Dinoflagellate cyst biostratigraphy of the Upper Cretaceous black mudstones on Svartenhuk Halvø, West Greenland

Henrik Nøhr-Hansen

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Ujarassiortut Kalaallit Nunaanni Misissuisoqarfiat
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Abstract

Stratigraphical ranges and geographical distribution of dinoflagellate cysts and selected pollen species are described based on analysis of approximately 70 samples from 9 surface and 5 subsurface sections of Late Cretaceous age on Svartenhuk Halvø, West Greenland. The sections make up an approximately 300 m thick marine black mudstone succession, previously dated as Late Turonian to Early Campanian on the basis of scattered ammonite occurrences.

The dinoflagellate cysts date the majority of the studied samples to Coniacian to Early Santonian, whereas two samples are dated as Late Santonian/? Early Campanian. It has been possible to divide the studied succession into six distinguishable dinoflagellate cyst zones. The diversity of the studied dinoflagellate cysts is relatively high, more than 80 species were recorded. The assemblages are dominated by the genera *Chatangiella* and *Isabelidinium*, which in several samples constitute 20 to 50 percent of the dinoflagellate content.

CONTENTS

INTRODUCTION

The present study is part of the EFP–91 project 'Sequence analysis of the Cretaceous sediments in West Greenland', which aims to describe the Cretaceous sediments and set up a palynostratigraphy for sequence stratigraphical analysis for the Disko–Nuussuaq–Svartenhuk area in West Greenland (Christiansen *et al.*, 1992; Christiansen, 1993).

The Upper Cretaceous–Lower Tertiary black mudstone on Disko, Nuussuaq and Svartenhuk Halvø are the only marine sediments of this age exposed in the entire Labrador Sea–Baffin Bay region and studies of these are essential for a detailed interpretation of the offshore geology.

Field work on the marine succession in the summers 1990 to 1992 has been 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 TURONIAN TO CAMPANIAN OF GREENLAND AND ELSEWHERE, A REVEIW.

West Greenland

Previous studies of Upper Cretaceous dinoflagellate cysts from West Greenland are very sparse (Croxton, 1976; 1978; 1980; Ehman *et al.*, 1976; Lentin & Williams, 1980). Lentin & Williams mentioned (1980, p. 20) that the Campanian assemblage from West Greenland contain elements of both the offshore eastern Canadian assemblages (also called the Williams suite) and the Mackenzie Delta, Arctic Canada, assemblages (the so-called McIntyre suite) described by McIntyre (1974; 1975). The Paleocene dinoflagellate cyst assemblages from West Greenland have been described by Hansen (1980).

Croxton (1978) briefly described the palynomorph content from three localities at Svartenhuk Halvø and Itsako (C10, C11, C12). The locality C10 were given an Paleocene age by Croxton (1978) on the basis of pollen, whereas she gave the C12 locality a Coniacian to Campanian age on the basis of pollen and dinoflagellates. Croxton (1978, p. 65) mentioned that the thermally altered palynomorphs from the Itsako section C11 have caused problems; however on the basis of pollen she dated the lower part of the section as

Late Albian–Early Cenomanian, whereas pollen from the top of the section may indicate a Paleocene age.

The ages given by Ehman *et al.* (1976) are not consistent from text to logs (Pulvertaft, 1987; Table 1). However these workers reported a Cenomanian age for their two localities S5 and S1 in the Umîvik area.

Hansen (1980, p. 92) recorded uppermost Lower Paleocene dinoflagellate cysts in the Svartenhuk area (locality unspecified).

The above mentioned palynological investigations have been reviewed and commented on by Pulvertaft (1987).

Arctic Canada

Upper Cretaceous dinoflagellate cysts have been described from Arctic Canada by Manum (1963); Manum & Cookson (1964). Felix & Burbridge (1976) mentioned that the samples that Manum & Cookson described from the Hassel Formation (Upper Albian–Lower Cenomanian) were from the Kanguk Formation (Upper Cenomanian–Lower Campanian). McIntyre (1974; 1975) described a Santonian (Upper?) to Maastrichtian assemblage from the Mackenzie Delta. Doerenkamp *et al.* (1976) proposed zonation for the Cretaceous Aptian to Upper Albian (Isachsen, Christopher and Hassel Formations), the Santonian to Maastrichtian Kanguk Formation and the Paleocene to Eocene Eureka Sound Formation from Banks Island and adjacent areas. Doerenkamp *et al.*'s study indicates the presence of a hiatus between Upper Albian and Santonian.

Ioannides & McIntyre (1980) recognized 4 palynological associations from the District of Mackenzie; one of these associations is Upper Campanian. Núñez-Betelu & Hills (1992) preliminarily described the palynomorph content of the Kanguk Formation (Turonian to Campanian) on Ellesmere Island. 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 Ionnanides' stratigraphy is not very detailed, due to poor outcrop, and absence of macrofossils.

Western Canada, Western U.S.A.

Wall & Singh (1975) reported a most probably Campanian age microfossil assemblage from North-Central Alberta; Harland (1973) described the marine palynomorphs of the Bearpaw Formation (Upper Campanian) in southern Alberta and continued (Harland, 1977) with the description of the palynomorphs of the Bearpaw Formation (?Upper Campanian–Maastrichtian) in Montana, U.S.A. Sweet & McIntyre (1988) described Upper Turonian palynomorphs from North Central Alberta, Bloch *et al.* (1993) presented a revised stratigraphy for the lower part of the Colorado Group (Albian to Turonian) in Western Canada. Stone (1973) described the palynology from the ammonite dated Almond Formation (Upper Campanian to possibly Maastrichtian) in Wyoming. Harker *et al.* (1990) described the Campanian dinoflagellate cyst assemblage of the Interior Plains of Canada, Wyoming and Texas.

Offshore Eastern Canada, Eastern U.S.A.

The following papers all describe the Upper Cretaceous dinoflagellate cyst content from wells in the Gulf of Lawrence, Scotian Shelf, Grand Banks and Labrador shelf offshore eastern Canada: 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.

Benson (1976) described the dinoflagellate cyst assemblages from the Maastrichtian and Paleocene in Maryland. May (1980) described the dinoflagellate cyst assemblage from the Campanian to Maastrichtian Monmouth Group of New Jersey. Aurisano & Habib (1977) established a Campanian to lowermost Tertiary dinoflagellate cyst zonation from New Jersey. Aurisano (1989) proposed a Cenomanian to Maastrichtian dinoflagellate cyst zonation for the Atlantic Coastal Plain of New Jersey and Delaware. Tocher (1987) described the Campanian to Maastrichtian dinoflagellate cyst assemblage from the United States Atlantic Margin.

Northern North Sea, clastic deposits

According to Costa & Davey (1992, pp. 105–106) no dinoflagellate cyst information has been published from these regions, but unpublished personal observation by Lucy. I. Costa (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 by Costa & Davey (1992) who probably included some of Foucher's numerous data in their description of the stratigraphical ranges of Upper Cretaceous dinoflagellate cysts from the British Isles, the North Sea and around the Shetland Islands. Clarke & Verdier (1967) described the Cenomanian to Campanian on the Isle of Wight and made the first and only attempt to establish a dinoflagellate zonation for the British Upper Cretaceous. Hart *et al.* (1987) listed dinoflagellate cysts together with microfossils from key Upper Cretaceous sections on the Isle of Wight.

The dinoflagellate cyst assemblage from the Turonian type area around Saumur in France has been described by Foucher (1982). Tocher & Jarvis (1987) described Turonian dinoflagellate cysts from Devon, England. Jarvis *et al.* (1987; 1988) described the Albian to Turonian stratigraphy and anoxic events in the Cenomanian–Turonian.

Foucher (1971a,b) and Robaszynski *et al.* (1980) described dinoflagellate cyst assemblages of Coniacian age from France. Schiøler (1992) described a diverse dinoflagellate cyst assemblage from the island of Bornholm, Denmark. Westin (1992) established a dinoflagellate cyst stratigraphy from the Albian to Santonian in the southern Sweden. The diverse assemblages described from Bornholm (Schiøler, 1992) and Sweden (Westin, 1992) are dominated by North Sea and North-West European limestone facies species; however the abundance of the northern North Sea genus *Chatangiella*, especially in southern Sweden, is remarkable.

Yun (1981) described a Lower Santonian dinoflagellate cyst assemblage from northwest Germany.

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 quite similar on assemblage level to the material recorded from West Greenland, whereas moving down to 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

The Upper Cretaceous samples analysed in the present biostratigraphic study were collected during hydrocarbon-related field work carried out by the Geological Survey of Greenland (GGU) in the summers of 1990 to 1992, in onshore areas of West Greenland (69°–72°N) (Christiansen *et al.*, 1992; Christiansen, 1993).

A dinoflagellate cyst stratigraphy has been established for the Upper Cretaceous sediments in the Umîvik area of Svartenhuk Halvø (Fig. 1). Marine palynomorphs was recorded from nine outcrop localities and five subsurface sections represented by slim cores from shallow wells drilled in 1992 by GGU is helicopter-transportable drilling equipment. The sections represent thicknesses of 2 to 150 metres. The sections make up an approximately 300 m thick sandy shale sequence (Fig. 2).

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 was 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 5 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 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 text 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 where they are accessible for examination.

Composition of the organic material; maturation

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

The 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.

DINOFLAGELLATE CYST STRATIGRAPHY AND ZONATION ON SVARTENHUK HALVØ

A dinoflagellate cyst stratigraphy has been established for the Upper Cretaceous sediments in the Umîvik area of Svartenhuk Halvø (Fig. 1). Marine palynomorphs was recorded from nine outcrop localities and five subsurface sections represented by slim cores from shallow wells drilled in 1992 by GGU's helicopter-transportable drilling equipment.

Due to the very sparse macrofossil content and the rather homogeneous lithology, the stratigraphical correlation of the geographically widely spread 14 sections is based solely on the first and the last occurrences and acme of stratigraphically important dinoflagellate species.

The dinoflagellate cyst assemblages in all the studied sections are characterised by a large number of *Chatangiella* specimens. According to the literature the genus *Chatangiella* ranges from the Upper Cenomanian to the Upper Maastrichtian (Costa & Davey, 1992, and many others). Geographically the genus *Chatangiella* dominates Upper Cretaceous assemblages in Western Interior, U.S.A., Western Canada, Arctic Canada and the northern North Sea. The genus *Chatangiella* is also very abundant in the southern hemisphere (especially in Australia and Antarctica), whereas the genus is less distributed in Northwestern Europe and in the Tethyan realm (Lentin & Williams, 1980, Costa & Davey, 1992).

The presence of the species *Heterosphaeridium difficile* in all but one of the studied sections on Svartenhuk Halvø indicates an Early/Middle Turonian to Early (?Late) Santonian age (Haq *et al.*, 1987; Costa & Davey, 1992). The presence of *Isabelidinium cooksoniae* indicates a post Early Turonian age (Costa & Davey, 1992).

The absence of the characteristic species *Litosphaeridium siphoniphorum* and *Stephodinium coronatum*, both of which have their last occurrence in the Turonian, the presence of *Heterosphaeridium difficile* and the abundance of *Chatangiella* specimens advocate for a post-Turonian to pre-Campanian age for all, except one, of the studied sections at Svartenhuk Halvø.

The species list on the cumulate range chart illustrates that the assemblage changes only little with time. However, based on the first and last occurrences of a few morphologically characteristic and stratigraphically important species, it has been possible to distinguish six dinoflagellate zones from the cumulate section.

***Chatangiella* aff. *tripartita* Zone**

The dinoflagellate cyst assemblage recorded from the well GGU 400709 (Encl. 2) indicates the presence of the oldest recorded marine influenced depositional environment on Svartenhuk Halvø.

Age. The age of the zone is most likely Coniacian but a latest Turonian age cannot be excluded.

Definition. The zone is defined by the interval containing *Chatangiella* aff. *tripartita*, its upper limit being the lowermost occurrence of *Spinidinium echinoideum*.

Thickness and distribution. The zone has only been recorded in well GGU 400709 (Encl. 2), where it is represented by approximately 75 m sediments.

Characteristic species. The zone is characterised by the presence of the species *Chatangiella* aff. *tripartita*, *C. granulifera*, *C. verrucosa*, *Heterosphaeridium difficile*, *Surculosphaeridium? longifurcatum*, *Florentinia* aff. *deanei*, *Palaeohystrichophora infusorioides*, *Dinopterygium* aff. *cladoides*, *Cribroperidinium* aff. *intricatum*, *Scriniodinium* aff. *obscurum*, *Odontochitina striatoperforata*, *Desmocysta plekta*, *Trigonopyxidia ginella*, *Fromea fragilis*, a few *Florentinia* aff. *mantelli* specimens, a few specimens of *Isabelidinium* aff. *magnum* and a single specimen of *Xenascus* aff. *perforatus*.

Discussion. According to Costa & Davey's (1992) observations from the North Sea, region the presence of *Heterospaeridium difficile* and *Surculosphaeridium? longifurcatum* throughout the zone indicates an age no younger than Early Santonian. *Florentinia deanei* has its last occurrence in the uppermost Coniacian in Europe (Foucher, 1979; Costa & Davey, 1992). According to Costa & Davey (1992) and Williams *et al.* (1993) *Florentinia mantelli* has its last occurrence in the uppermost Turonian. Schiøler (1992) reported *F.*

mantelli as a presumed reworked species in his study of Coniacian on Bornholm, Denmark, whereas Yun (1982) reported *F. mantelli* in *situ* from Santonian deposits in Germany.

Williams *et al.* (1993) reported that the species *Chatangiella verrocosa* has its first occurrence in the Lower Coniacian and ranges to the Upper Campanian in the northern hemisphere. Williams & Bujak (1985) reported a similar range (Lower Coniacian to Upper Campanian) for the morphologically closely related *Chatangiella granulifera*, whereas Costa & Davey (1992) reported a Lower Turonian to Upper Campanian range for *C. granulifera*.

Williams & Bujak (1985) also reported a Lower Coniacian to Upper Campanian range for the species *Trigonopyxidia ginella*, which was described from the ?Upper Albian–Cenomanian from Australia by Cookson & Eisenack (1960).

In the present study the species *Chatangiella* aff. *tripartita* has only been recorded from well GGU 400709 (Encl. 2) and the lowermost sample in well GGU 400712 (Encl. 8). *Chatangiella tripartita* was described by Cookson & Eisenack (1960) from probably Upper Turonian to Middle Senonian of Australia. Schiøler (1992) reported *C. tripartita* from the Lower to "mid"-Coniacian on the Danish island of Bornholm. Davey & Costa (1992) reported the *C. tripartita/victoriensis* complex from Upper Cenomanian to Lower Maastrichtian in the North Sea region. Helby *et al.* (1987) reported the species from Lower Santonian (consistent) to Middle and Upper Santonian (inconsistent).

The presence of only a few species characteristic for the Turonian advocates an Coniacian age, for this zone.

Spinidinium echinoideum Zone

Age. Coniacian or ?Early Santonian.

Definition. Interval from the first occurrence of *Spinidinium echinoideum* to immediately below the first occurrence of *Arvalidinium* aff. *sheii*.

Thickness and distribution. The zone is only represented by two samples in the upper part of well GGU 400709 (Encl. 2), where it constitutes approximately 10 m of the section.

Characteristic species. The zone is characterised by the presence of the species *Spinidinium echinoideum*, *Chatangiella* aff. *tripartita*, *C. granulifera*, *C. verrucosa*, *Heterosphaeridium difficile*, *Surculosphaeridium? longifurcatum*, *Palaeohystrichophora infusorioides*, *Florentinia* aff. *deanei*, *Cribroperidinium* aff. *intricatum*, *Scriniodinium* aff. *obscurum*, *Odontochitina striatoperforata*, *Fromea fragilis* and a few *Florentinia* aff. *mantelli* specimens.

Discussion. The first occurrence of the species *Spinidinium echinoideum* in the upper part of well GGU 400709 (Encl. 2) indicates a Coniacian to Early Santonian age. The species was described by Cookson & Eisenack (1960) from the Santonian and Campanian in Australia. According to Clarke & Verdier (1967) and Foucher (1979) *Spinidinium echinoideum* ranges from the Lower Santonian to the lowermost Campanian in England and France. However, Foucher (1979) reported in addition a *S.* cf. *enchinoideum* from the Upper Turonian in France. Schiøler (1992) recorded *S. echinoideum echinoideum* from Coniacian deposits from the island of Bornholm, Denmark.

The species *S. mariae* is according to the present author almost identical with *S. echinoideum*. According to Aurisano (1984, 1989) *Spinidinium mariae* ranges in the Atlantic Coastal plain of New Jersey, U.S.A. from Lower Santonian to uppermost Lower Campanian.

***Arvalidinium* aff. *sheii* Zone**

Age. Coniacian or ?Early Santonian

Definition. Interval from the first occurrence of *Arvalidinium* aff. *sheii* to immediately below the first occurrence of *Laciniadinium arcticum*.

Thickness and distribution. The zone is represented by the lower 57 m of well GGU 400712 (Encl. 8) and maybe by the two lowermost samples (approximately 40 m) from section C12 (Encl. 12).

Comments. The diversity of the present zone is remarkably higher than in the two previous zones. The appearance of several species not recorded from the older zones, could indicate that in the Svartenhuk area there exist sediments of older age than the age represented by the *Arvalidinium* aff. *sheii* Zone and younger than the *Spinidinium echinoideum* Zone these are probably situated in the subsurface below the lowermost sample in well GGU 400712 (Encl. 8). A hiatus could also explain the remarkable diversity change.

Characteristic species. The zone is characterised by the presence of numerous *Chatangiella* specimens, which constitute between 35 and 53% of the dinoflagellate cysts assemblages, and *Odontochitina striatoperforata* which constitutes up to 10% of the assemblage. The zone is also characterised by the incoming of the species *Arvalidinium* aff. *sheii*, *Chatangiella* aff. *spectabilis*, *C.* aff. *ditissima*, *Eurydinium* aff. *glomeratum* and *Palaeotetradinium silicorum* whereas the following characteristic species continue their occurrence from the previous *Spinidinium echinoideum* Zone: *Spinidinium echinoideum*, *C. granulifera*, *C. verrucosa*, *Heterosphaeridium difficile*, *Surculosphaeridium? longifurcatum*, *Palaeohystrichophora infusorioides*, *Florentinia* aff. *deanei*, *Odontochitina striatoperforata*, *Desmocysta plekta*, *Trigonopyxidia ginella*, *Fromea fragilis*, *Wallodinium anglicum*, *Trithyrodinium* aff. *suspectum*, a few *Florentinia* aff. *mantelli* specimens and a single specimen of *Xenascus* aff. *perforatus* and *Dorocysta litotes*.

The species *Chatangiella* aff. *tripartita* is only represented in the lowermost sample in the present zone.

