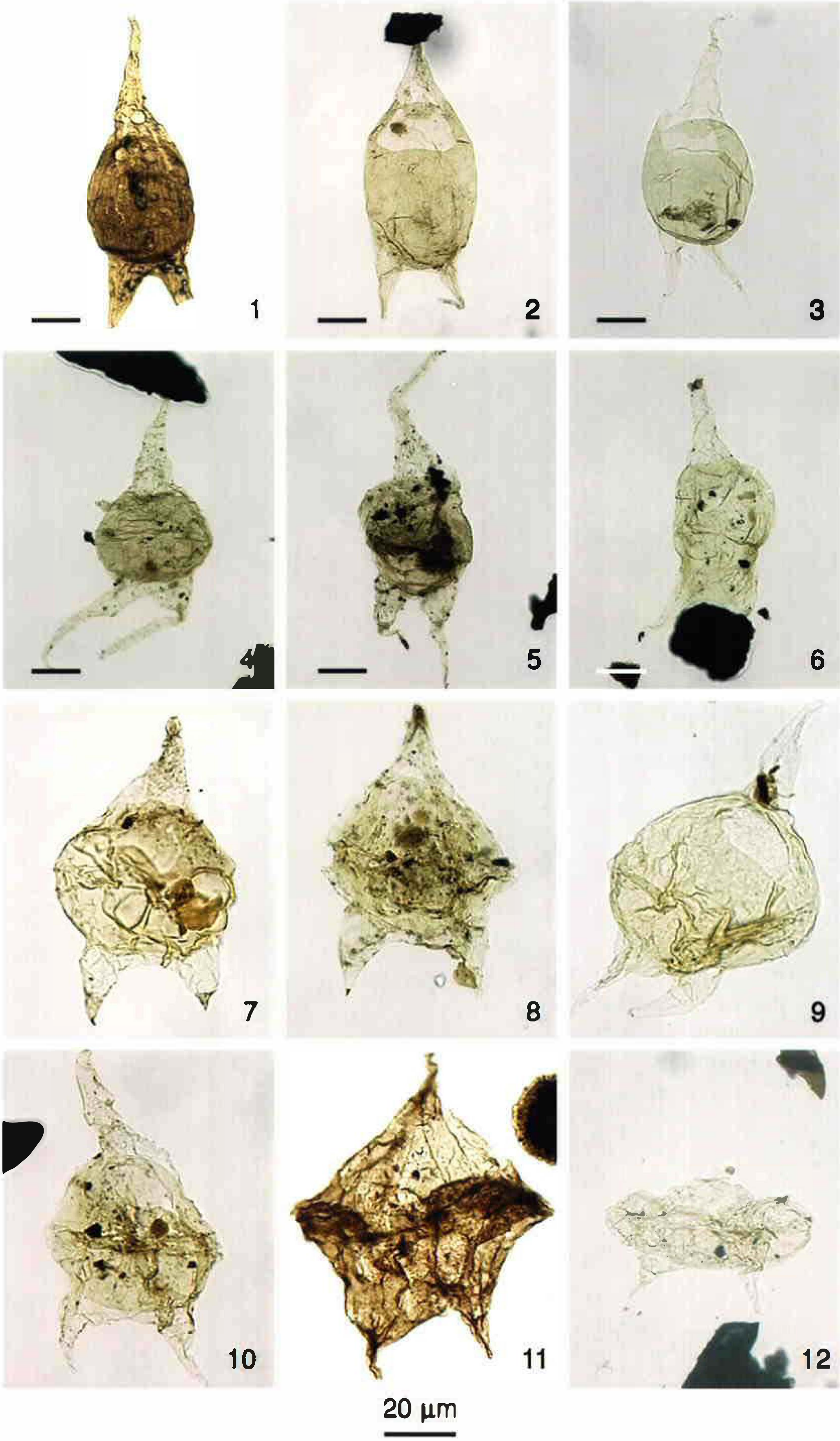


Plate 2. Northern Nuussuaq

Fig. 1. *Deflandrea galeata*, GGU 366591-5, Annertuneq, 56.1-112.8; LVR 1.633; MI 322

Fig. 2. *Deflandrea galeata*, GGU 408885-2, Annertuneq, 22.3-104.7; LVR 1.4012; MI 2980

Fig. 3. *Deflandrea galeata*, GGU 408885-8, Annertuneq, 28.3-92.9; LVR 1.4013; MI 2981

Fig. 4. *Deflandrea galeata*, GGU 408887-7, Annertuneq, 38.0-114.1; LVR 1.4055; MI 3012

Fig. 5. *Deflandrea galeata*, GGU 408893-4, Annertuneq, 24.4-112.4; LVR 1.4075; MI 3030

Fig. 6. *Deflandrea galeata*, GGU 408886-8, Annertuneq, 54.6-100.1; LVR 1.4047; MI 3005

Fig. 7. *Deflandrea galeata*, GGU 408887-4, Annertuneq, 44.0-99.1; LVR 1.4059; MI 3016

Fig. 8. *Deflandrea* aff. ?*galeata*, GGU 408887-3, Annertuneq, 50.0-99.6; LVR 1.4060; MI 3017

Fig. 9. *Deflandrea* aff. ?*galeata*, GGU 408887-4, Annertuneq, 41.0-93.0; LVR 1.4061; MI 3018

Fig. 10. *Deflandrea* aff. ?*galeata*, GGU 408887-7, Annertuneq, 58.2-91.7; LVR 1.4064; MI 3021

Fig. 11. *Deflandrea* aff. ?*galeata*, GGU 408887-7, Annertuneq, 24.5-95.0; LVR 1.4062; MI 3019

Fig. 12. Dinocyst sp. B HNH GGU 408888-2, Annertuneq, 47.7-97.7; LVR 1.4049; MI 3007