Discussion. The abundance of the species *Arvalidinium* aff. *sheii* in the present zone is quite interesting. Previously *A. sheii* only has been reported by Manum (1963) who described the species (as *Deflandrea sheii*) from a "Deflandreoid"-dominated assemblage from Graham Island, arctic Canada, where according to Manum (1963) and Manum & Cookson (1964) it is very common. The dinoflagellate cyst assemblage from the sample reported by Manum & Cookson (1964) from the presumed Kanguk Formation at Graham Island is quite similar to the assemblage recorded from the *A.* aff. *sheii* Zone on Svartenhuk Halvø. However the appearance of the species *Laciniadinium arcticum* (as *Diconodinium arcticum*) on Graham Island has not been observed in the *A.* aff. *sheii* Zone on Svartenhuk Halvø. Manum (1963) and Manum & Cookson (1964) indicated that their samples were from the Upper Albian–lower Cenomanian Hassel Formation, whereas Felix & Budbridge (1976) considered that Manum's samples more likely represented the Kanguk Formation of Late Cenomanian to Early Campanian age.

Laciniadinium arcticum Zone

Age. Coniacian or ?Early Santonian

Definition. Interval from the first occurrence of *Laciniadinium arcticum* to the last occurrence of *Arvalidinium* aff. *sheii.*

Thickness and distribution. The zone is represented by approximately 50 m in well GGU 400711 (Encl. 10), approximately 50 m in section C12 (Encl. 12), approximately 20 m in the composite section GGU 400712+HNH 920821/1 (Encl. 8) and maybe by one sample in section HNH920822/3 (Encl. 6)

Characteristic species. The zone is like the underlying zone characterised by the presence of numerous *Chatangiella* specimens. The zone is also characterised by the incoming of the species *Laciniadinium arcticum*, *Isabelidinium* aff. *acuminatum* and *Eurydinium* aff. *glomeratum* with a small apical horn. The species *Microdinium reticulatum*, *Tanyosphaeridium* cf. *variecalamus*, *Scriniodinium campanula* and *Florentinia* sp. 1 HNH are only recorded from the present zone, however their appearance is rare. The following species continue their appearance from the previous *Arvalidinium* aff. *sheii* zone: *Arvalidinium* aff. *sheii*, *Chatangiella* aff. *spectabilis*, *C.* aff. *ditissima*, *Spinidinium echinoideum*, *C. granulifera*, *C. verrucosa*, *Heterosphaeridium difficile*, *Surculosphaeridium? longifurcatum*, *Palaeohystrichophora infusorioides*, *Florentinia* aff. *deanei*, *Odontochitina striatoperforata*, *Desmocysta plekta*, *Trigonopyxidia ginella*, *Fromea fragilis*, *Wallodinium anglicum*, *Trithyrodinium* aff. *suspectum*, *Xenascus* aff. *perforatus* and *Florentinia* aff. *mantelli.* The species *Eurydinium* aff. *glomeratum* and *Palaeotetradinium silicorum* have their last occurrence in the lower part of the zone.

Discussion. The palynomorph assemblage of the present zone is very similar to the "Deflandreoid"-dominated assemblage from Graham Island, arctic Canada, recorded by Manum (1963) and Manum & Cookson (1964). In addition to the abundance of the species *Arvalidinium* aff. *sheii* and the presence of *Laciniadinium arcticum* there are 15 other palynospecies from the present zone that are also represented in the Graham Island samples.

Heterosphaeridium difficile Zone

Age. Coniacian or ?Early Santonian

Definition. Interval from immediately above the last occurrence of *Arvalidinium* aff. *sheii* to the last occurrence of *Heterosphaeridium difficile.*

Thickness and distribution. The zone is represented in six outcrop sections and two subsurface sections in the Svartenhuk area. The zone is represented by 94 m in the composite section GGU 400708+HNH 920806/1 (Encl. 3), 16 m in section HNH 920809/1 (Encl. 4), 20 m in section HNH 920822/2 (Encl. 5), maybe from the uppermost sample in section HNH 920822/3 (Encl. 6), 15 m in section HNH 920822/5 (Encl. 9), 71 m in the composed section GGU 400710+FGC 910807/2 (Encl. 11) and by approximately 60 m in section C12 C.C (Encl. 12).

Characteristic species. The zone is characterised by a poorly preserved low diversity palynomorph assemblage.

The frequency of *Chatangiella* specimens is very low compared to the previous zone. Species such as *Laciniadinium arcticum*, *Spinidinium echinoideum*, *Heterosphaeridium difficile*, *Palaeohystrichophora infusorioides*, *Odontochitina striatoperforata* and *Chatangiella* aff. *ditissima* are present throughout the zone, whereas *Surculosphaeridium? longifurcatum*, *Isabelidinium* aff. *acuminatum*, *Trigonopyxidia ginella*, *Wallodinium anglicum* and *Eurydinium* aff. *glomeratum* (with a small apical horn) are only recorded from the lower part of the zone. The following species have a more sporadic occurrence whit in the zone: *Chatangiella granulifera*, *C.* aff. *spectabilis*, *Desmocysta plekta*, *Xenascus* aff. *perforatus*, *Florentinia* aff. *deanei* and *F.* aff. *mantelli.*

Discussion. The last occurrences of *Heterosphaeridium difficile* and *Surculosphaeridium? longifurcatum* with in the zone indicate according to Costa & Davey (1992) an age no younger than Early Santonian.

Dinogymnium cf. _sibiricum_ Zone

Age. ?Late Santonian or ?Early Campanian

Definition. Interval from immediately above the last occurrence of *Heterosphaeridium difficile* up to the last occurrence of *Dinogymnium* cf. *sibiricum.*

Thickness and distribution. The zone has only been recorded in a three metre interval in the section JLG (Encl. 7) situated just below the base of the hyaloclastic basalt.

Characteristic species. The zone is represented by a low diversity palynomorph assemblage, characterised by well preserved specimens of *Isabelidinium* aff. *?acuminatum*, and very few specimens of *Dinogymnium* cf. *sibiricum.* The following stratigraphically interesting species continue their occurrence from the previous zones: *Chatangiella* aff. *ditissima*, *Palaeohystrichophora infusorioides*, *Spinidinium echinoideum*, *Trithyrodinium* sp. and *Xenascus* aff. *perforatus.*

Discussion. The presence of the species *Chatangiella* aff. *ditissima*, *Palaeohystrichophora infusorioides* and *Trithyrodinium* indicates according to Costa & Davey (1992) an age no younger than Campanian; the same authors mention that the species *Isabelidinium acuminatum* first occurs, or first become consistent in the Lower Campanian. The presence of *Spinidinium echinoideum* indicates according to Foucher (1979) an age no younger than Early Campanian. The species *Dinogymnium sibiricum* has a Coniacian to Early Santonian range according to Costa & Davey (1992), whereas McIntyre (1974) reported a Late

Santonian to Late Campanian range for the very similar species *Dinogymnium* sp. cf. *Gymnodinium sibiricum.*

The discussion above clearly illustrates the difficulties in dating the present zone. However the absence of *Heterosphaeridium difficile* and the presence of *Spinidinium echinoideum* indicate a Late Santonian/Early Campanian age.

COMPARISON WITH PREVIOUSLY REPORTED MACROFOSSIL AGES

The presence of ammonites of Late Turonian, Coniacian, Santonian and Early Campanian ages on south-east Svartenhuk Halvø (Fig. 3) was recorded by Birkelund (1965; Fig. 2, Table 1) 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 northern West Greenland.

Birkelund (1965) recorded *in situ* ammonites indicating the presence of Lower Coniacian deposits at the ammonite locality at Umîvik. This locality corresponds to the uppermost part of well GGU 400712 which in the present study has been referred to the *Laciniadinium arcticum* dinoflagellate zone (Coniacian or Lower Santonian). From the same locality Birkelund (1965) recorded ammonites of Santonian and Early Campanian ages in displaced blocks.

The loose specimens of ammonites recorded from the Store Tange V locality indicate a Late Turonian age (Birkelund, 1965), this locality corresponds to the locality C12/CC (Encl. 12) collected by Catherine A. Croxton, which according to the present dinoflagellate study is of Coniacian or Early Santonian age.

A little north of the Store Tange V locality at Lille Tange V Birkelund (1965) recorded ammonites of Early Santonian age *in situ* at 180–200 m above sea-level, which correlate well with the age indicated by dinoflagellate from the upper part of section C12/CC (Encl 12).

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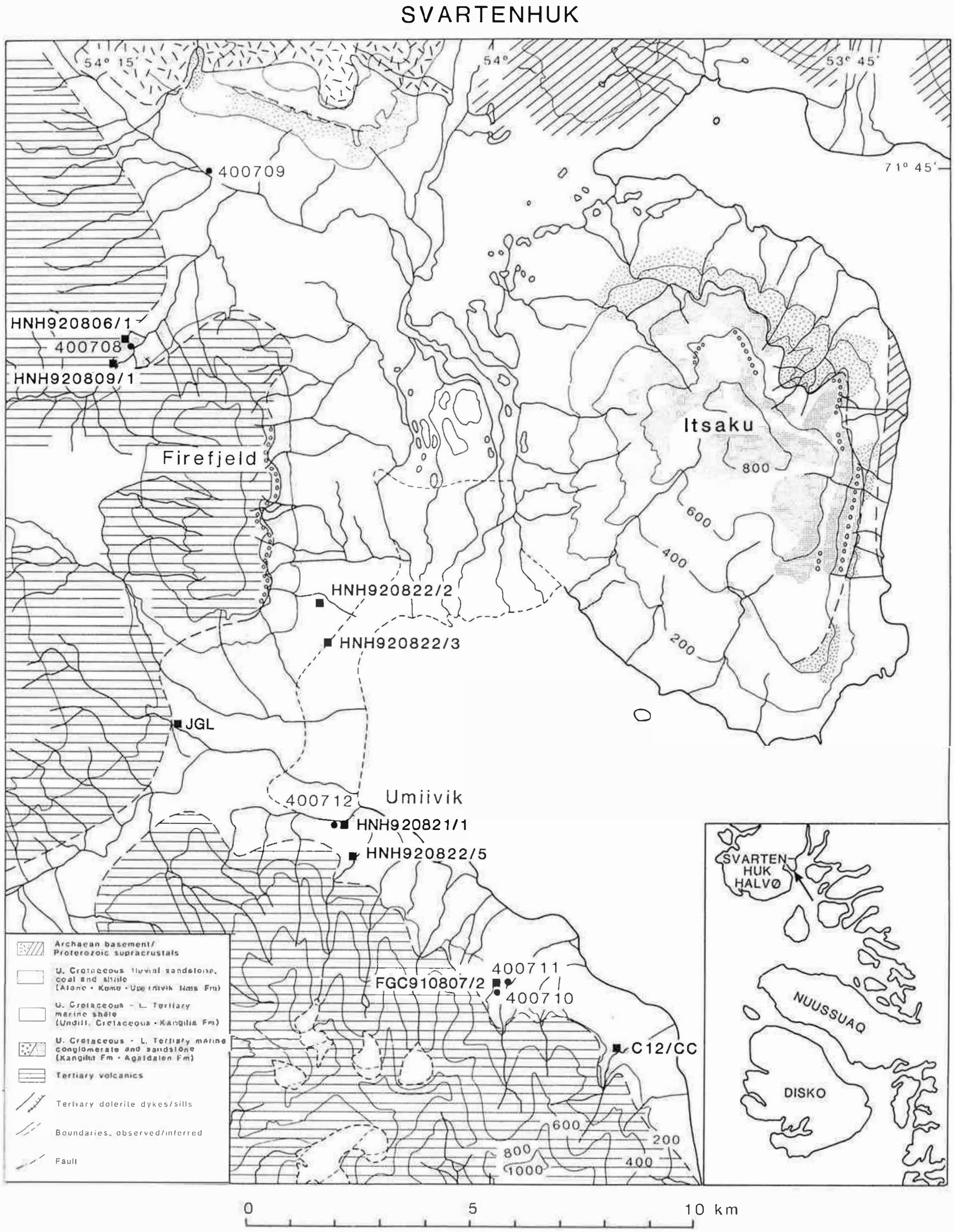

Fig. 1. Location of the examined outcrops and subsurface sections that yielded dinoflagellate cysts.

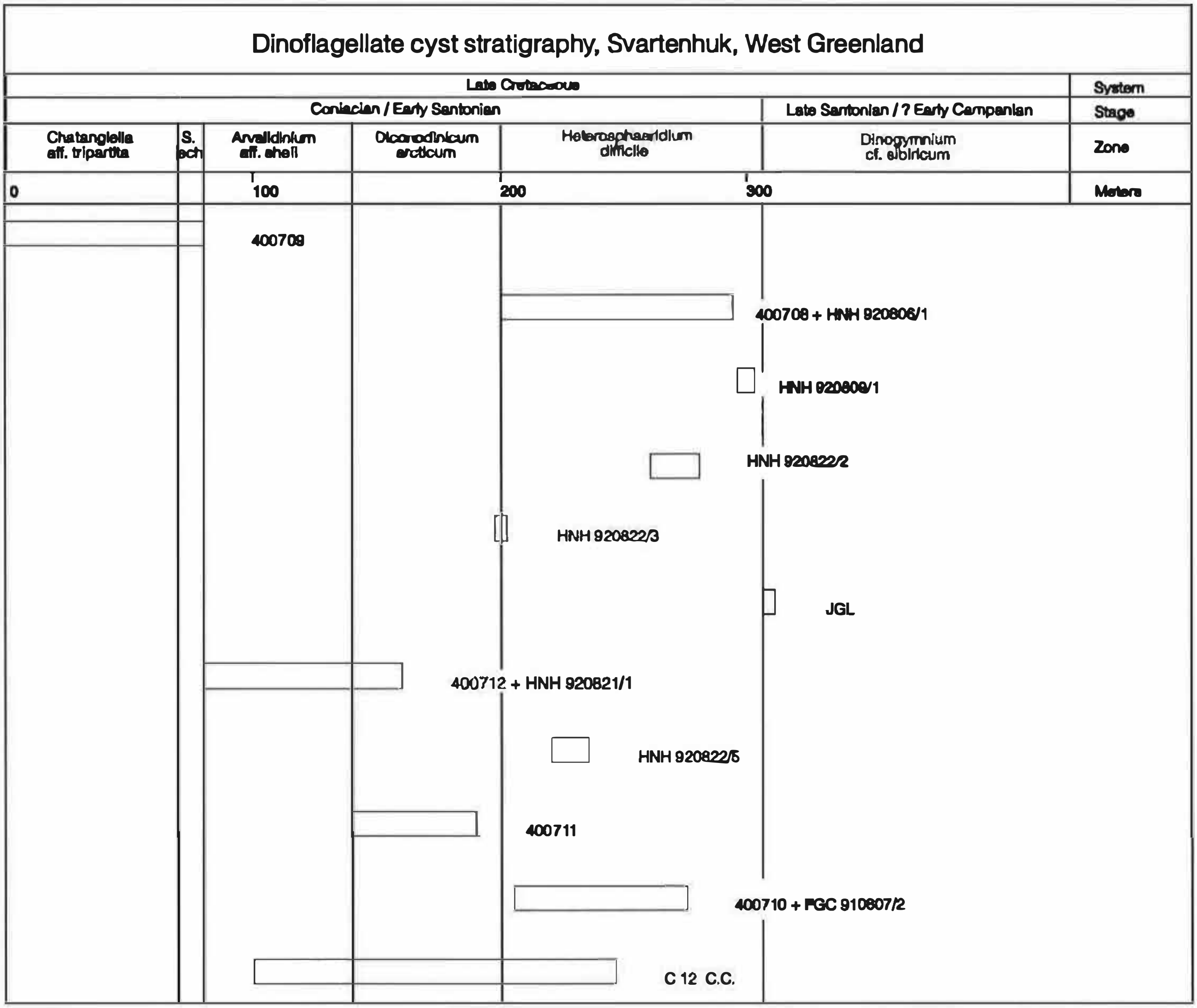

Fig. 2 Stratigraphical correlation of the sections that yielded dinoflagellate cysts.

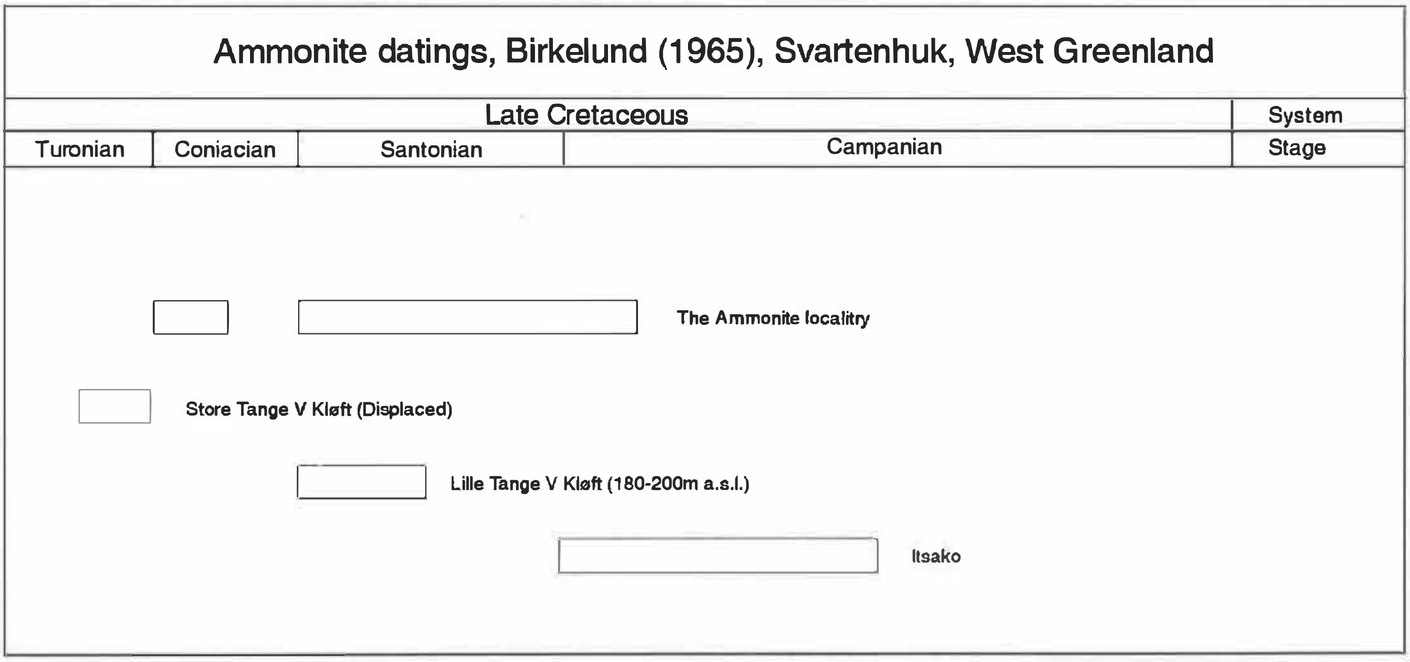

Fig. 3. Previous ammonite datings obtained from Birkelund (1965)