NORTH COAST OF NUUSSUAQ

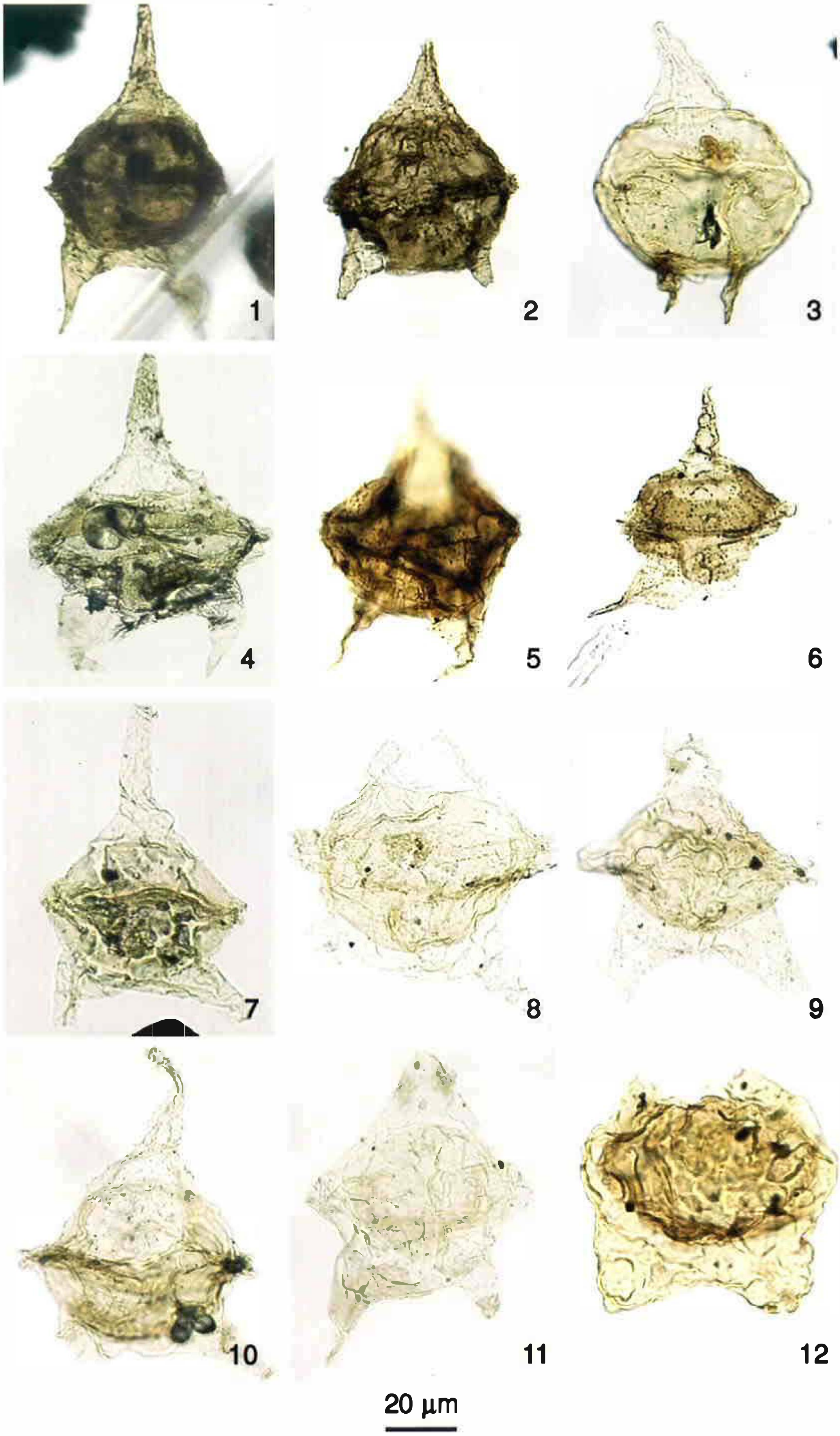


Plate 3. Northern Nuussuaq

Fig. 1. *Isabelidinium* aff. *belfastense*, GGU 408882-4, Annertuneq, 43.7-101.7; LVR 1.4009; MI 2977

Fig. 2. "*Isabelidinium bujakii*", GGU 408879-4, Annertuneq, 39.4-93.9; LVR 1.3998; MI 2967

Fig. 3. "*Isabelidinium bujakii*", GGU 408880-4, Annertuneq, 40.6-105.8; LVR 1.4002; MI 2971

Fig. 4. "*Isabelidinium bujakii*", GGU 366590-4, Annertuneq, 43.0-98.8; LVR 1.567; MI 268

Fig. 5. *Isabelidinium cooksoniae*, GGU 366583-4, Annertuneq, 42.8-102.7; LVR 1.447; MI 166

Fig. 6. *Isabelidinium cooksoniae*, GGU 366585-4, Annertuneq, 56.4-98.4; LVR 1.479; MI 192

Fig. 7. *Isabelidinium cooksoniae*, GGU 366584-4, Annertuneq, 43.4-104.0; LVR 1.452; MI 169

Fig. 8. *Isabelidinium cooksoniae*, GGU 366584-4, Annertuneq, 28.5-95.3; LVR 1.456; MI 172

Fig. 9. *Isabelidinium cooksoniae*, GGU 366586-3, Annertuneq, 44.4-102.6; LVR 1.483; MI 196

Fig. 10. *Isabelidinium cooksoniae*, GGU 366579-4, Annertuneq, 26.5-108.7; LVR 1.87; MI 17

Fig. 11. *Senegalinium? dilwynense*, GGU 366624-4, FGC900813/7 Ikorfat, 24.0-104.2; LVR 1.4078; MI 3032

Fig. 12. *Senegalinium? dilwynense*, GGU 366624-4, FGC900813/7 Ikorfat, 47.0-105.5; LVR 1.4080; MI 3034