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400711-6
40071015
40071013
40091011
400710-9
400710-7
358435
402610
402615
251506
251507
Fromea fragilis
Acritarch sp. 1 HNH
Veryhachium spp.
Fromea amphora
Schizocystia ssp.
Isabelidinium cooksoniae
Odontochitina operculata
Isabelidnium sp. 7 HNH
Chatangiella aff. tripartita
Chlamydophorella spp.
Pterodinium spp.
Chatangiella verrucosa
Dinopterygium aff. cladoides
Scriniodinium aff. obscurum
Cribroperidinium aff. intricatum
Surculosphaeridium longifurcatum
Florentinia aff. deanei
Palaeohystrichophora infusorioides
Exochosphaeridium spp.
Odontochitina striatoperforata
Stiphrosphaeridium anthophorum
Hystrichodinium pulchrum
Heterosphaeridium difficile
Circulodinium distinctum
Palaeoperidinium pyrophorum
Chatangiella granulifera
Spiniferites spp.
Trithyrodinium aff. suspectum
Senoniasphaera aff. protusa
Isabelidinium aff. magnum
Trigonopyxidia ginella
Desmocysta plekta
Spinidinium? sp.
Dinocyst HNH sp. 10
Oligosphaeridium pulcherrimum
Xenascus cf. ceratioides
Chorat sp. 2 HNH
Coronifera oceanica
Florentinia aff. mantellii
Scriniodinium aff. europylum
Wallodinium anglicum
Chlamydophorella nyei
Spinidinium echinoideum
Paraodinia spp.
Isabelidinium sp. 12 HNH
Eurydinium aff. glomeratum
Palaeoperidinium cretaceum
Arvalidinium aff. sheii
Isabelidinium cooksoniae
Oligosphaeridium complex
Chorat sp. 5 HNH
Trithyrodinium aff. suspectum
Chatangiella aff. ditissima
Palaeotetradinium silicorum
Oligosphaeridium aff. pulcherrimum
Membranilarnacia? spp.
Chlamydophorella trabeculosa
Trithyrodinium sp. small
Chatangiella aff. spectabilis
Achomosphaera aff. sagena
Dorocysta litotes
Microdinium spp.
Scriniodinium spp.
"Tenua" spp.
Vesperopsis? sp.
Stephodinium? sp.
Xiphophoridium aff. alatum
Chatangiella sp. A HNH
ENCL: 1
SVARTENHUK (300 - 0m)
ANALYSTS: 1993 HN-H
DATE: 3/12
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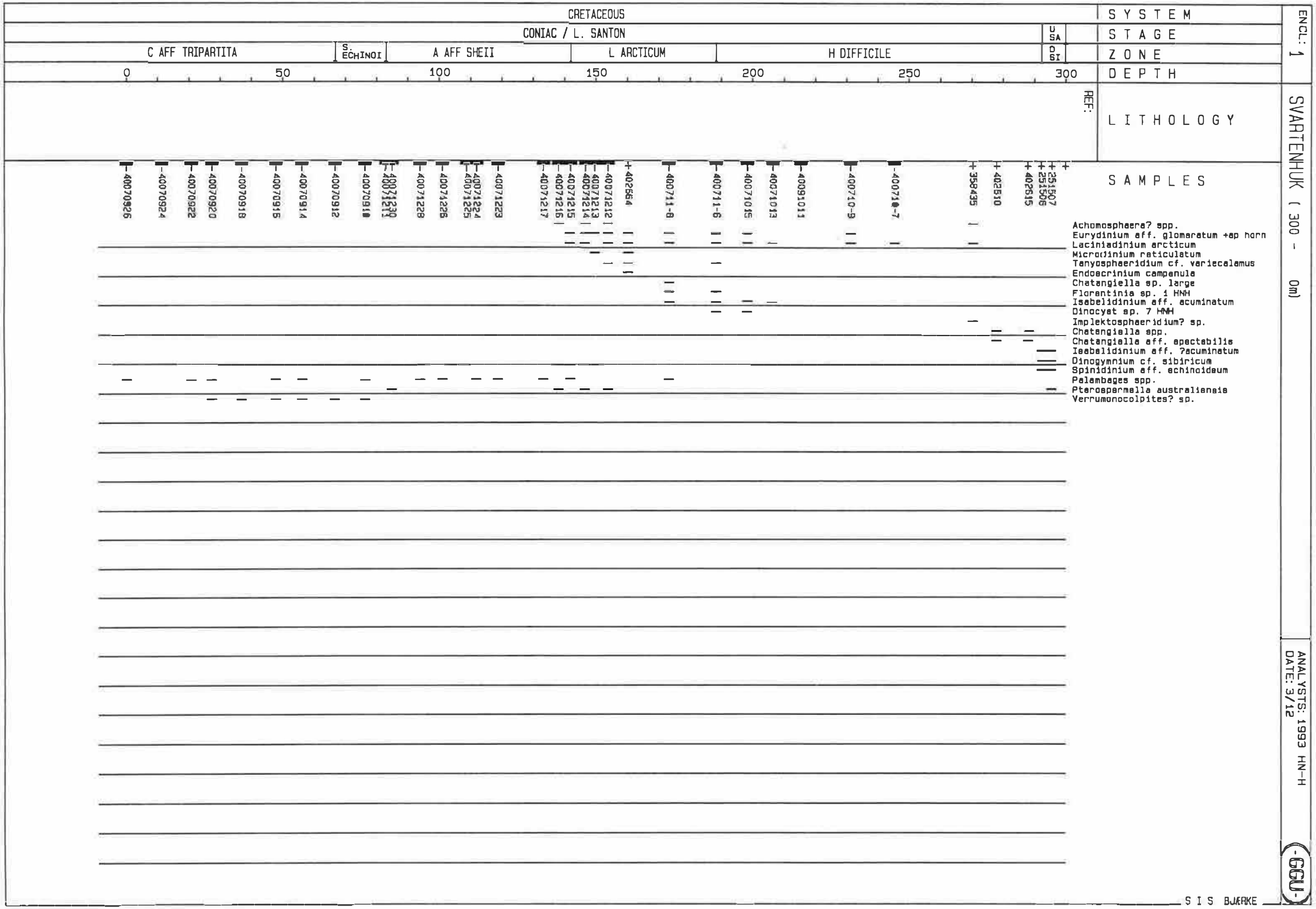

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402664
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40071015
40091011
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358435
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251507
Achomosphaera? spp.
Eurydinium aff. glomaratum +ap horn
Laciniadinium arcticum
Microdinium reticulatum
Tanyosphaeridium cf. variecalamus
Endoscrinium campanula
Chatangiella sp. large
Florentinia sp. 1 HNH
Isabelidinium aff. acuminatum
Dinocyst sp. 7 HNH
Implektosphaeridium? sp.
Chatangiella spp.
Chatangiella aff. spectabilis
Isabelidinium aff. ?acuminatum
Dinogymnium cf. sibiricum
Spinidinium aff. echinoideum
Palambages spp.
Pterospermella australiensis
Verrumonocolpites? sp.
ENCL: 1
SVARTENHUK (300 - 0m)
ANALYSIS: 1993 HN-H
DATE: 3/12
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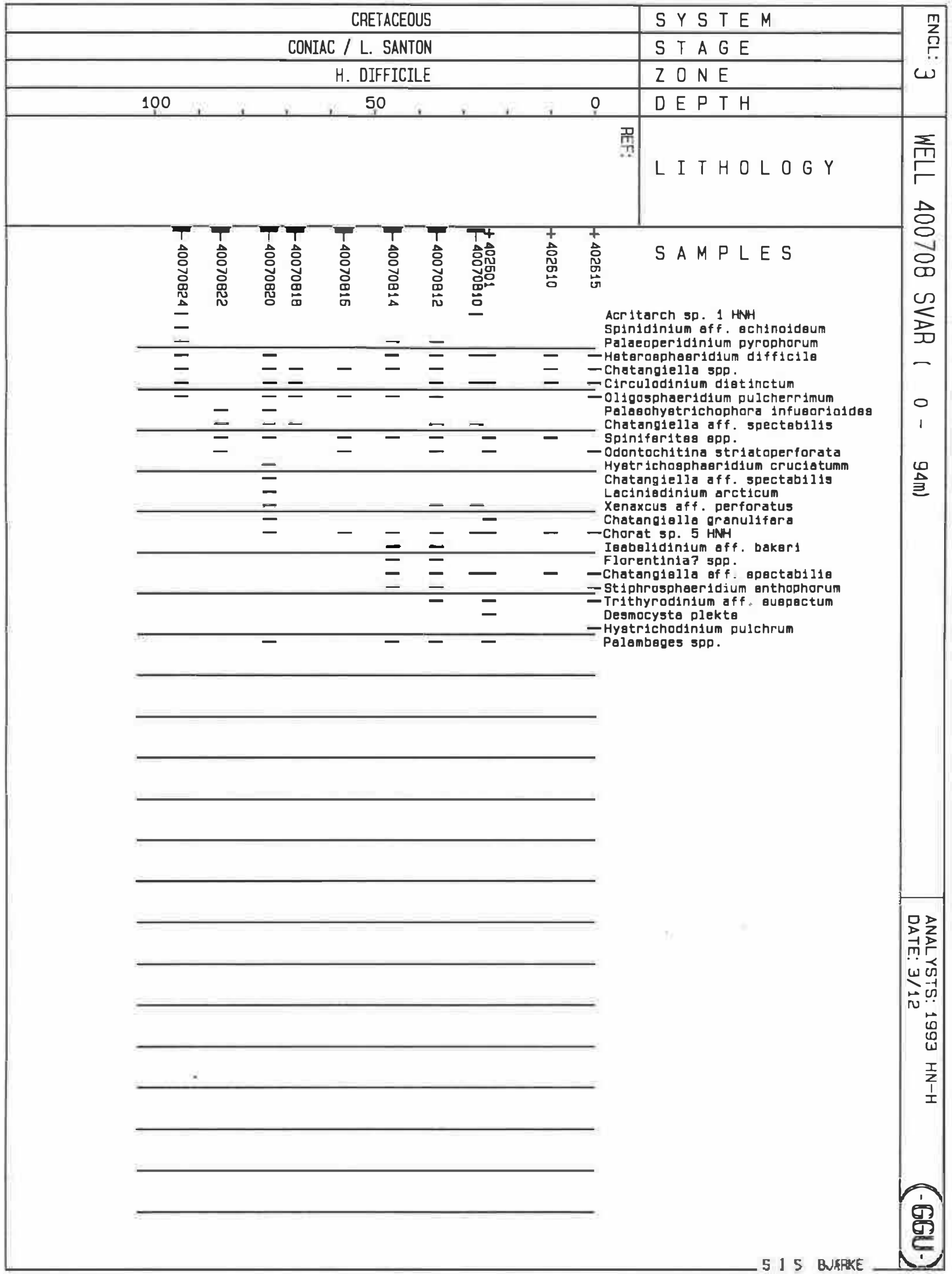

CRETACEOUS
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Acritarch sp. 1 HNH
Spinidinium aff. echinoideum
Palaeoperidinium pyrophorum
Heterosphaeridium difficile
Chatangiella spp.
Circulodinium distinctum
Oligosphaeridium pulcherrimum
Palaeohystrichophora infusorioides
Chatangiella aff. spectabilis
Spiniferites spp.
Odontochitina striatoperforata
Hystrichosphaeridium cruciatumm
Chatangiella aff. spectabilis
Laciniadinium arcticum
Xenaxcus aff. perforatus
Chatangiella granulifera
Chorat sp. 5 HNH
Isabelidinium aff. bakeri
Florentinia? spp.
Chatangiella aff. spectabilis
Stiphrosphaeridium anthophorum
Trithyrodinium aff. suspectum
Desmocysta plekta
Hystrichodinium pulchrum
Palambages spp.
ENCL: 3
WELL 400708 SVAR (0 - 94m)
ANALYSTS: 1993 HN-H
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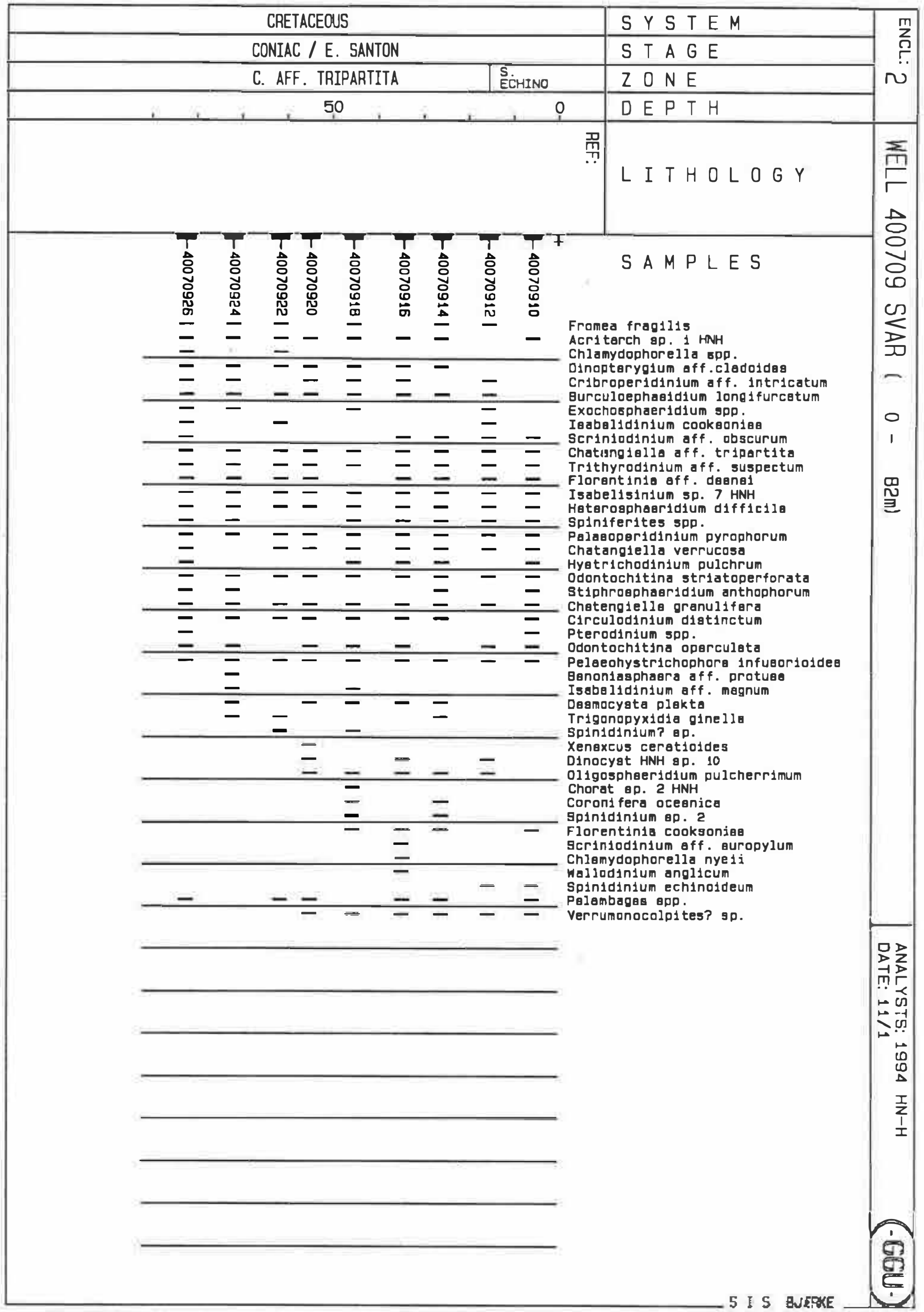

CRETACEOUS
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REF:
LITHOLOGY
SAMPLES
40070926
40070924
40070922
40070920
40070918
40070916
40070914
40070912
40070910
Fromea fragilis
Acritarch sp. 1 HNH
Chlamydophorella spp.
Dinopterygium aff.cladoides
Cribroperidinium aff. intricatum
Surculosphaeridium longifurcatum
Exochosphaeridium spp.
Isabelidinium cooksoniae
Scriniodinium aff. obscurum
Chatangiella aff. tripartita
Trithyrodinium aff. suspectum
Florentinia aff. deanei
Isabelidinium sp. 7 HNH
Heterosphaeridium difficile
Spiniferites spp.
Palaeoperidinium pyrophorum
Chatangiella verrucosa
Hystrichodinium pulchrum
Odontochitina striatoperforata
Stiphrosphaeridium anthophorum
Chatangiella granulifera
Circulodinium distinctum
Pterodinium spp.
Odontochitina operculata
Palaeohystrichophora infusorioides
Senoniasphaera aff. protusa
Isabelidinium aff. magnum
Desmocysta plekta
Trigonopyxidia ginella
Spinidinium? sp.
Xenascus ceratioides
Dinocyst HNH sp. 10
Oligosphaeridium pulcherrimum
Chorat sp. 2 HNH
Coronifera oceanica
Spinidinium sp. 2
Florentinia cooksoniae
Scriniodinium aff. europylum
Chlamydophorella nyeii
Wallodinium anglicum
Spinidinium echinoideum
Palambages spp.
Verrumonocolpites? sp.
ENCL: 2
WELL 400709 SVAR (0 - 82m)
ANALYSTS: 1994 HN-H
DATE: 11/1
GGU
5 I S BJÆRKE

ENCL: 5

NH92-8-22/2 SVAR (95 - 75m)

CRETACEOUS	SYSTEM
CONIAC / L. SANTON	STAGE
H. DIFFICILE	ZONE
100	DEPTH
REF:	LITHOLOGY

SAMPLES

	402669	402671	402672
Fromea amphora	x		
Acritarch sp. 1 HNH	x		
Palaeoperidinium pyrophorum	x		
Membranilarnacia? spp.	x		
Florentinia aff. deanei	x		
Dorocysta litotes	x		
Xenascus aff. perforatus	x		
Oligosphaeridium pulcherrimum	x		
Heterosphaeridium difficile	x		
Stiphrosphaeridium anthophorum	x		
Chatangiella granulifera	x		
Chatangiella aff. spectabilis	x	x	
Chorat sp. 5 HNH	x		x
Odontochitina striatoperforata	x		x
Circulodinium distinctum	x	x	x
Chatangiella aff. ditissima	x	x	x
Laciniadinium arcticum	x		x
Spiniferites spp.		x	x
Hystrichodinium pulchrum			x

ANALYSTS: 1994 HN-H
DATE: 3/1

GGU

S I S BJÆRKE

ENCL: 4

NH92-8-09/1 SVAR (151 - 135m)

CRETACEOUS	SYSTEM
CONIAC / L. SANTON	STAGE
H. DIFFICILE?	ZONE
150 200	DEPTH
REF:	LITHOLOGY

SAMPLES

	402625 / 402620	402628	402632
Fromea fragilis	x		
Chatangiella aff. spectabilis	x	x	
Heterosphaeridium difficile	x	x	x
Chorat sp. 5 HNH	x	x	x
Chatangiella aff. spectabilis	x	x	x
Palaeohystrichophora infusorioides	x	x	
Circulodinium distinctum	x	x	x
Chatangiella aff. spectabilis	x	x	x
Trithyrodinium suspectum		x	
Palaeoperidinium pyrophorum		x	
Achomosphaera aff. sagena		x	
Spiniferites spp.		x	x
Odontochitina striatoperforata		x	x
Spinidinium echinoideum		x	x
Oligosphaeridium pulcherrimum		x	x
Laciniadinium arcticum			x
Chatangiella granulifera			x
Tanyosphaeridium cf. variecalamus			x
Desmocysta plakta			x
Apendicisporites sp. 1 HNH	x	x	

ANALYSTS: 1993 HN-H
DATE: 3/12

GGU

S I S BJÆRKE

CRETACEOUS	SYSTEM
U. SANTON / L. CAM	STAGE
D. SIBIRICUM	ZONE
50	DEPTH
REF:	LITHOLOGY

ENCL: 7

JGL SVARTENHUK (35 - 32m)

SAMPLES

+251507
+251205

Acritarch sp. 1 HNH
Schizocystia ssp.
Xenaxcus aff. perforatus
Palaeoperidinium pyrophorum
Chatangiella aff. ditissima
Spinidinium echinoideum
Chatangiella granulifera
Dinogymnium cf. sibiricum
Isabelidinium aff. ?acuminatum
Circulodinium distinctum
Trithyrodinium aff. suspectum
Spiniferites spp.
Pterospermella australiensis

ANALYSTS: 1993 HN-H
DATE: 3/12

-GGU-

S I S BJÆRKE

CRETACEOUS	SYSTEM
CONIAC / L. SANTON	STAGE
L. ARCTICUM ⁝ H. DIFFICILE?	ZONE
0 50	DEPTH
REF:	LITHOLOGY

ENCL: 6

NH92-8-22/3 SVAR (30 - 2m)

SAMPLES

+402674
+402673

Fromea fragilis
Fromea amphora
Acritarch sp. 1 HNH
Chorat sp. 5 HNH
Desmocysta plekta
Pterodinium spp.
Eurydinium aff. glomeratum +ap horn
Chlamydophorella trabeculosa
Pareodinia spp.
Palaeohystrichophora infusorioides
Coronifera oceanica
Palaeotetradinium silicorum
Stiphrosphaeridium anthophorum
Dorocysta litotes
Arvalidinium aff. shaii
Oligosphaeridium pulcherrimum
Circulodinium distinctum
Laciniadinium arcticum
Spinidinium echinoideum
Chatangiella aff. ditissima
Spiniferites spp.
Heterosphaeridium difficile
Surculosphaeridium longifurcatum
Odontochitina striatoperforata
Chatangiella aff. spectabilis
Florentinia aff. deanei
Xenaxcus aff. perforatus
Palaeoperidinium pyrophorum
Wallodinium anglicum
Chatangiella granulifera
Trithyrodinium aff. suspectum
Exochosphaeridium spp.
Chlamydophorella nyei
Palambages spp.