NORTH COAST OF NUUSSUAQ

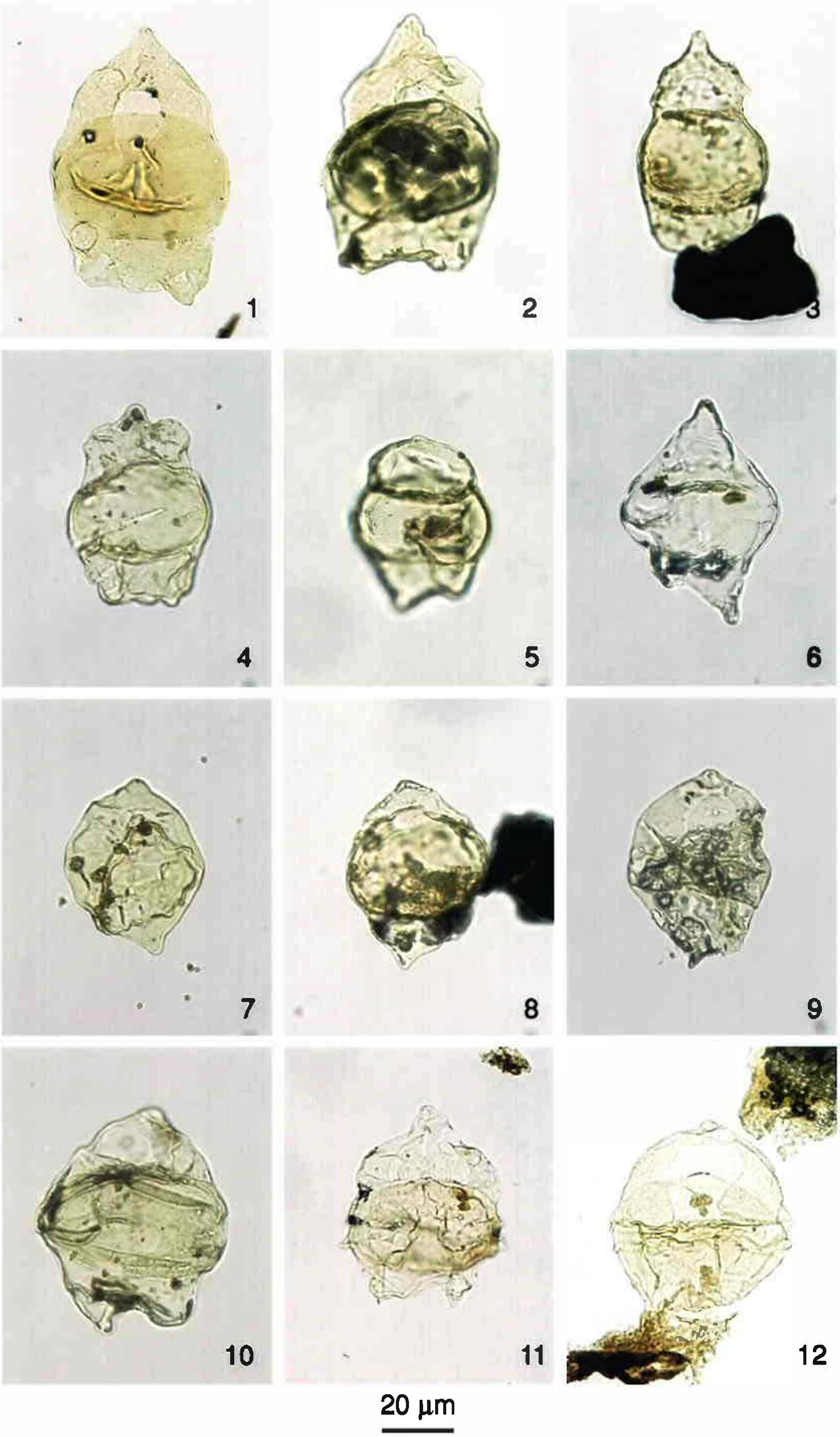


Plate 4. Northern Nuussuaq

Fig. 1. *Palaeocystodinium golzowense* GGU 366906-8, Annertuneq, 41.9-108.1; LVR 1.622; MI 312

Fig. 2. *Palaeocystodinium golzowense* GGU 366593-3, Annertuneq, 31.1-96.0; LVR 1.651; MI 337. 40x

Fig. 3. *Palaeocystodinium golzowense* GGU 366593-4, Annertuneq, 18.3-92.3; LVR 1.662; MI 346. 40x

Fig. 4. *Palaeocystodinium golzowense*, GGU 408880-4, Annertuneq, 47.5-94.6; LVR 1.3999; MI 2968. 25x

Fig. 5. *Palaeocystodinium golzowense*, GGU 400886-7, Annertuneq, 29.2-100.7; LVR 1.4039; MI 3001. 40x

Fig. 6. *Palaeocystodinium golzowense*, GGU 366622-5, FGC900813/7 Ikorfat, 22.6-104.0; LVR 1.4077; MI 3031

Fig. 7. *Odontochitina striatoperforata*, GGU 369615-8, Annertuneq, 24.4-95.5 LVR 1.414; MI 139

Fig. 8. *Odontochitina striatoperforata*, GGU 366588-7, Annertuneq, 26.8-93.5 LVR 1.529; MI 232

Fig. 9. *Xenascus* aff. *perforatus*, GGU 366586-4, Annertuneq, 55.1-112.6; LVR 1.488; MI 200. 40x

Fig. 10. *Xenascus* aff. *perforatus*, GGU 366586-3, Annertuneq, 34.2-101.9; LVR 1.490; MI 201. 40x

Fig. 11. *Fromea fragilis*, GGU 366586-4, Annertuneq, 52.3-113.0; LVR 1.492; MI 203

Fig. 12. *Fromea fragilis*, GGU 366906-4, Annertuneq, 38.5-98.4; LVR 1.593; MI 290

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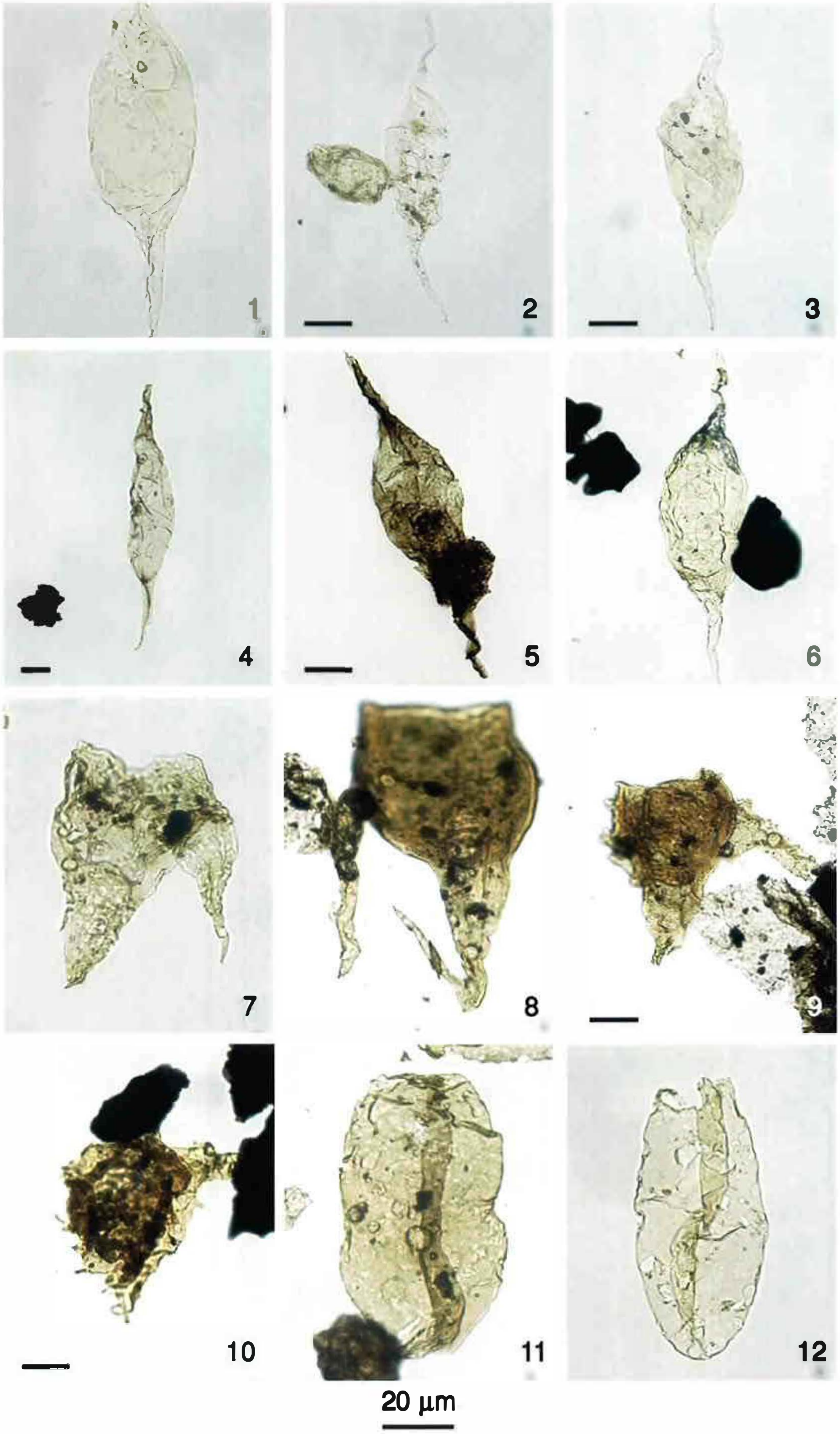