ANALYSTS: 1993 HN-H
DATE: 3/12

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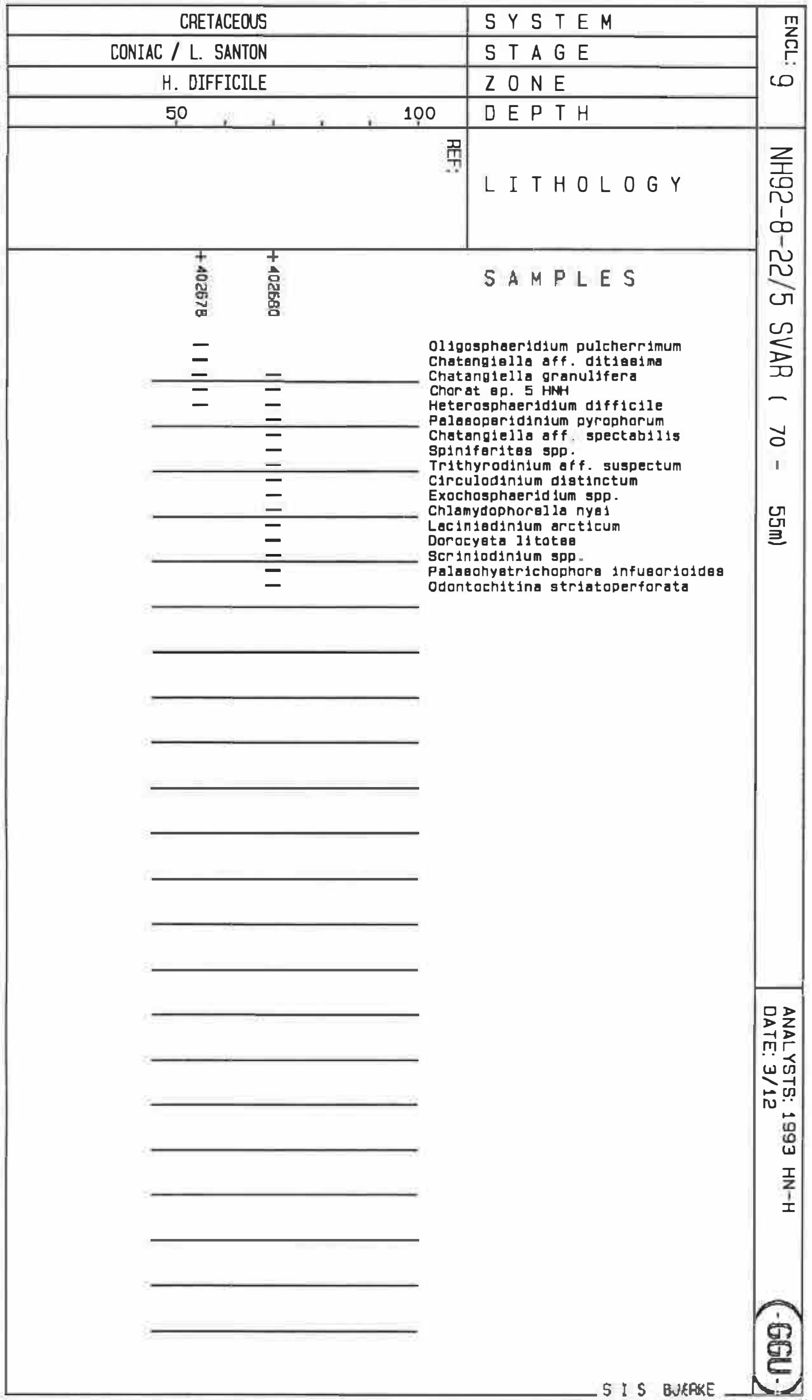
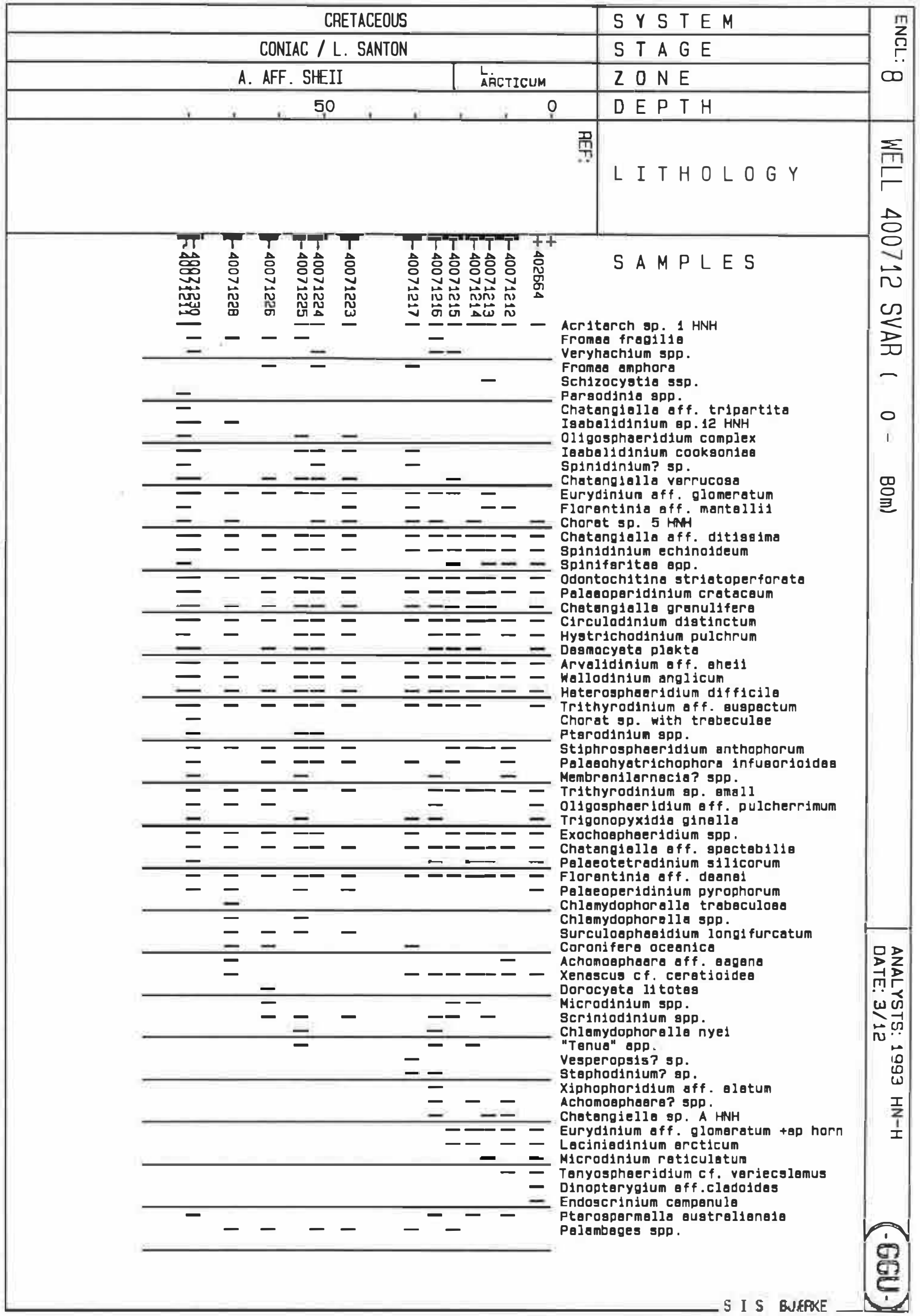
S I S BJÆRKE



CRETACEOUS
SYSTEM
CONIAC / L. SANTON
STAGE
H. DIFFICILE
ZONE
50
100
DEPTH
REF:
LITHOLOGY
402678
402680
SAMPLES
Oligosphaeridium pulcherrimum
Chatangiella aff. ditissima
Chatangiella granulifera
Chorat sp. 5 HNH
Heterosphaeridium difficile
Palaeoperidinium pyrophorum
Chatangiella aff. spectabilis
Spiniferites spp.
Trithyrodinium aff. suspectum
Circulodinium distinctum
Exochosphaeridium spp.
Chlamydophorella nyei
Laciniadinium arcticum
Dorocysta litotes
Scriniodinium spp.
Palaeohystrichophora infusorioides
Odontochitina striatoperforata
ENCL: 9
NH92-8-22/5 SVAR (70 - 55m)
ANALYSTS: 1993 HN-H
DATE: 3/12
-GGU-
S I S BJÆRKE



CRETACEOUS
SYSTEM
CONIAC / L. SANTON
STAGE
A. AFF. SHEII
L. ARCTICUM
ZONE
50
0
DEPTH
REF:
LITHOLOGY
40071228
40071226
40071225
40071224
40071223
40071217
40071216
40071215
40071214
40071213
40071212
402664
SAMPLES
Acritarch sp. 1 HNH
Fromea fragilis
Veryhachium spp.
Fromea amphora
Schizocystia ssp.
Parsodinia spp.
Chatangiella aff. tripartita
Isabelidinium sp.12 HNH
Oligosphaeridium complex
Isabelidinium cooksoniae
Spinidinium? sp.
Chatangiella verrucosa
Eurydinium aff. glomeratum
Florentinia aff. mantellii
Chorat sp. 5 HNH
Chatangiella aff. ditissima
Spinidinium echinoideum
Spiniferites spp.
Odontochitina striatoperforata
Palaeoperidinium cretaceum
Chatangiella granulifera
Circulodinium distinctum
Hystrichodinium pulchrum
Desmocysta plekta
Arvalidinium aff. sheii
Wallodinium anglicum
Heterosphaeridium difficile
Trithyrodinium aff. suspectum
Chorat sp. with trabeculae
Pterodinium spp.
Stiphrosphaeridium anthophorum
Palaeohystrichophora infusorioides
Membranilarnacia? spp.
Trithyrodinium sp. small
Oligosphaeridium aff. pulcherrimum
Trigonopyxidia ginella
Exochosphaeridium spp.
Chatangiella aff. spectabilis
Palaeotetradinium silicorum
Florentinia aff. deanei
Palaeoperidinium pyrophorum
Chlamydophorella trabeculosa
Chlamydophorella spp.
Surculosphaeidium longifurcatum
Coronifera oceanica
Achomosphaera aff. sagena
Xenascus cf. ceratioides
Dorocysta litotes
Microdinium spp.
Scriniodinium spp.
Chlamydophorella nyei
"Tenua" spp.
Vesperopsis? sp.
Stephodinium? sp.
Xiphophoridium aff. alatum
Achomosphaera? spp.
Chatangiella sp. A HNH
Eurydinium aff. glomeratum +sp horn
Laciniadinium arcticum
Microdinium reticulatum
Tanyosphaeridium cf. variecalamus
Dinopterygium aff.cladoides
Endoscrinium campanula
Pterospermella australiensis
Palambages spp.
ENCL: 8
WELL 400712 SVAR (0 - 80m)
ANALYSTS: 1993 HN-H
DATE: 3/12
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S I S BJÆRKE

CRETACEOUS	SYSTEM
CONIAC / L. SANTON	STAGE
H. DIFFICILE	ZONE
50 0	DEPTH
REF:	LITHOLOGY

ENCL: 11

WELL 400710 SVAR (5 - 76m)

SAMPLES

400710151, 40071013, 40071011, 400710-9, 400710-7, +358435

Acritarch sp. 2 HNH
Fromea amphora
Acritarch sp. 1 HNH
Trithyrodinium sp. small
Dinocyst sp. 7 HNH
Florentinia? spp.
Trigonopyxidia ginella
Trithyrodinium aff. suspectum
Surculosphaeidium longifurcatum
Eurydinium aff. glomeratum
Isabelidinium aff. acuminatum
Eurydinium aff. glomeratum +ap horn
Spiniferites spp.
Palaeohystrichophora infusorioides
Stiphrosphaeridium anthophorum
Exochosphaeridium spp.
Chatangiella aff. ditissima
Heterosphaeridium difficile
Palaeoperidinium pyrophorum
Oamocysta plakta
Laciniadinium arcticum
Odontochitina striatoperforata
Circulodinium distinctum
Chatangiella aff. spectabilis
Spinidinium echinoideum
Hystrichodinium pulchrum
Wallodinium anglicum
Florentinia aff. deanei
Florentinia aff. mantellii
Oligosphaeridium pulcherrimum
Isabelidinium aff. bakeri
Paraodinia spp.
Xenaxcus aff. perforatus
Oligosphaeridium complex
Chatangiella granulifera
Chlamydophorella nyei
Achomosphaera? spp.
Implaktosphaeridium? sp.
Trithyrodinium aff. suspectum

ANALYSTS: 1993 HN-H
DATE: 3/12

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S I S BJÆRKE

CRETACEOUS	SYSTEM
CONIAC / L. SANTON	STAGE
L. ARCTICUM	ZONE
50 0	DEPTH
REF:	LITHOLOGY

ENCL: 10

WELL 400711 SVAR (0 - 54m)

SAMPLES

400711141, 400711121, 400711101, 400711-81, 400711-61

Acritarch sp. 1 HNH
Fromea amphora
Fromea fragilis
Veryhachium spp.
Schizocystia ssp.
Isabelidinium cooksoniae
Trithyrodinium sp. small
Oligosphaeridium complex
Wallodinium anglicum
Chatangiella granulifera
Chatangiella verrucosa
Chatangiella aff. ditissima
Florentinia aff. mantellii
Exochosphaeridium spp.
Laciniadinium arcticum
Florentinia aff. deanei
Trithyrodinium aff. suspectum
Xenaxcus aff. perforatus
Scriniodinium? aff. obscurum
Spiniferites spp.
Eurydinium aff. glomeratum +ap horn
Oligosphaeridium pulcherrimum
Hystrichodinium pulchrum
Membranilarnacia? spp.
Spinidinium echinoideum
Palaeoperidinium pyrophorum
Palaeohystrichophora infusorioides
Oamocysta plakta
Circulodinium distinctum
Heterosphaeridium difficile
Odontochitina striatoperforata
Pterodinium spp.
Isabelidinium aff. acuminatum
Chatangiella aff. spectabilis
Arvalidinium aff. sheii
Trigonopyxidia ginella
Tanyosphaeridium variecalamum
Hystrichosphaeridium cruciatumm
Florentinia sp. 1 HNH
Stiphrosphaeridium anthophorum
Dorocysta litotas
Chlamydophorella nyei
Cribroperidinium aff. intricatum
Dinopterygium aff.cladoides
Chatangiella sp. large
Surculosphaeidium longifurcatum
Coronifera oceanica
Chlamydophorella trabeculosa
Dinocyst sp. 7 HNH
Achomosphaera aff. sagena
Palambages spp.
Pterospermella australiensis

ANALYSTS: 1993 HN-H
DATE: 3/12

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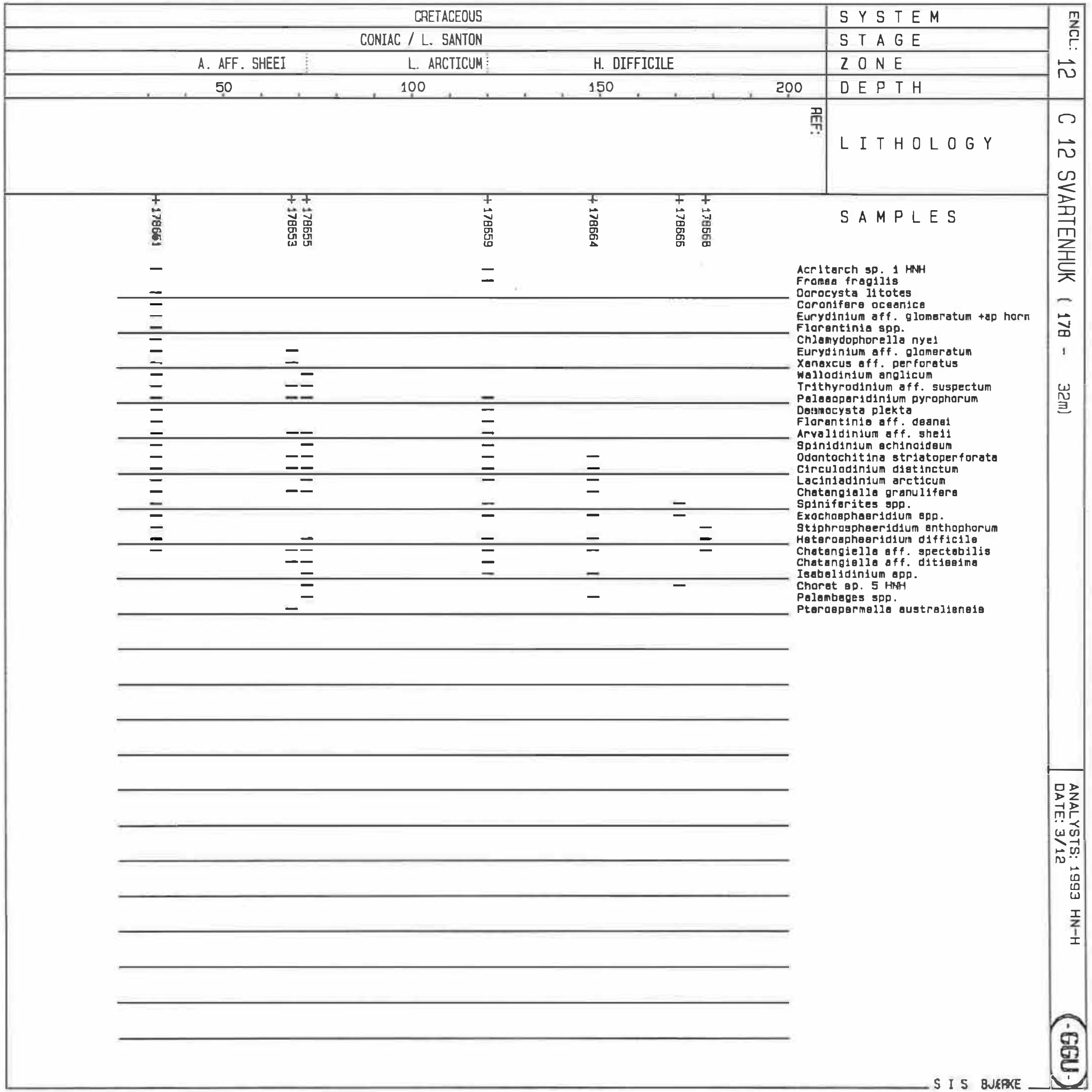
S I S BJÆRKE


CRETACEOUS
CONIAC / L. SANTON
A. AFF. SHEEI
L. ARCTICUM
H. DIFFICILE
50
100
150
200
REF:
SYSTEM
STAGE
ZONE
DEPTH
LITHOLOGY
SAMPLES
178653
178655
178659
178664
178666
178668
Acritarch sp. 1 HNH
Fromea fragilis
Oorocysta litotes
Coronifera oceanica
Eurydinium aff. glomeratum +ap horn
Florentinia spp.
Chlamydophorella nyei
Eurydinium aff. glomeratum
Xenaxcus aff. perforatus
Wallodinium anglicum
Trithyrodinium aff. suspectum
Palaeoperidinium pyrophorum
Dermocysta plekta
Florentinia aff. deanei
Arvalidinium aff. sheii
Spinidinium echinoideum
Odontochitina striatoperforata
Circulodinium distinctum
Laciniadinium arcticum
Chatangiella granulifera
Spiniferites spp.
Exochosphaeridium spp.
Stiphrosphaeridium anthophorum
Heterosphaeridium difficile
Chatangiella aff. spectabilis
Chatangiella aff. ditissima
Isabelidinium spp.
Chorat sp. 5 HNH
Palambages spp.
Pterospermella australiensis
ENCL: 12
C 12 SVARTENHUK (178 - 32m)
ANALYSTS: 1993 HN-H
DATE: 3/12
GGU
S I S BJERKE

Index of Figured Species

Dinoflagellate cysts

Plate 1 Svartenhuk

Fig. 1. *Arvalidinium* aff. *sheii*, GGU 400711-12-4, 45.6-107.3; LVR 1.1352; MI 851

Fig. 2. *Arvalidinium* aff. *sheii*, GGU 400711-10-4, 22.1-94.7; LVR 1.1416; MI 902

Fig. 3. *Arvalidinium* aff. *sheii*, GGU 400712-15-4, 33.9-100.9; LVR 1.1661; MI 1119

Fig. 4. *Arvalidinium* aff. *sheii*, GGU 400711-10-3, 43.2-110.0; LVR 1.1418; MI 903

Fig. 5. *Chatangiella* aff. *granulifera*, GGU 400709-14-3, 43.4-99.5; LVR 1.837; MI 509

Fig. 6. *Chatangiella* aff. *granulifera*, GGU 400709-12-4, 41.0-103.7; LVR 1.846; MI 518

Fig. 7. *Chatangiella granulifera*, GGU 402680-4, HNH920822/3; 51.2-97.0; LVR 1.1204; MI 722

Fig. 8. *Chatangiella granulifera*, GGU 400709-12-3, 32.4-100.5; LVR 1.844; MI 516

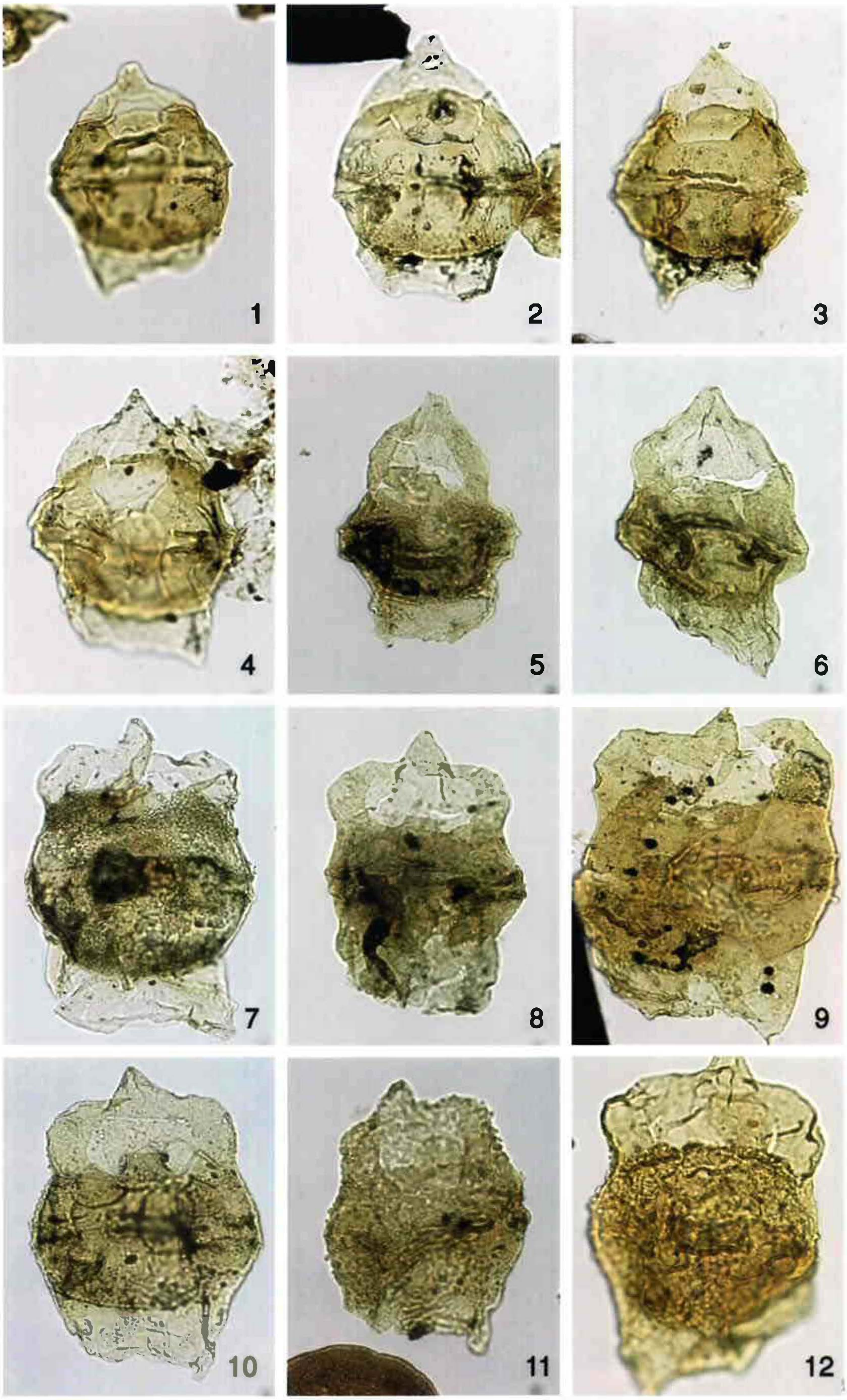
Fig. 9. *Chatangiella granulifera*, GGU 400712-25-4; 53.5-109.2; LVR 1.1789; MI 1242

Fig. 10. *Chatangiella verrucosa*, GGU 400709-14-5, 29.6-94.8; LVR 1.829; MI 502

Fig. 11. *Chatangiella verrucosa*, GGU 400709-26-3, 53.7-107.0; LVR 1.726; MI 405

Fig. 12. *Chatangiella verrucosa*, GGU 400712-25-4, 43.1-102.9; LVR 1.1788; MI 1241

SVARTENHUK



20 my

Plate 2 Svartenhuk

Fig. 1. *Chatangiella* aff. *ditissima*, GGU 251507-4, JGL; 53.0-113.6; LVR 1.710; MI 392

Fig. 2. *Chatangiella* aff. *ditissima*, GGU 400711-10-4; 38.9-108.5; LVR 1.1424; MI 907

Fig. 3. *Chatangiella* aff. *ditissima*, GGU 400712-25-3; 52.1-105.0; LVR 1.1792; MI 1245

Fig. 4. *Chatangiella* aff. *ditissima*, GGU 400712-24-3; 49.0-100.5; LVR 1.1760; MI 1214

Fig. 5. *Chatangiella* aff. *ditissima*, GGU 400711-10-4; 30.0-99.0; LVR 1.1424; MI 907

Fig. 6. *Chatangiella* aff. *ditissima*, GGU 251507-9, JGl; 40.0-103.5; LVR 1.716; MI 396

Fig. 7. *Chatangiella* aff. *tripartita*, GGU 400709-26-3; 46.9-102.5; LVR 1.724; MI 404

Fig. 8. *Chatangiella* aff. *tripartita*, GGU 400709-26-3; 53.7-107.0; LVR 1.725; MI 405

Fig. 9. *Chatangiella* aff. *tripartita*, GGU 400709-12-3; 48.5-96.0; LVR 1.842; MI 514

Fig. 10. *Chatangiella* aff. *tripartita*, GGU 400709-16-3; 51.8-105.0; LVR 1.821; MI 494

Fig. 11. *Isabelidinium* aff. *bakeri*, GGU 400708-14-4; 26.3-93.8; LVR 1.1299; MI 803

Fig. 12. *Isabelidinium* aff. *bakeri*, GGU 400708-20-3; 36.2-105.8; LVR 1.1283; MI 789

SVARTENHUK

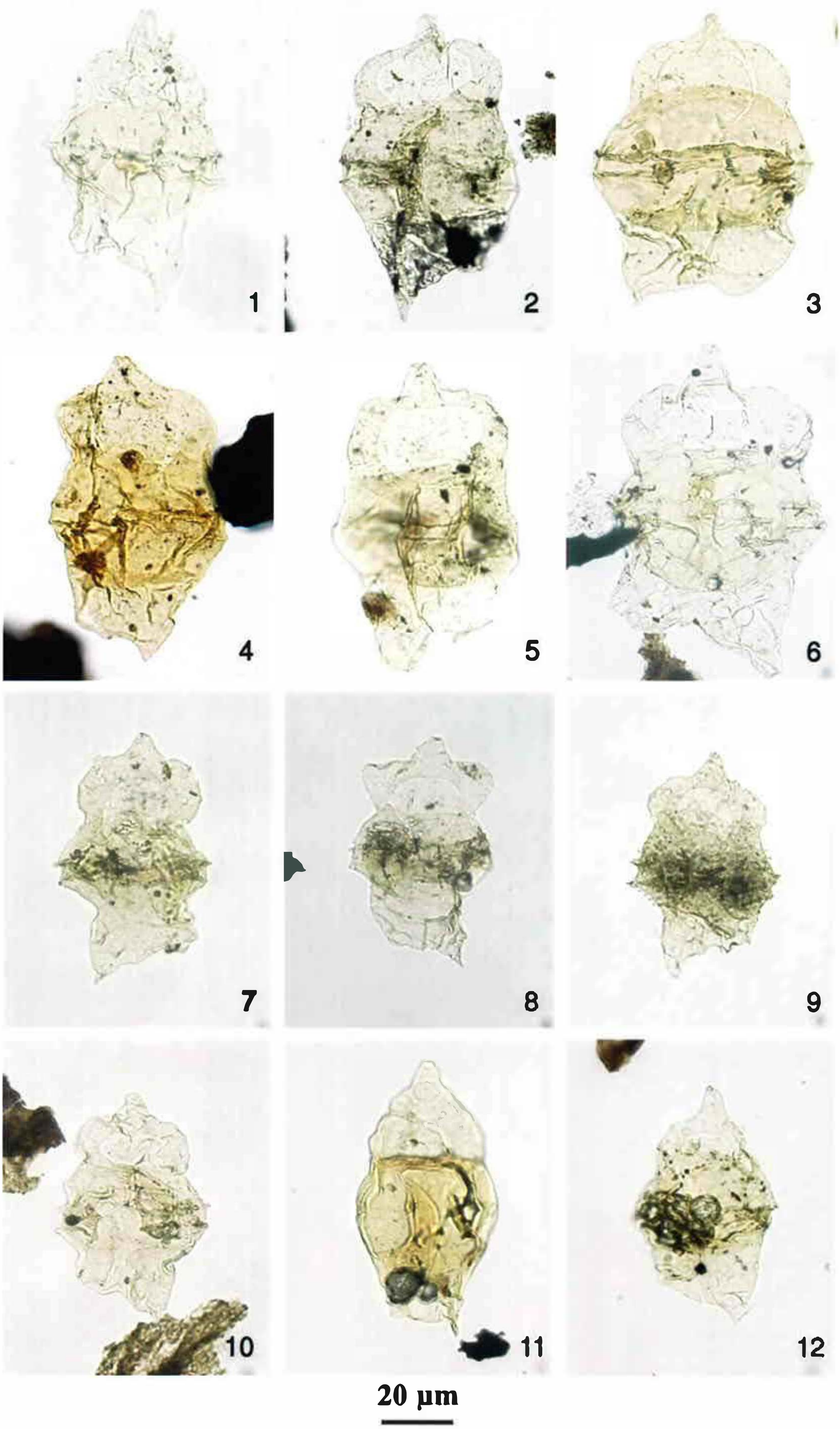


Plate 3 Svartenhuk

Fig. 1. *Chatangiella* aff. *spectabilis*, GGU 400712-23-3; 38.8-95.1; LVR 1.1732; MI 1188

Fig. 2. *Chatangiella* aff. *spectabilis*, GGU 400712-24-3; 34.2-103.1; LVR 1.1765; MI 1218

Fig. 3. *Chatangiella* aff. *spectabilis*, GGU 400711-6-7; 29.0-101.6; LVR 1.1502; MI 979

Fig. 4. *Chatangiella* aff. *spectabilis*, GGU 400712-14-4; 47.8-98.0; LVR 1.1634; MI 1092

Fig. 5. *Chatangiella* aff. *spectabilis*, GGU 402664-7, 400712; 52.1-103.0; LVR 1.1618; MI 1077

Fig. 6. *Chatangiella* aff. *spectabilis*, GGU 400712-14-4; 31.2-111.5; LVR 1.1632; MI 1090

Fig. 7. *Chatangiella* aff. *spectabilis*, GGU 400711-10-4; 29.6-105.0; LVR 1.1427; MI 910

Fig. 8. *Chatangiella* aff. *spectabilis*, GGU 400712-25-3; 37.6-101,3; LVR 1.1790; MI 1243

Fig. 9. *Chatangiella* aff. *spectabilis*, GGU 400711-8-4; 44,7-102.7; LVR 1.1457; MI 937

Fig. 10. *Chatangiella* aff. *spectabilis*, GGU 400711-6-4; 43.0-104.8; LVR 1.1488; MI 965

Fig. 11. *Chatangiella* aff. *spectabilis*, GGU 400711-10-4; 27.2-96.2; LVR 1.1422; MI 905

Fig. 12. *Chatangiella* aff. *spectabilis*, GGU 402632-4, HNH920809/1; 21.7-109.9; LVR 1.1268; MI 778

SVARTENHUK

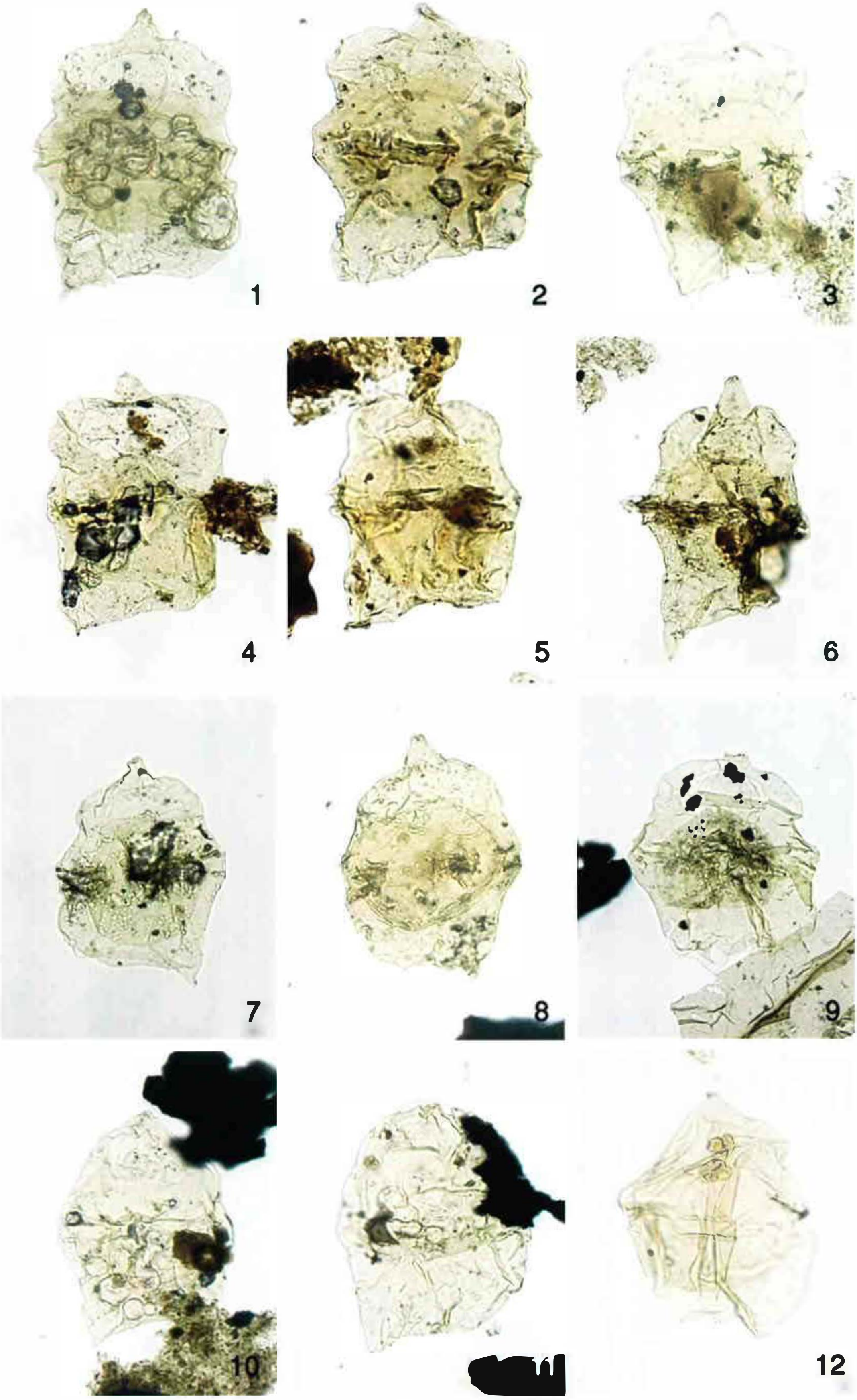


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Plate 4 Svartenhuk

Fig. 1. *Isabelidinium* sp. 7 HNH, GGU 400709-22-3; 31.3-99.5; LVR 1.775; MI 451

Fig. 2. *Isabelidinium* sp. 7 HNH, GGU 400709-12-3; 34.8-97.6; LVR 1.1126; MI 646