Plate 5. Northern Nuussuaq

Fig. 1. *"Hystrichosphaeridium proprium proprium"*, GGU 366589-3, Annertuneq, 50.6-93.9; LVR 1.542; MI 245

Fig. 2. *"Hystrichosphaeridium proprium proprium"*, GGU 366589-7, Annertuneq, 48.0-95.0; LVR 1.545; MI 248

Fig. 3. *"Hystrichosphaeridium proprium proprium"*, GGU 366590-8, Annertuneq, 23.5-109.2; LVR 1.581; MI 281

Fig. 4. *"Hystrichosphaeridium proprium brevispinum"*, GGU 408885-4, Annertuneq, 49.4-111.1; LVR 1.4016; MI 2983

Fig. 5. *"Hystrichosphaeridium proprium brevispinum"*, GGU 408886-4, Annertuneq, 41.1-106.0; LVR 1.4020; MI 2987

Fig. 6. *"Hystrichosphaeridium proprium brevispinum"*, GGU 408886-4, Annertuneq, 41.1-106.0; LVR 1.4022; MI 2987

Fig. 7. *"Hystrichosphaeridium proprium brevispinum"*, GGU 408886-8, Annertuneq, 35.4-103.5; LVR 1.4023; MI 2988

Fig. 8. *"Hystrichosphaeridium proprium brevispinum"*, GGU 408886-8, Annertuneq, 35.4-103.5; LVR 1.4024; MI 2988

Fig. 9. *"Hystrichosphaeridium proprium brevispinum"*, GGU 408886-8, Annertuneq, 35.4-103.5; LVR 1.4025; MI 2988

Fig. 10. *Surculodinium ?longifurcatum*, GGU 408885-8, Annertuneq, 46.9-100.0 LVR 1.4019; MI 2986

Fig. 11. *Achomosphaera*? sp. 3 HNH, GGU 408880-4, Annertuneq, 28.5-101.5; LVR 1.4004 MI 2972

Fig. 12. *Achomosphaera*? sp. 4 HNH, GGU 408880-4, Annertuneq, 46.5-105.6; LVR 1.4005 MI 2973