Fig. 3. *Isabelidinium* sp. 7 HNH, GGU 400711-12-4; 50.3-103.0; LVR 1.1365; MI 861

Fig. 4. *Isabelidinium* aff. *magnum*, GGU 400709-18-3; 23.0-103.5; LVR 1.804; MI 478

Fig. 5. *Isabelidinium* aff. *magnum*, GGU 400709-24-3; 28.7-107.3; LVR 1.746; MI 423

Fig. 6. *Isabelidinium* aff. *magnum*, GGU 400709-24-3; 37.5-100.8; LVR 1.748; MI 425

Fig. 7. *Isabelidinium* aff. *acuminatum*, GGU 400711-6-7; 28.4-101.8; LVR 1.2789; MI 2076

Fig. 8. *Isabelidinium* aff. *acuminatum*, GGU 400711-14-4; 48.9-100.6; LVR 1.1330; MI 833

Fig. 9. *Isabelidinium* aff. *acuminatum*, GGU 400710-15-4; 55.0-101.0; LVR 1.1515; MI 990

Fig. 10. *Isabelidinium* aff. *acuminatum*, GGU 400710-7-4; 51.0-109.8; LVR 1.1550; MI 1021

Fig. 11. *Isabelidinium cooksoniae*, GGU 400709-22-3; 24.9-111.6; LVR 1.774; MI 450

Fig. 12. *Isabelidinium cooksoniae*, GGU 400710-11-7; 29.6-103.7; LVR 1.1534; MI 1006

SVARTENHUK

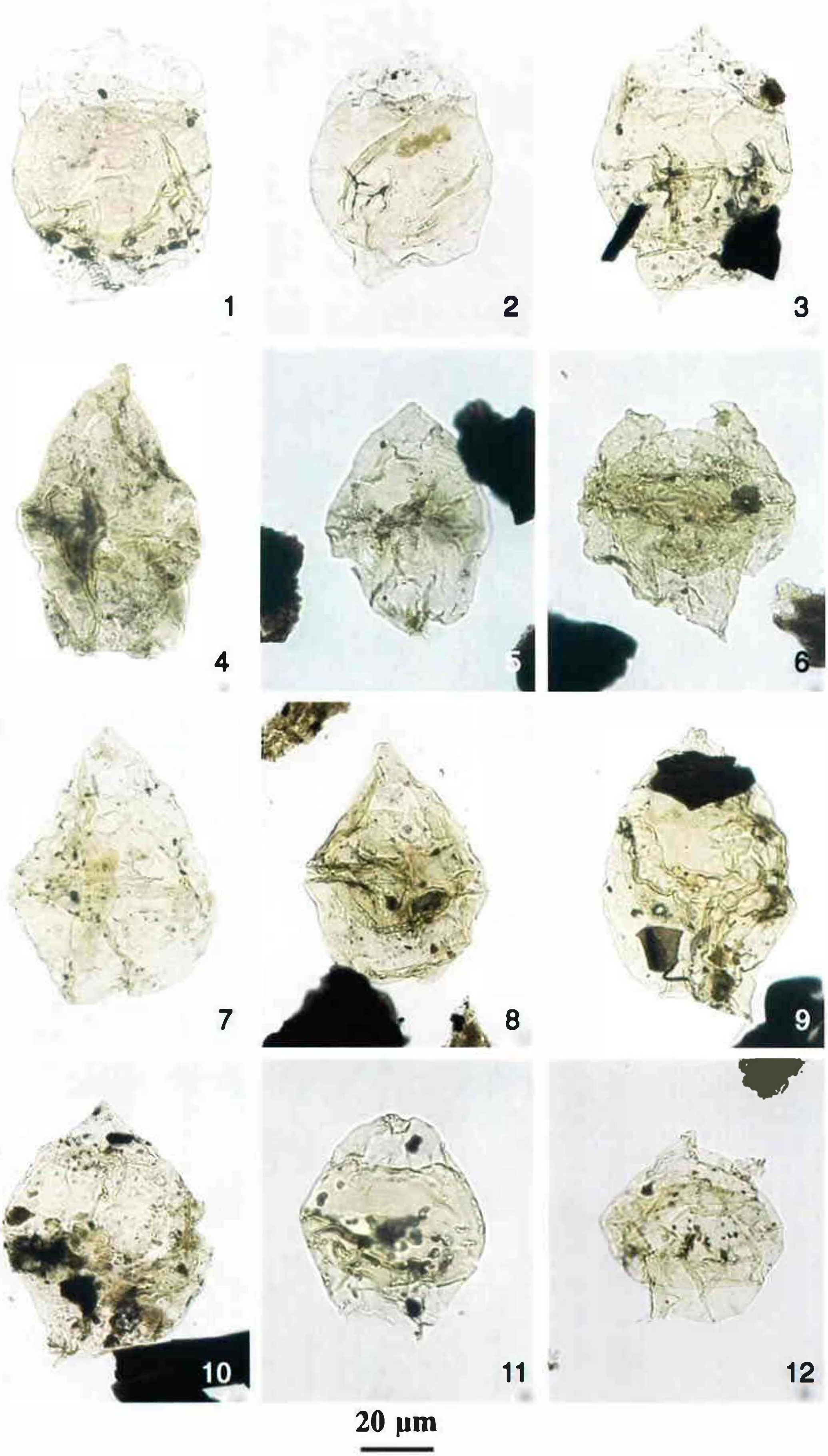

Plate 5 Svartenhuk

Fig. 1. *Isabelidinium* aff. *acuminatum*, GGU 251506-,7 JGL; 26.1-103.0; LVR 1.701; MI 384

Fig. 2. *Isabelidinium* aff. *acuminatum*, GGU 251506-,7 JGL; 50.6-106.8; LVR 1.702; MI 385

Fig. 3. *Isabelidinium* aff. *acuminatum*, GGU 251507-,4 JGL; 22.6-106.3; LVR 1.707; MI 389

Fig. 4. *Eurydinium* aff. *glomeratum*, GGU 400712-26-4; 26.6-97.0; LVR 1.1824; MI 1274

Fig. 5. *Eurydinium* aff. *glomeratum*, GGU 400712-26-4; 46.1-103.9; LVR 1.1825; MI 1275

Fig. 6. *Eurydinium* aff. *glomeratum*, GGU 400712-11-8; 36,9-99.2; LVR 1.1866; MI 1316

Fig. 7. *Eurydinium* aff. *glomeratum* + apical horn, GGU 400712-15-4; 28,9-106.4; LVR 1.1664; MI 1122

Fig. 8. *Eurydinium* aff. *glomeratum* + apical horn, GGU 400712-15-4; 35,5-102.1; LVR 1.1666; MI 1124

Fig. 9. *Eurydinium* aff. *glomeratum* + apical horn, GGU 400712-15-4; 45,0-104.3; LVR 1.1667; MI 1125

Fig. 10. *Eurydinium* aff. *glomeratum* + apical horn, GGU 400712-17-4; 43,9-94.0; LVR 1.1710; MI 1166

Fig. 11. *Eurydinium* aff. *glomeratum* + apical horn, GGU 400712-14-4; 44,3-98.3; LVR 1.1646; MI 1104

Fig. 12. *Eurydinium* aff. *glomeratum* + apical horn, GGU 402664-4, 400712; 45,7-104.2; LVR 1.1606; MI 1065

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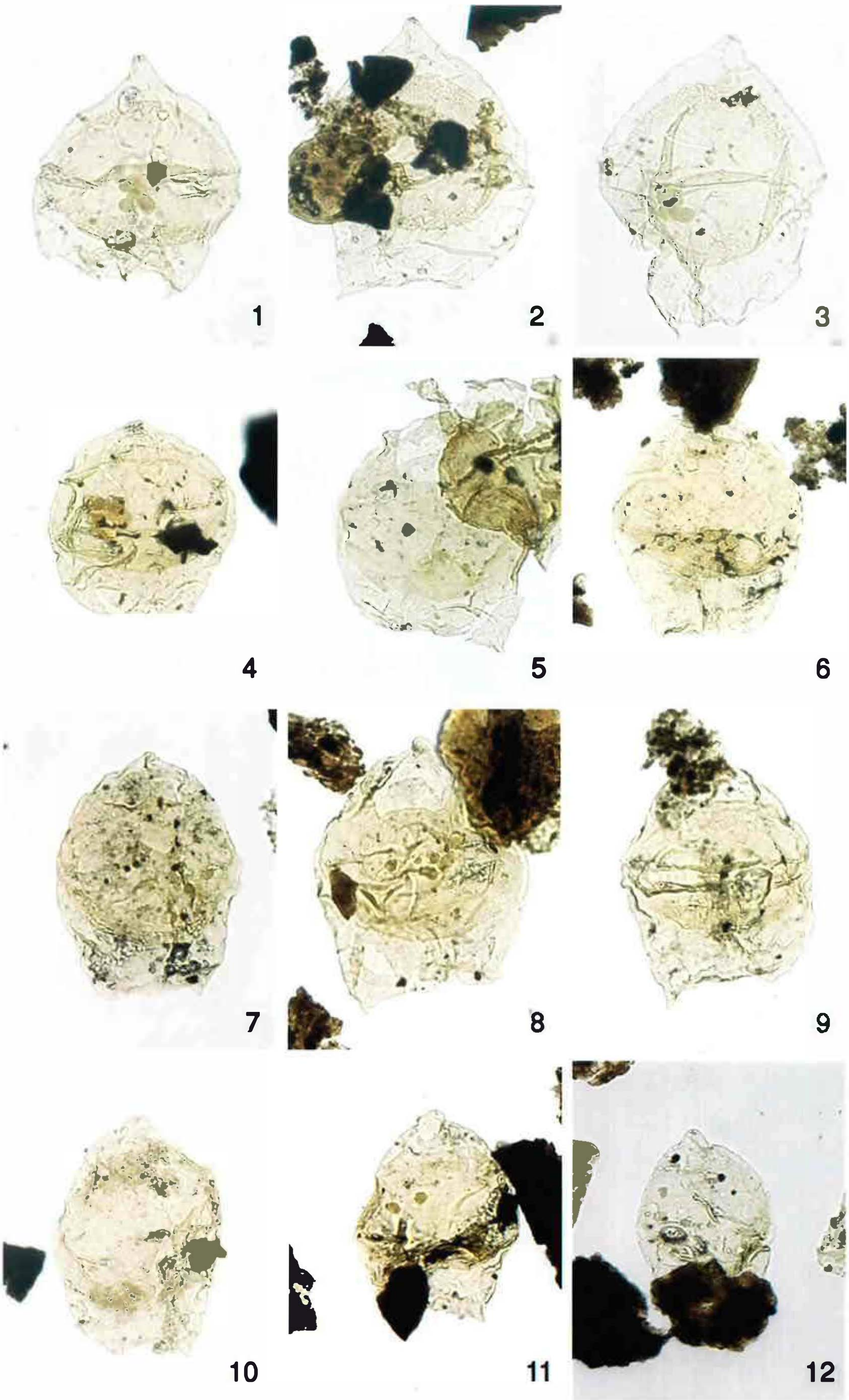

20 µm

Plate 6 Svartenhuk

Fig. 1. *Laciniadinium arcticum*, GGU 400711-8-4; 53.8-95.6; LVR 1.1458; MI 938

Fig. 2. *Laciniadinium arcticum*, GGU 400711-12-4; 21.8-99.1; LVR 1.1368; MI 864

Fig. 3. *Laciniadinium arcticum*, GGU 402680-7, HNH920822/5; 31.4-100.8; LVR 1.1218; MI 736

Fig. 4. *Spinidinium echinoideum*, GGU 400712-26-3; 28.8-98.0; LVR 1.1836; MI 1286

Fig. 5. *Spinidinium echinoideum*, GGU 400710-15-4; 30.8-106.0; LVR 1.1521; MI 994

Fig. 6. *Spinidinium echinoideum*, GGU 400712-25-4; 35.1-109.1; LVR 1.1813; MI 1265

Fig. 7. *Spinidinium echinoideum*, GGU 400712-14-4; 52.9-109.4; LVR 1.1647; MI 1105

Fig. 8. *Spinidinium echinoideum*, GGU 400710-11-7; 55.7-107.0; LVR 1.1539; MI 1011

Fig. 9. *Spinidinium echinoideum*, GGU 400711-12-4; 41.6-98.5; LVR 1.1398; MI 886

Fig. 10. *Spinidinium echinoideum*, with very reduced echinae, GGU 400712-25-4; 51.2-98.9; LVR 1.1814; MI 1266

Fig. 11. *Spinidinium echinoideum*, with very reduced echinae, GGU 400712-11-4; 18.3-110.0; LVR 1.1851; MI 1301

Fig. 12. *Spinidinium echinoideum*, with very reduced echinae, GGU 400712-23-3; 18.6-107.3; LVR 1.1742; MI 1198

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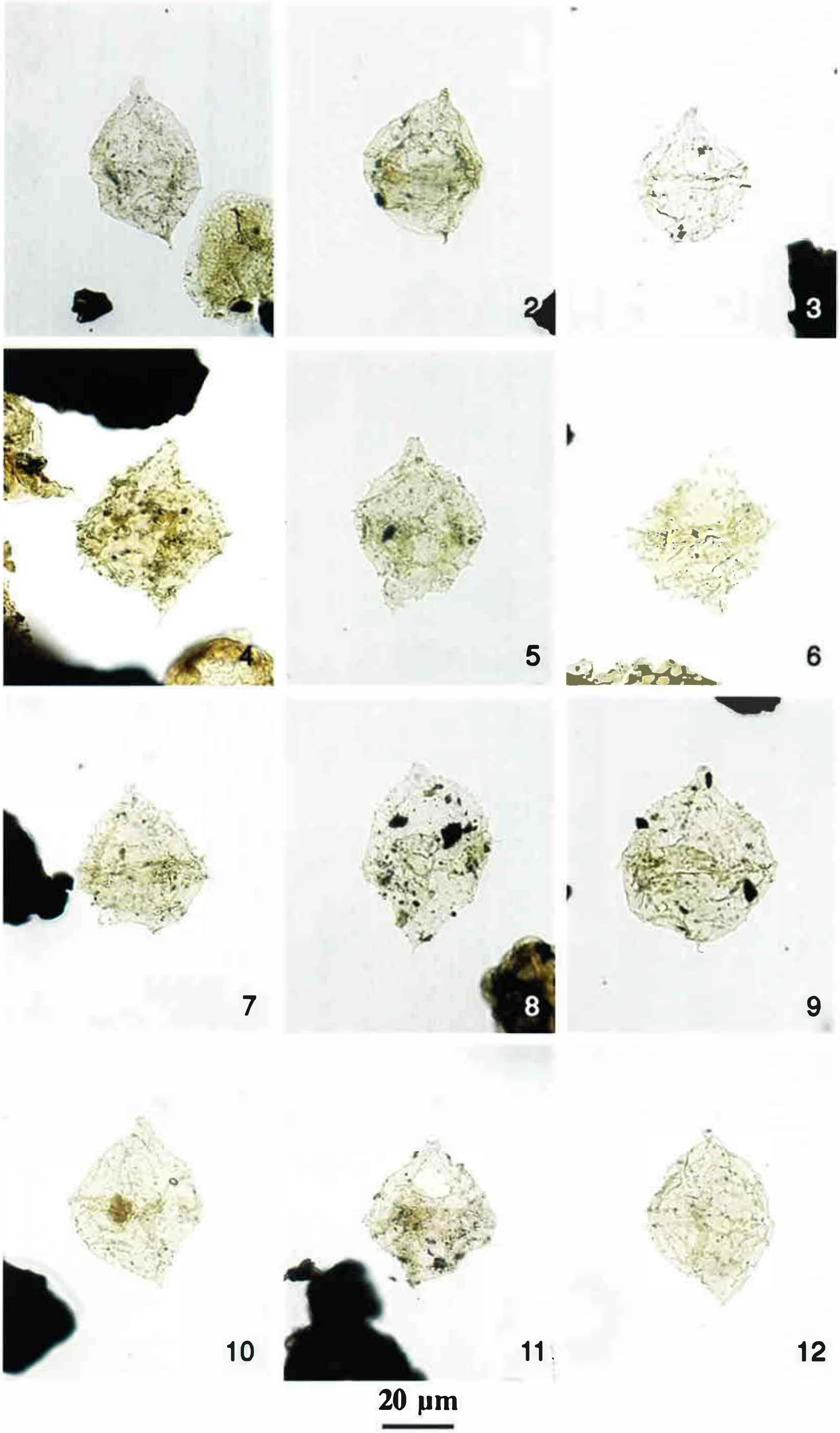

Plate 7 Svartenhuk

Fig. 1. *Cribroperidinium* aff. *intricatum*, GGU 400709-24-3; 52.4-107.6; LVR 1.762; MI 439

Fig. 2. *Cribroperidinium* aff. *intricatum*, GGU 400709-20-3; 22.7-103.8; LVR 1.786; MI 462

Fig. 3. *Cribroperidinium* sp., GGU 400711-8-4; 34.8-112.5; LVR 1.1464; MI 944

Fig. 4. *Dinopterygiumm* aff. *cladoides*, GGU 400709-26-3; 49.4-101.0; LVR 1.738; MI 417

Fig. 5. *Dinopterygiumm* aff. *cladoides*, GGU 400709-24-3; 30.5-108.7; LVR 1.760; MI 437

Fig. 6. *Dinopterygiumm* aff.?*cladoides*, GGU 400711-8-4; 50.8-95.6; LVR 1.1472; MI 951

Fig. 7. *Palaeohystrichodinium infusorioides*, GGU 400709-24-3; 30.6-99.0; LVR 1.750; MI 427

Fig. 8. *Endoscrinium campanula*, GGU 402664-8, 400712; 26.0-105.8; LVR 1.1620; MI 1079

Fig. 9. *Scriniodinium*? sp., GGU 402680-7, HNH920822/5; 53.8-98.6; LVR 1.1222; MI 740

Fig. 10. *Scriniodinium*? aff. *obscurum*, GGU 400709-12-5; 37.6-101.2; LVR 1.1128; MI 648

Fig.11. *Scriniodinium*? aff. *obscurum*, GGU 400712-15-4; 40.0-104.5; LVR 1.1678; MI 1136

Fig. 12. *Scriniodinium*? aff. *obscurum*, GGU 400712-26-3; 32.0-109.0; LVR 1.2204; MI 1566

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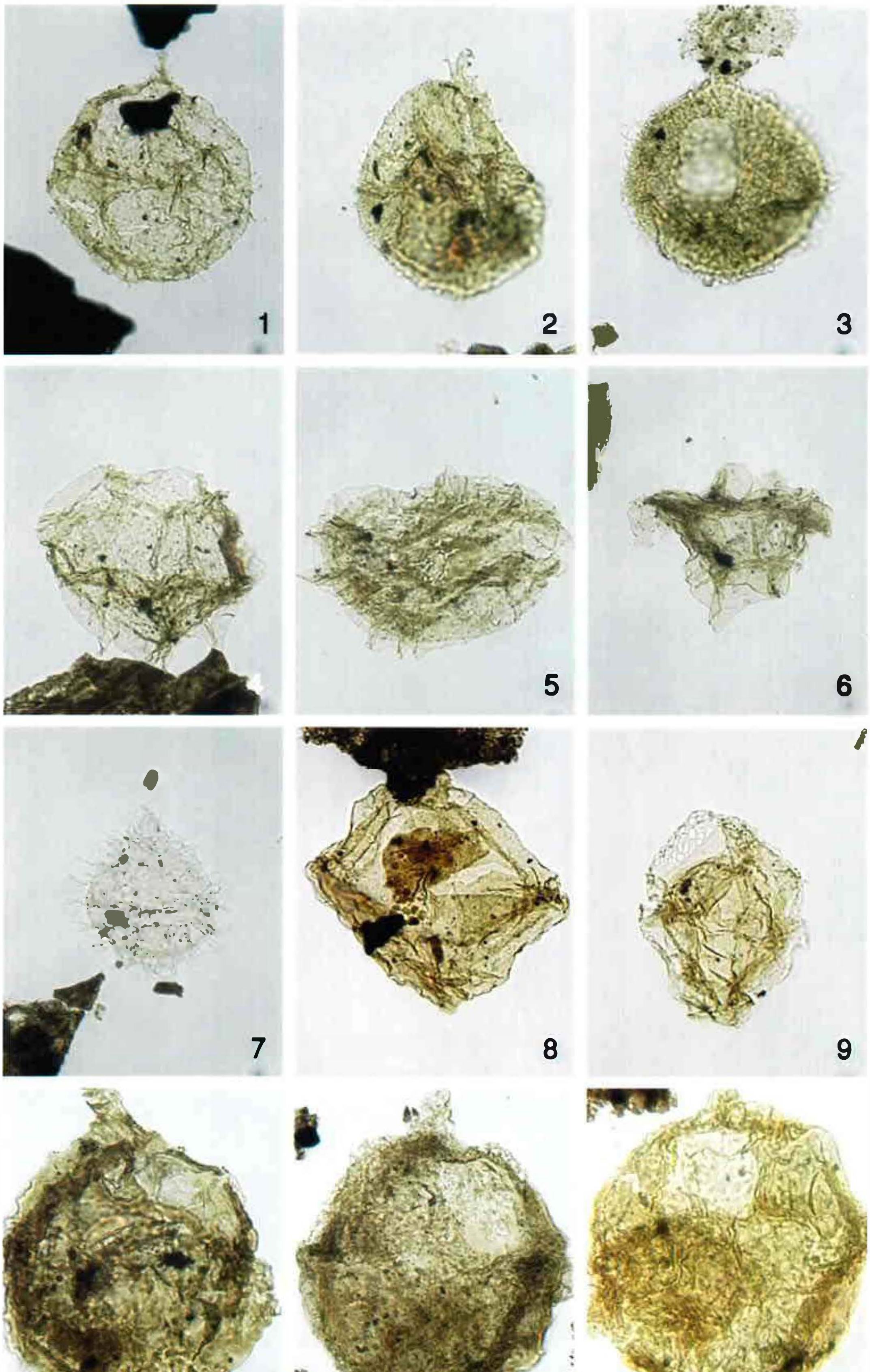

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Plate 8 Svartenhuk

Fig. 1. *Odonthochitina striatoperforata*, GGU 400709-10-4, 42.8-107.3; LVR 1.1151; MI 669

Fig. 2. *Odonthochitina striatoperforata*, GGU 400711-14-4, 41.2-99.9; LVR 1.1325; MI 828

Fig. 3. *Odonthochitina striatoperforata*, GGU 400711-8-4, 47.9-108.0; LVR 1.1463; MI 943

Fig. 4. *Odonthochitina striatoperforata*, GGU 400712-17-4, 35.6-94.5; LVR 1.1715; MI 1171

Fig. 5. *Odonthochitina striatoperforata*, GGU 400712-23-3 42.8-107.3; LVR 1.1738; MI 1194

Fig. 6. *Odonthochitina striatoperforata*, GGU 400712-25-4, 31.1-111.9; LVR 1.1800; MI 1253

Fig. 7. *Odonthochitina striatoperforata*, GGU 400712-11-7, 30.6-105.7; LVR 1.1870; MI 1320

Fig. 8. *Odonthochitina striatoperforata*, GGU 400709-20-3, 54.4-110.0; LVR 1.794; MI 469

Fig. 9. *Xenascus* aff. *perforatus*, GGU 400711-6-4, 49.5-109.0; LVR 1.1481; MI 959

Fig. 10. *Xenascus* aff. *perforatus*, GGU 400711-12-3, 47.8-109.7; LVR 1.1376; MI 869

Fig. 11. *Xenascus* aff. *perforatus*, GGU 400711-12-3, 56.2-101.9; LVR 1.1377; MI 870

Fig. 12. *Xenascus* aff. *perforatus*, GGU 402664-8, 400712, 46.8-103.4; LVR 1.1621; MI 1080

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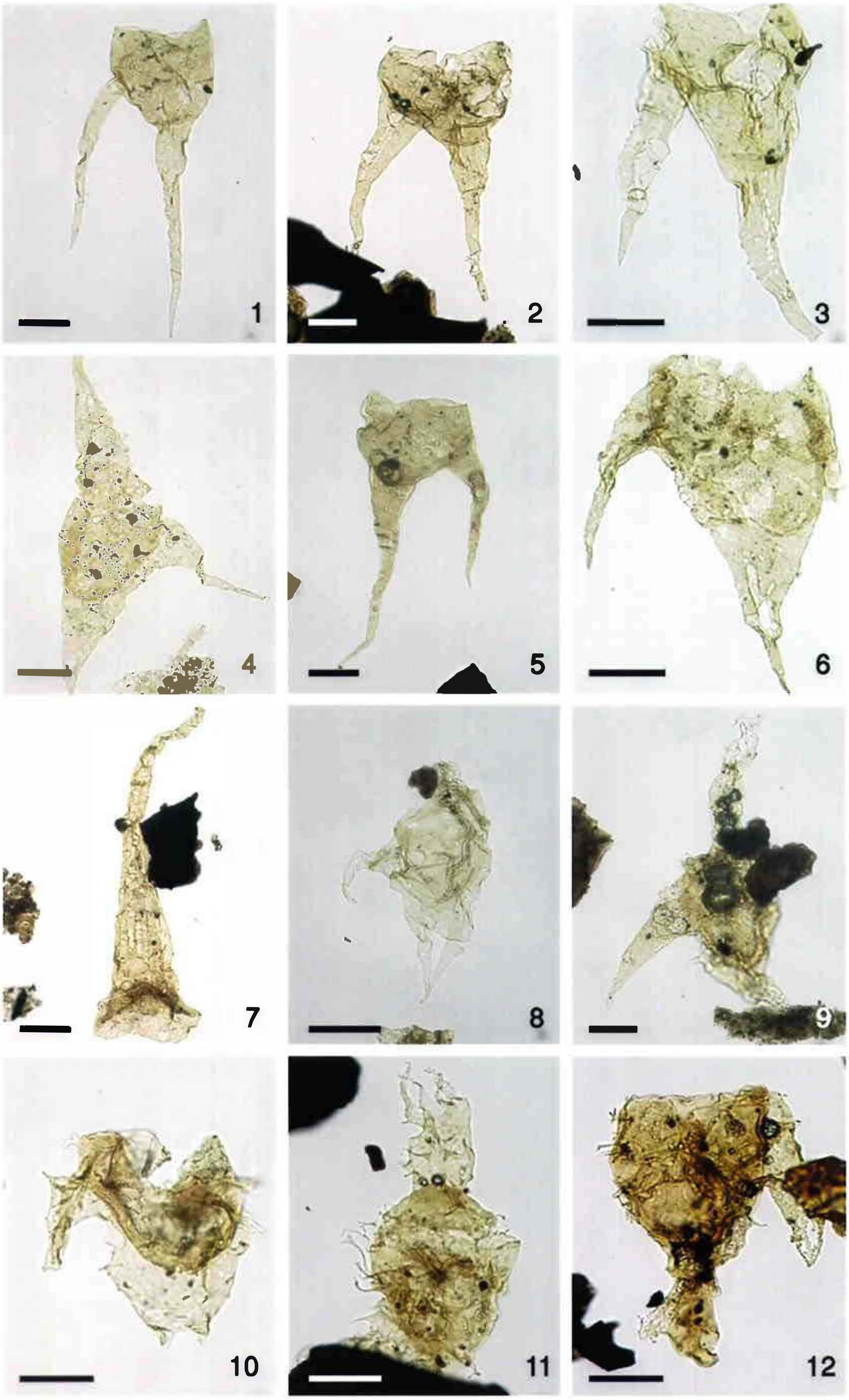

Plate 9 Svartenhuk

Fig. 1. *Microdinium reticulatum* 402664-9, 400712; 48.3-110.3; LVR 1.1293; MI 799

Fig. 2. *Microdinium*? sp. 1 HNH, GGU 400711-12-4; 37.9-102.8; LVR 1.1391; MI 880

Fig. 3. *Microdinium*? sp. 1 HNH, GGU 400711-12-4; 46.0-110.5; LVR 1.1392; MI 881

Fig. 4. *Microdinium*? sp. 1 HNH, GGU 400710-15-4; 47.4-95.1; LVR 1.1527; MI 999

Fig. 5. *Microdinium*? sp. 1 HNH, GGU 400712-16-4; 36.2-104.8; LVR 1.1703; MI 1159

Fig. 6. *Microdinium*? sp. 1 HNH, GGU 400712-16-4; 53.8-104.2; LVR 1.1704; MI 1160

Fig. 7. *Microdinium*? sp. 1 HNH, GGU 400712-25-4; 38.0-93.1; LVR 1.1812; MI 1264

Fig. 8. *Microdinium*? sp. 2 HNH, GGU 400708-20-6; 44.5-111.7; LVR 1.1293; MI 799

Fig. 9. *Microdinium*? sp. 2 HNH, GGU 400712-14-4; 19.6-112.0; LVR 1.1637; MI 1095

Fig. 10. *Tanyosphaeridium variecalamus*, GGU 402664-7, 400712; 47.3-107.8; LVR 1.1612; MI 1071

Fig. 11. *Trithyrodinium*? sp. 2 HNH, GGU 400712-25-4, 28.8-104.0; LVR 1.1799; MI 1252

Fig. 12. *Trithyrodinium*? sp. HNH, GGU 400711-6-7, 30.7-103.7; LVR 1.1505; MI 982

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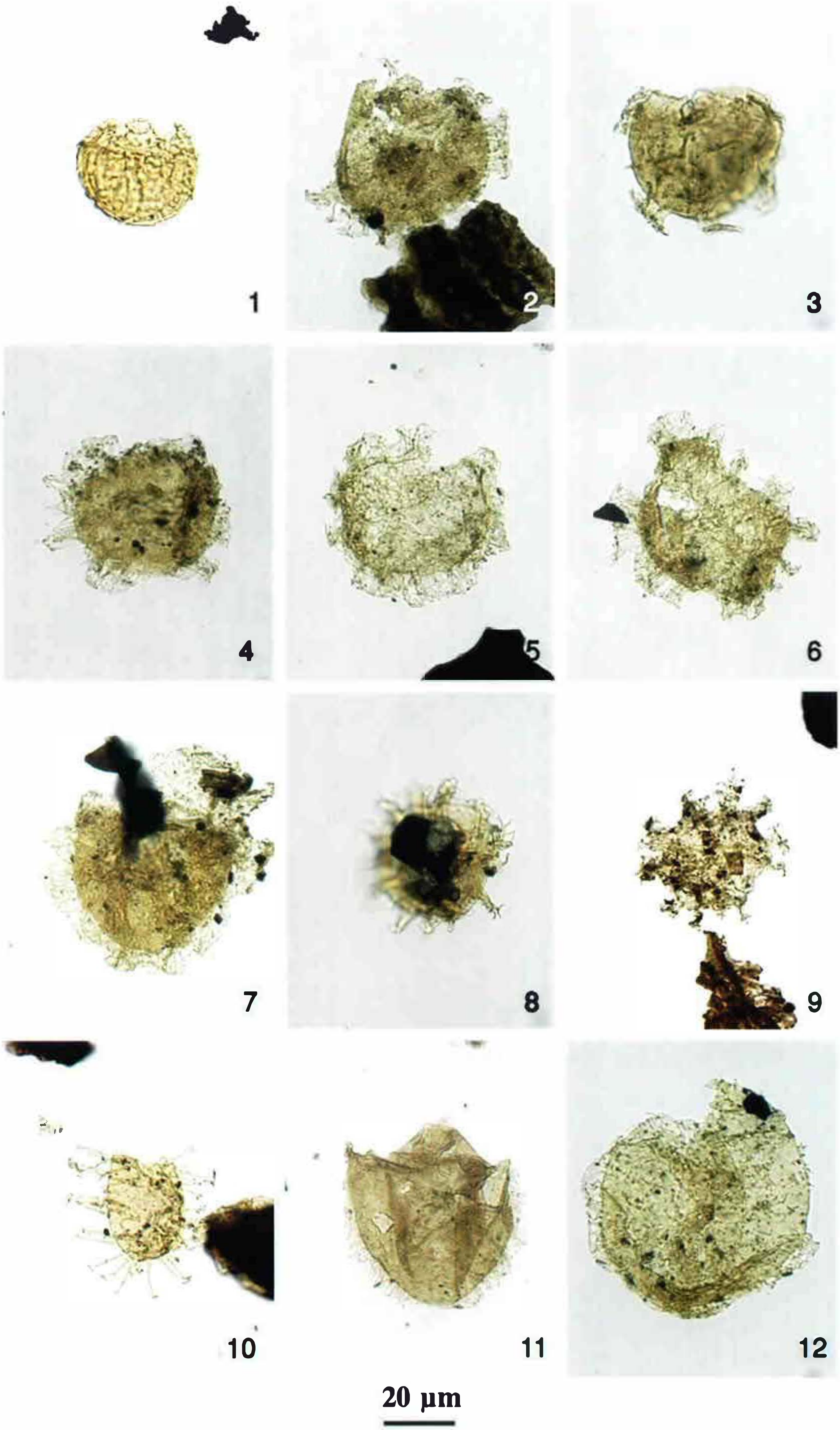

Plate 10 Svartenhuk

Fig. 1. *Trithyrodinium* aff. *suspectum*, GGU 402680-7, HNH920822/5; 46.9-107.3; LVR 1.1221; MI 739

Fig. 2. *Trithyrodinium* aff. *suspectum*, GGU 400712-23-3; 31.5-100.6; LVR 1.1750; MI 1205

Fig. 3. *Trithyrodinium* aff. *suspectum*, GGU 400712-24-3; 37.6-95.8; LVR 1.1785; MI 1238

Fig. 4. *Trithyrodinium* aff. *suspectum*, GGU 251506-5, JGL; 32.3-102.8; LVR 1.695; MI 379

Fig. 5. *Trithyrodinium*? sp., GGU 400712-15-4; 41.8-96.0; LVR 1.1680; MI 1137

Fig. 6. *Trithyrodinium*? sp., GGU 400712-26-4; 24.8-93.7; LVR 1.1840; MI 1290

Fig. 7. *Trithyrodinium*? sp., GGU 400709-24-3; 36.9-104.5; LVR 1.752; MI 429

Fig. 8. *Trithyrodinium* aff. ?*suspectum*, GGU 400711-10-4; 37.0-104.5; LVR 1.1437; MI 920

Fig. 9. *Trithyrodinium* aff. ?*suspectum*, GGU 402664-8, 400712; 24.8-96.1; LVR 1.1622; MI 1081

Fig. 10. *Trithyrodinium* aff. ?*suspectum*, GGU 400712-15-4; 24.7-98.4; LVR 1.1648; MI 1106

Fig. 11. *Trithyrodinium*? sp., GGU 400712-14-4; 28.2-111.8; LVR 1.1648; MI 1106

Fig. 12. *Trithyrodinium*? sp., GGU 400712-14-4; 39.9-96.4; LVR 1.650; MI 1108

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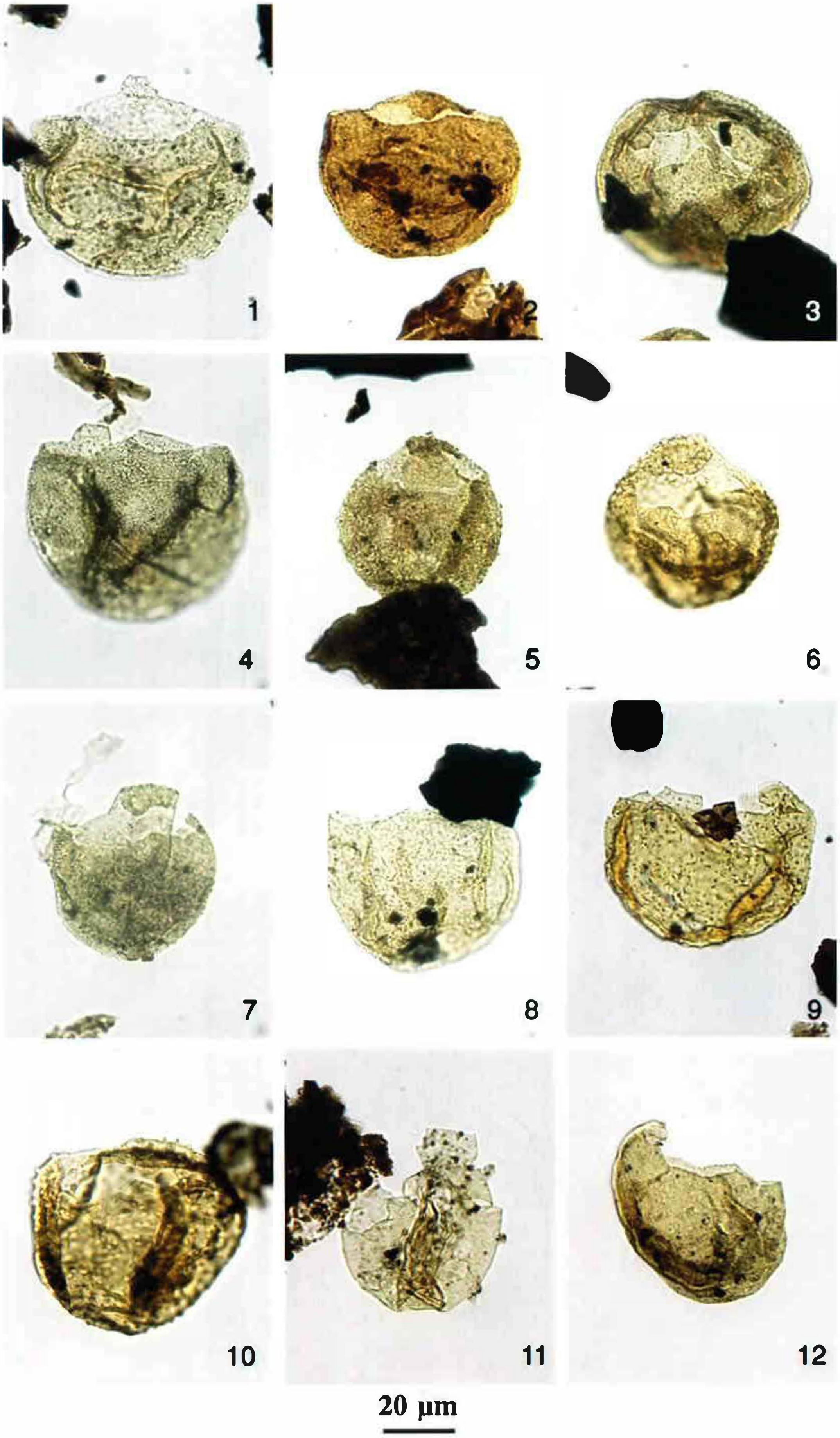