NORTH COAST OF NUUSSUAQ

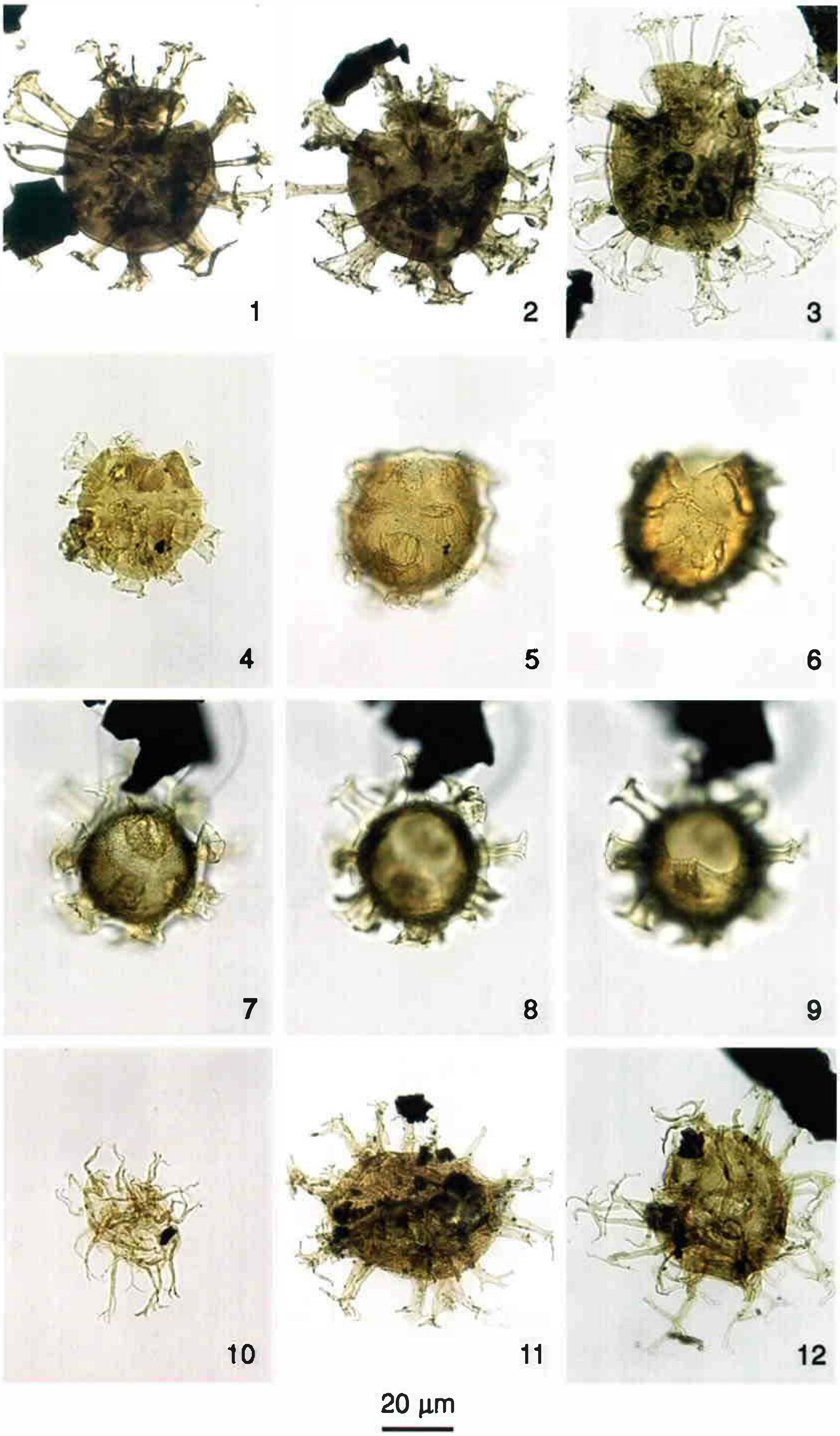

Plate 6. Northern Nuussuaq

Fig. 1. *Hystrichosphaeridium* sp. 1 HNH, GGU 366582-5, Annertuneq, 54.0-106.5; LVR 1.423; MI 146

Fig. 2. *Hystrichosphaeridium* cf. *stellatum*, GGU 366586-4, Annertuneq, 45.9-102.3; LVR 1.500; MI 208

Fig. 3. *Hystrichosphaeridium* cf. *stellatum*, GGU 366588-7, Annertuneq, 24.3-98.0; LVR 1.527; MI 231

Fig. 4. *Kiokansium* sp., GGU 366584-4, Annertuneq, 41.7-111.0; LVR 1.457; MI 173

Fig. 5. *Hystrichodinium pulchrum*, GGU 366585-4, Annertuneq, 48.7-104.0; LVR 1.480; MI 193

Fig. 6. *Fibrocysta* cf. *F. vectensis*, GGU 366588-7, Annertuneq, 28.5-110.7; LVR 1.530; MI 233

Fig. 7. Acritarch sp 1 HNH, GGU 366582-4, Annertuneq, 56.1-96.1; LVR 1.422; MI 145

Fig. 8. Acritarch sp 1 HNH, GGU 366583-4, Annertuneq, 34.6-100.7; LVR 1.451; MI 168

Fig. 9. *Glaphyrocysta* sp., GGU 408891-4, Annertuneq, 27.0-105.5; LVR 1.4069; MI 3025

Fig. 10. *Chatangiella* aff. *granulifera*, GGU 366589-4, Annertuneq, 49.6-106.2; LVR 1.538; MI 241

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Fig. 12. *Chatangiella* aff. *ditissima*, GGU 366588-4, Annertuneq, 25.8-104.7; LVR 1.506; MI 212

NORTH COAST OF NUUSSUAQ

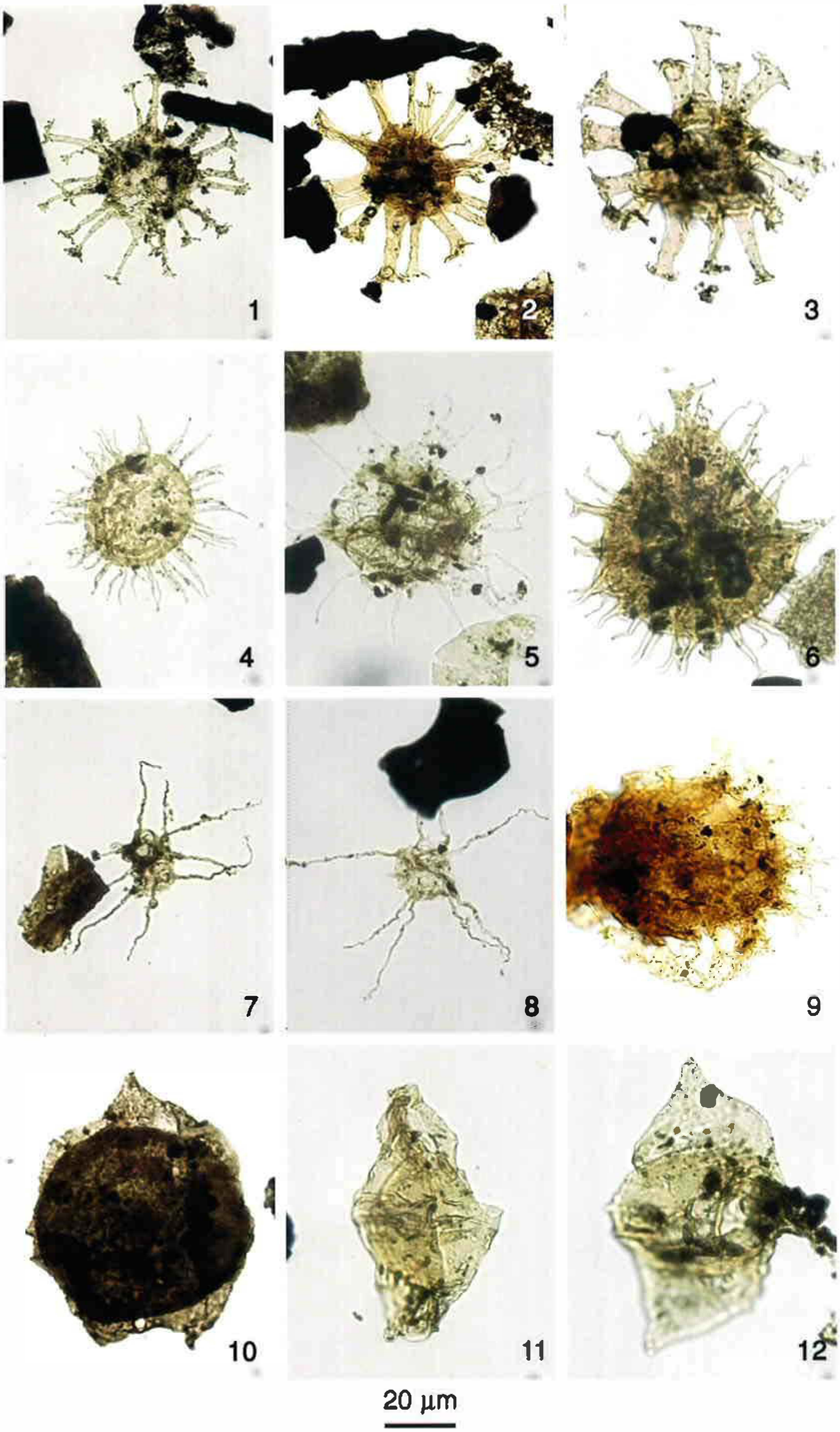

Plate 7. Northern Nuussuaq

Fig. 1. *Impagidinium* cf. *dispertitum*, GGU 408886-8, Annertuneq, 33.0-107.0; LVR 1.4041; MI 3003

Fig. 2. *Impagidinium* cf. *dispertitum*, GGU 408886-8, Annertuneq, 33.0-107.0; LVR 1.4042; MI 3003

Fig. 3. *Impagidinium* cf. *dispertitum*, GGU 408886-8, Annertuneq, 33.0-107.0; LVR 1.4043; MI 3003

Fig. 4. *Impagidinium* cf. *dispertitum*, GGU 408886-8, Annertuneq, 41.4-99.6; LVR 1.4044; MI 3004

Fig. 5. *Impagidinium* cf. *dispertitum*, GGU 408886-8, Annertuneq, 41.4-99.6; LVR 1.4045; MI 3004

Fig. 6. *Impagidinium* cf. *dispertitum*, GGU 408886-8, Annertuneq, 41.4-99.6; LVR 1.4046; MI 3004

Fig. 7. *Cribroperidinium*? sp., GGU 408887-4, Annertuneq, 45.5-108.3; LVR 1.4057; MI 3014. 40x

Fig. 8. *Cribroperidinium*? sp., GGU 408887-4, Annertuneq, 21.2-97.3; LVR 1.4058; MI 3015. 40x

Fig. 9. *Spinidinium*? cf. *clavus*, GGU 366589-4, Annertuneq, 36.7-106.4; LVR 1.556; MI 259

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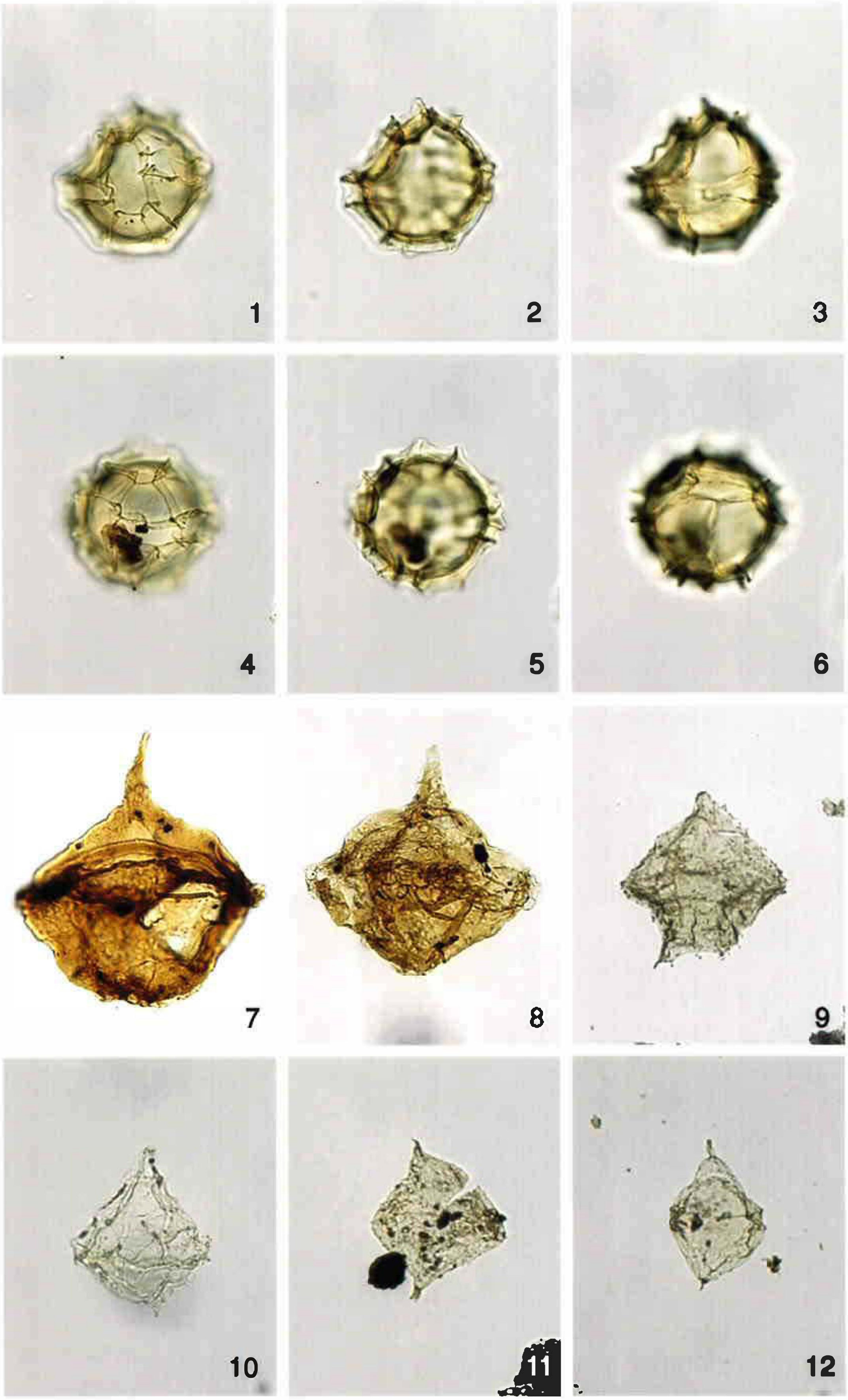
NORTH COAST OF NUUSSUAQ



20 µm

Plate 8. Northern Nuussuaq

Fig. 1. *Aquilapollenites stelckii*, GGU 366582-7, Annertuneq, 25.4-102.2; LVR 1.431; MI 153

Fig. 2. *Aquilapollenites stelckii*, GGU 366583-4, Annertuneq, 23.0-96.1; LVR 1.432; MI 154

Fig. 3. *Aquilapollenites stelckii*, GGU 366584-7, Annertuneq, 36.2-109.8; LVR 1.460; MI 176

Fig. 4. *Aquilapollenites stelckii*, GGU 366906-4, Annertuneq, 47.3-102.0; LVR 1.599; MI 296

Fig. 5a. *Aquilapollenites clarireticulatus*, GGU 366906-4, Annertuneq, 46.9-112.3; LVR 1.600; MI 297

Fig. 5b. *Aquilapollenites clarireticulatus*, GGU 366906-4, Annertuneq, 46.9-112.3; LVR 1.601; MI 297

Fig. 6a. *Aquilapollenites drumhellerensis*, GGU 366906-4, Annertuneq, 49.1-108.3; LVR 1.603; MI 299

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Fig. 7. *Aquilapollenites clarireticulatus*, GGU 366906-4, Annertuneq, 38.7-95.7; LVR 1.602; MI 298

Fig. 8. *Aquilapollenites* sp., GGU 408886-4, Annertuneq, 25.1-92.0; LVR 1.4026; MI 2989

Fig. 9. *Pseudointegricorpus protusum*, GGU 366589-7, Annertuneq, 44.6-111.5; LVR 1.566; MI 267

Fig. 10. *Pseudointegricorpus protusum*, GGU 366906-4, Annertuneq, 42.2-100.0; LVR 1.605; MI 301

Fig. 11. Dinocyst? sp. A HNH, GGU 408886-4, Annertuneq, 26.0-106.6; LVR 1.4034; MI 2996

Fig. 12. Dinocyst? sp. A HNH, GGU 408886-7, Annertuneq, 33.1-97.7; LVR 1.4036; MI 2998

NORTH COAST OF NUUSSUAQ

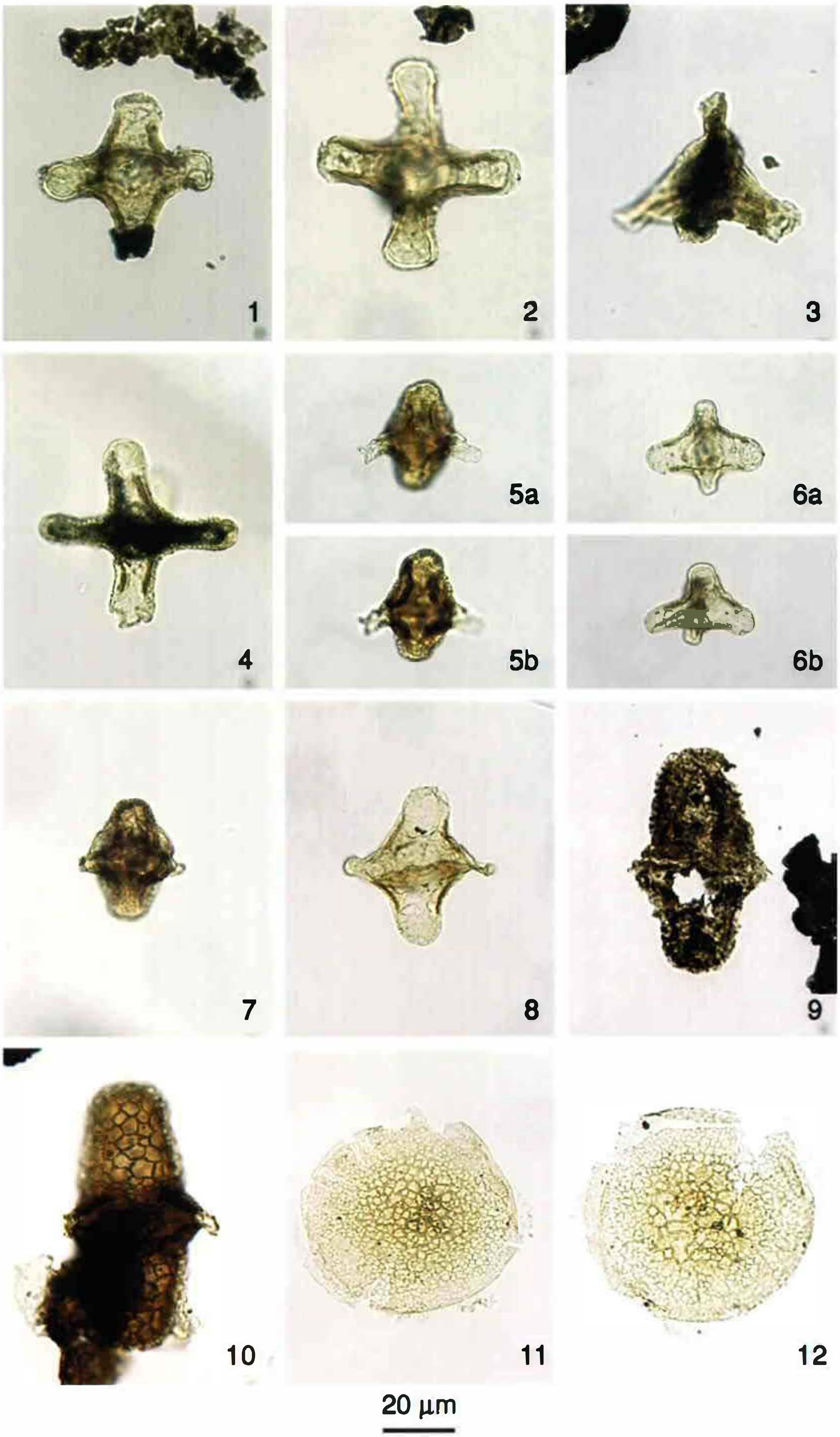

Plate 9. Northern Nuussuaq

Fig. 1. *Wodehouseia spinata*, GGU 366906-4, Annertuneq, 38.7-96.2; LVR 1.596; MI 293

Fig. 2. *Wodehouseia spinata*, GGU 408892-3, Annertuneq, 22.2-110.8; LVR 1.4071; MI 3027

Fig. 3. *Wodehouseia spinata*, GGU 408893-7, Annertuneq, 41.3-101.7; LVR 1.4074; MI 3029

Fig. 4. *Wodehouseia stanleyi*, GGU 366592-4, Annertuneq, 50.9-95.4; LVR 1.641; MI 329

Fig. 5. *Wodehouseia stanleyi*, GGU 408886-4, Annertuneq, 25.6-109.1; LVR 1.4027; MI 2990

Fig. 6. *Wodehouseia stanleyi*, GGU 408886-8, Annertuneq, 48.3-108.6; LVR 1.4032; MI 2994

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Fig. 10. *Wodehouseia* cf. *fimbriata*, GGU 408892-4, Annertuneq, 41.7-101.4; LVR 1.4073; MI 3028

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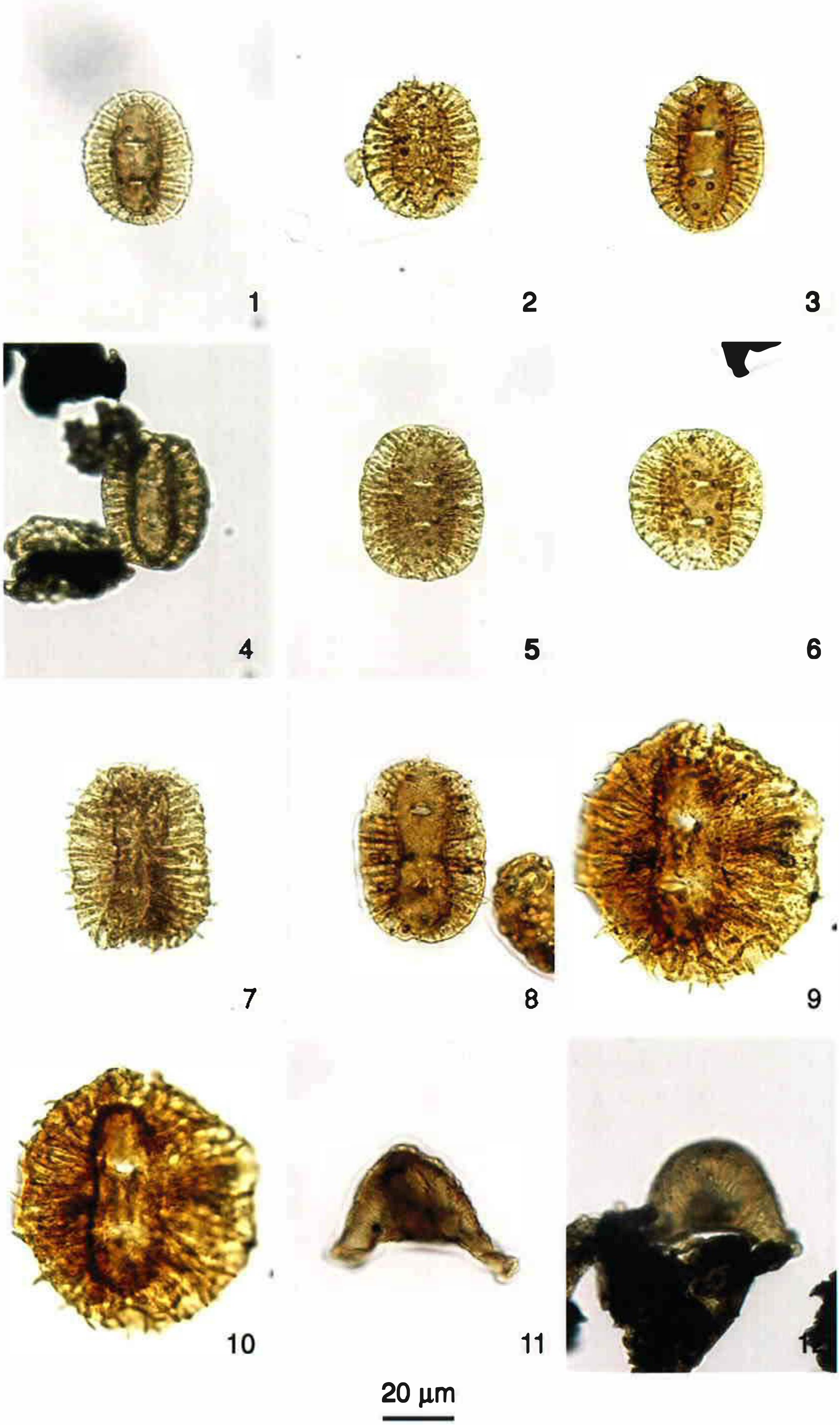
Fig. 12. *?Scollardia* sp., cf. *S. trapaformis*, GGU 366592-4, Annertuneq, 30.2-110.0; LVR 1.644; MI 331

NORTH COAST OF NUUSSUAQ



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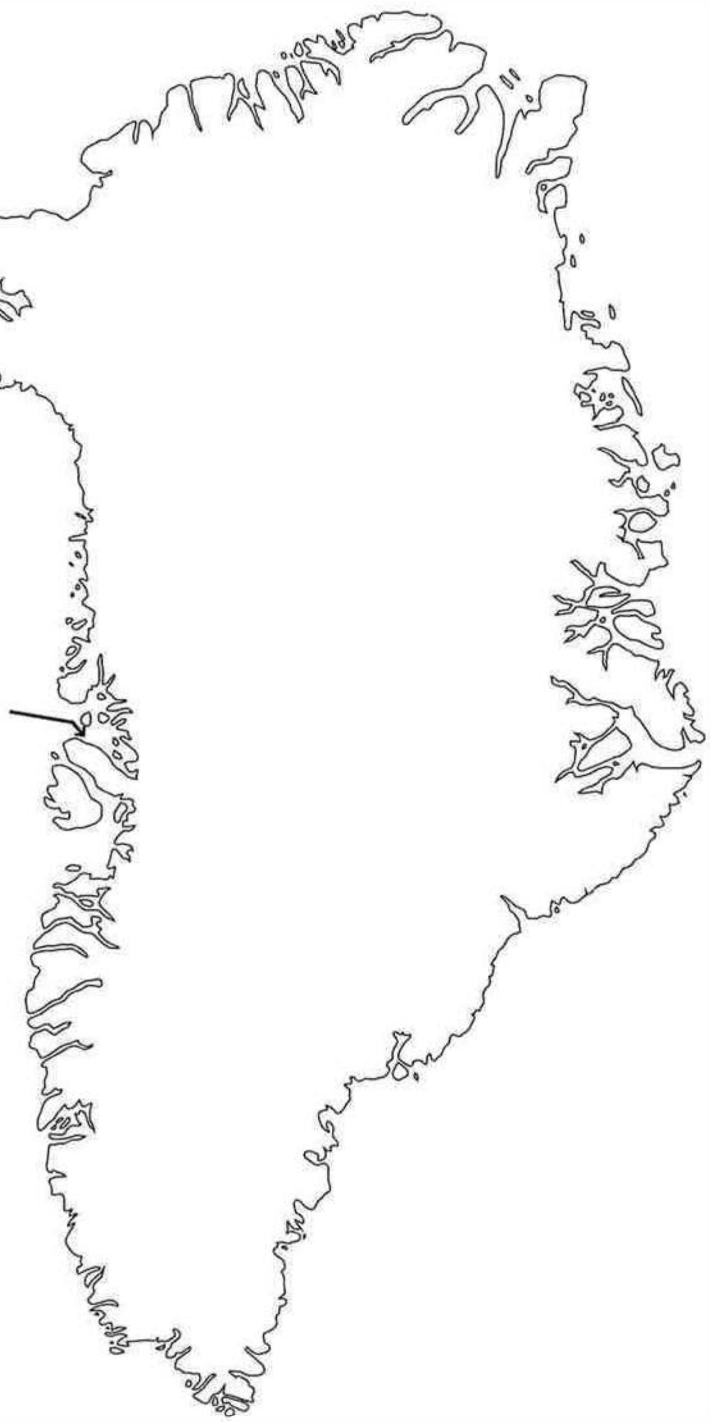

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