Plate 11 Svartenhuk

Fig. 1. *Achomosphaera*? sp. 400709-20-3, 28.0-96.4; LVR 1.793; MI 468

Fig. 2. *Achomosphaera* aff. *sagena*, GGU 402673-4, HNH920822/3; 24.3-109.7; LVR 1670; MI 354

Fig. 3. *Oligosphaeridium complex*, GGU 400712-23-3, 32.4-101.7; LVR 1.1747; MI 1203

Fig. 4. *Oligosphaeridium* aff. *complex*, GGU 400711-12-4, 46.0-97.5; LVR 1.1407; MI 894

Fig. 5. *Oligosphaeridium* aff. *pulcherrimum*, GGU 400709-14-5, 41.2-106.0; LVR 1.831; MI 504

Fig. 6. *Oligosphaeridium* aff. *pulcherrimum*, GGU 400711-10-4, 44.8-111.9; LVR 1.1444; MI 926

Fig. 7. *Stiphrosphaeridium* aff. *anthophorum*, GGU 400711-12-4 44.3-106.4; LVR 1.1404; MI 892

Fig. 8. *Stiphrosphaeridium* aff. *anthophorum*, GGU 400712-26-4 37.3-106.9; LVR 1.1835; MI 1285

Fig. 9. *Hystrichodinium pulchrum*, GGU 400712-16-4, 30.6-112.9; LVR 1.1700; MI 1156

Fig. 10. *Surculosphaeridium*? *longifurcatum*, GGU 400709-16-3, 55.3-100.6; LVR 1.826; MI 499

Fig. 11. *Surculosphaeridium*? *longifurcatum*, GGU 400709-18-3, 24.6-106.4; LVR 1.810; MI 484

Fig. 12. *Surculosphaeridium*? *longifurcatum*, GGU 400712-23-4, 26.0-97.0; LVR 1.1737; MI 1193

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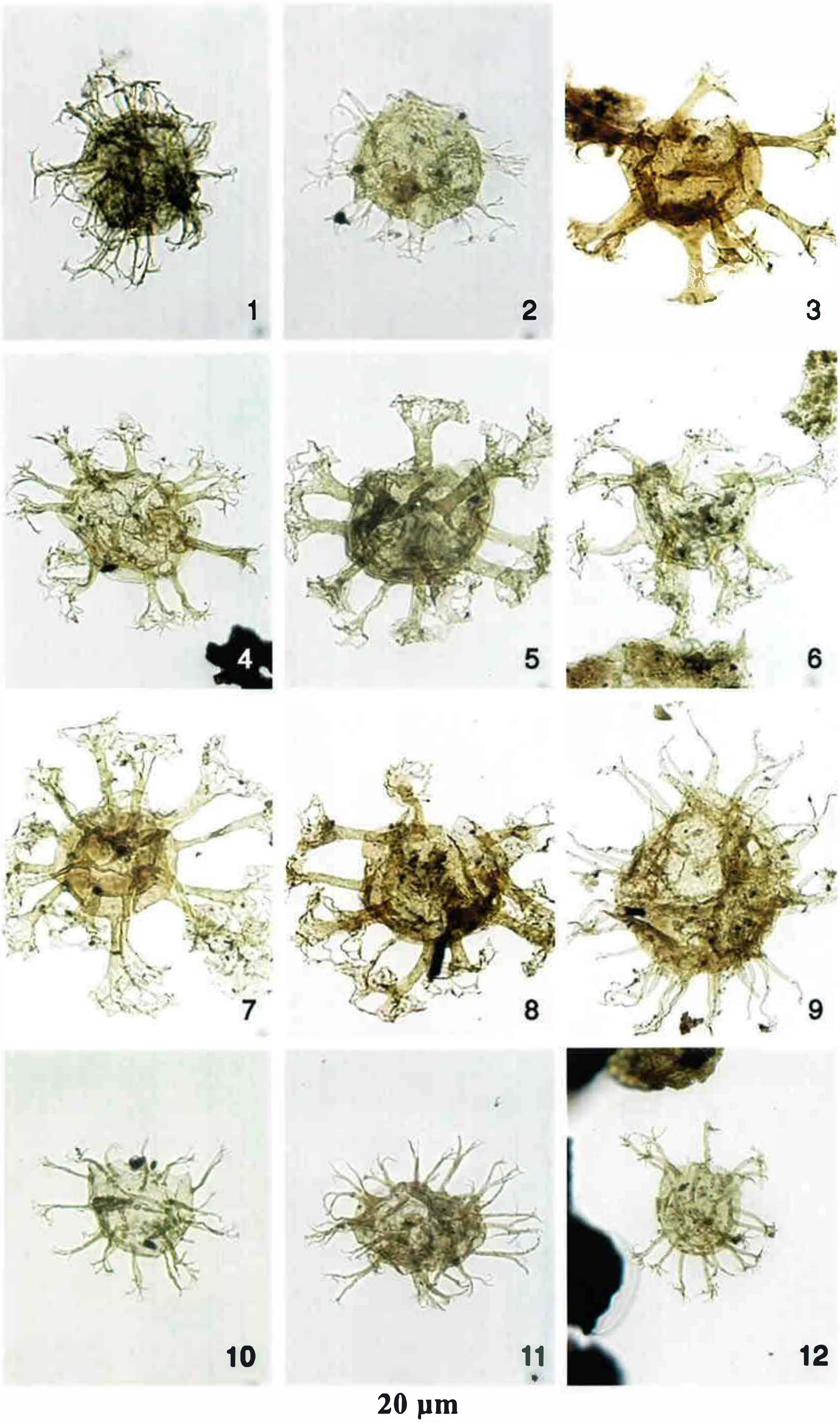

Plate 12 Svartenhuk

Fig. 1. *Florentinia* aff. *mantellii*, GGU 400709-24-3; 29.1-96.8; LVR 1.757; MI 434

Fig. 2. *Florentinia* aff. *mantellii*, GGU 400709-16-4; 37.8-99.5; LVR 1.828; MI 501

Fig. 3. *Florentinia* aff. *deanei*, GGU 400712-17-4; 35.3-101.5; LVR 1.1720; MI 1176

Fig. 4. *Florentinia* aff. *deanei*, GGU 400712-26-5; 42.9-108.2; LVR 1.2203; MI 1565

Fig. 5. *Florentinia* aff. *deanei*, GGU 400712-25-5; 42.9-105.9; LVR 1.2208; MI 1570

Fig. 6. *Florentinia* aff. *deanei*, GGU 400712-15-4; 51.0-109.3; LVR 1.1684; MI 1141

Fig. 7. *Florentinia* aff. *deanei*, GGU 402664-10, 400712; 37.3-109.0; LVR 1.1628; MI 1086

Fig. 8. *Florentinia* sp. 1 HNH, GGU 400711-14-3; 24.1-112.2; LVR 1.1345; MI 846

Fig. 9. *Florentinia* sp. 1 HNH, GGU 400711-12-4; 42.6-112.9; LVR 1.1399; MI 887

Fig. 10. *Florentinia* sp. 1 HNH, GGU 400711-12-4; 58.7-100.6; LVR 1.1401; MI 888

Fig. 11. *Florentinia* sp. 1 HNH, GGU 400711-12-3; 37.1-97.0; LVR 1.1402; MI 889

Fig. 12. *Florentinia* sp. 1 HNH, GGU 400711-12-7; 24.1-102.6; LVR 1.2780; MI 2067

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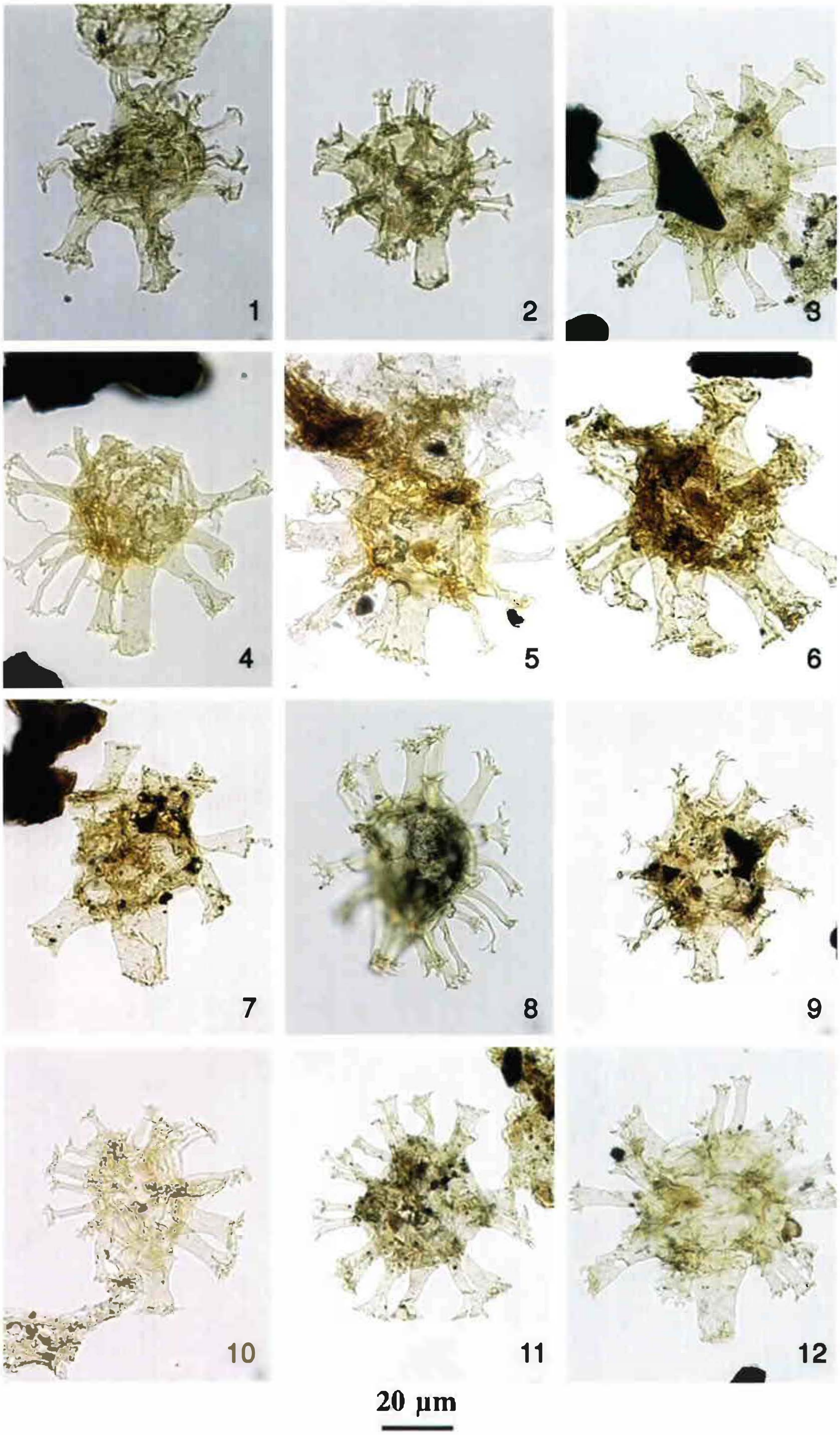

Plate 13 Svartenhuk

Fig. 1. *Florentinia* sp. 1 HNH, GGU 400711-12-8; 54.8-95.1; LVR 1.2781; MI 2068

Fig. 2. *Florentinia* aff. *deanei*, GGU 400711-8-8; 47.0-92.9; LVR 1.2787; MI 2074

Fig. 3. *Florentinia* sp. 1 HNH, GGU 400711-8-8; 37.0-109.2; LVR 1.2788; MI 2075

Fig. 4. *Florentinia*? sp. HNH, GGU 400711-12-8; 48.4-96.5; LVR 1.2784; MI 2071

Fig. 5. *Florentinia*? sp. HNH, GGU 400711-12-8; 23.0-102.5; LVR 1.2782; MI 2069

Fig. 6. *Florentinia*? sp. HNH, GGU 400711-12-8; 25.1-109.6; LVR 1.2783; MI 2070

Fig. 7. *Heterosphaeridium difficile*, GGU 400711-14-4; 28.3-104.2; LVR 1.1319; MI 822

Fig. 8. *Heterosphaeridium difficile*, GGU 400709-18-3; 23.3-101.8; LVR 1.807; MI 481

Fig. 9. *Heterosphaeridium difficile*, GGU 402680-7, HNH920822/5; 31.4-102.8; LVR 1.1194; MI 712

Fig. 10. *Heterosphaeridium difficile*, operculum, GGU 402680-7, HNH920822/5; 19.6-105.0; LVR 1.1195; MI 713

Fig. 11. *Heterosphaeridium difficile*, GGU 400710-15-7; 25.1-98.7; LVR 1.1522; MI 995

Fig. 12. *Heterosphaeridium difficile*, GGU 400712-26-4; 48.1-106.2; LVR 1.1842; MI 1292

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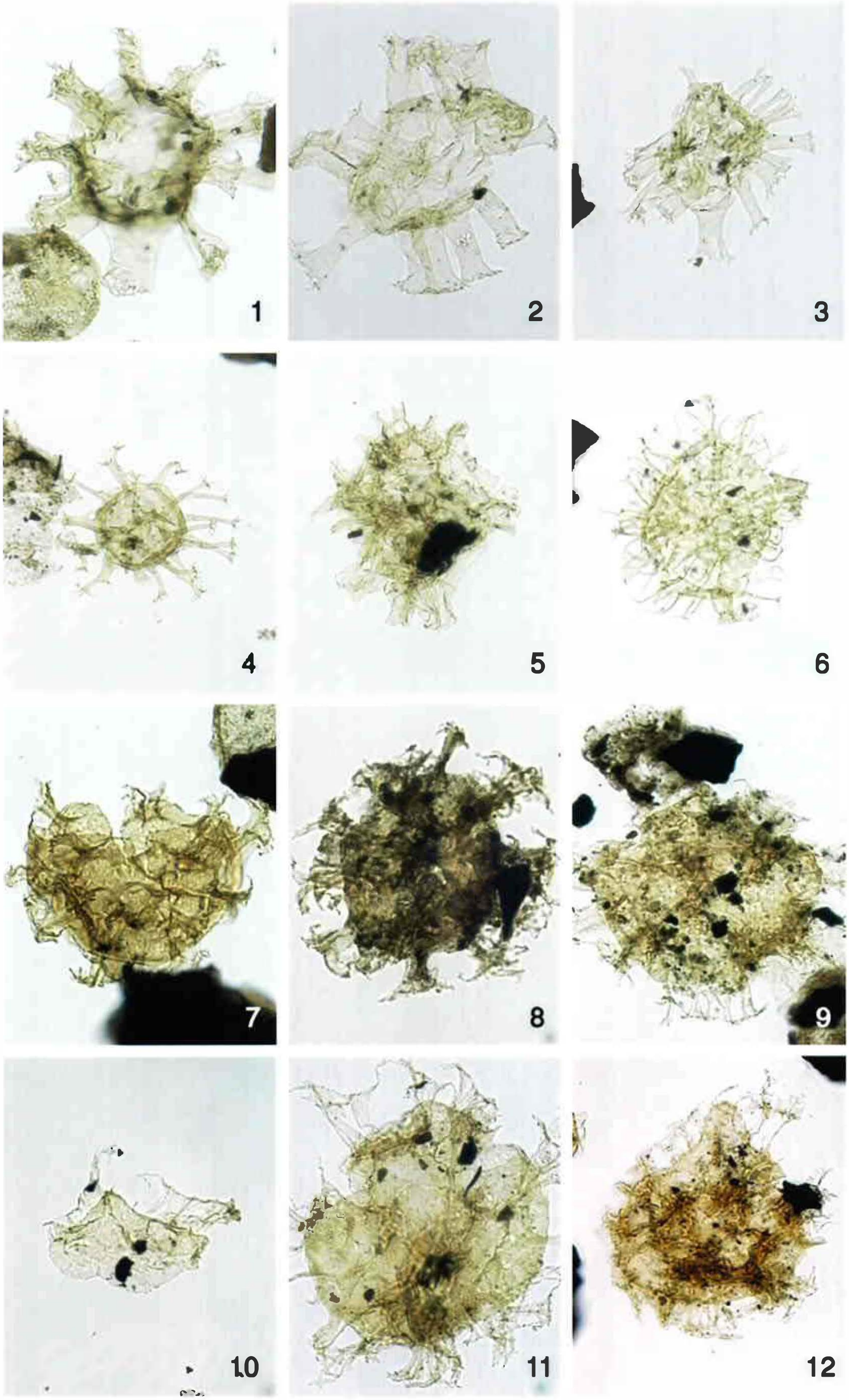

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Plate 14 Svartenhuk

Fig. 1. *Chlamydophorella*? aff. *grossa*, GGU 400712-25-4; 44.1-107.0; LVR 1.1803; MI 1256

Fig. 2. *Chlamydophorella* sp. 2 HNH, GGU 402680-7, HNH920822/5; 32.6-111.4; LVR 1.1200; MI 718

Fig. 3. *Chlamydophorella* sp. 3 HNH, GGU 400711-12-4; 33.7-107.4; LVR 1.1371; MI 866

Fig. 4. *Chlamydophorella* sp. 5 HNH, GGU 400712-25-4; 20.4-112.5; LVR 1.1801; MI 1254

Fig. 5. *Chlamydophorella* sp. 6 HNH, GGU 400712-25-4; 21.9-94.8 LVR 1.1802; MI 1255

Fig. 6. *Chlamydophorella nyei*, GGU 402680-4, HNH920822/5; 32,3.1-112.0; LVR 1.1199; MI 717

Fig. 7. *Exochosphaeridium* sp. 2 HNH, GGU 400711-10-4; 48.6-99.9 LVR 1.1435; MI 918

Fig. 8. *Exochosphaeridium* sp. 1 HNH, GGU 400710-15-7; 30.7-107.7 LVR 1.1530; MI 1002

Fig. 9. *Exochosphaeridium* sp. 1 HNH, GGU 400712-17-4; 53.1-108.0 LVR 1.1724; MI 1180

Fig. 10. *Exochosphaeridium* sp. 1 HNH, GGU 400712-25-4; 25.1-109.0 LVR 1.1804; MI 1257

Fig. 11. *Exochosphaeridium* sp. 1 HNH, GGU 400712-25-4; 32.8-101.4 LVR 1.1805; MI 1258

Fig. 12. *Exochosphaeridium* sp. 1 HNH, GGU 400711-12.4; 40.0-102.5 LVR 1.1396; MI 885

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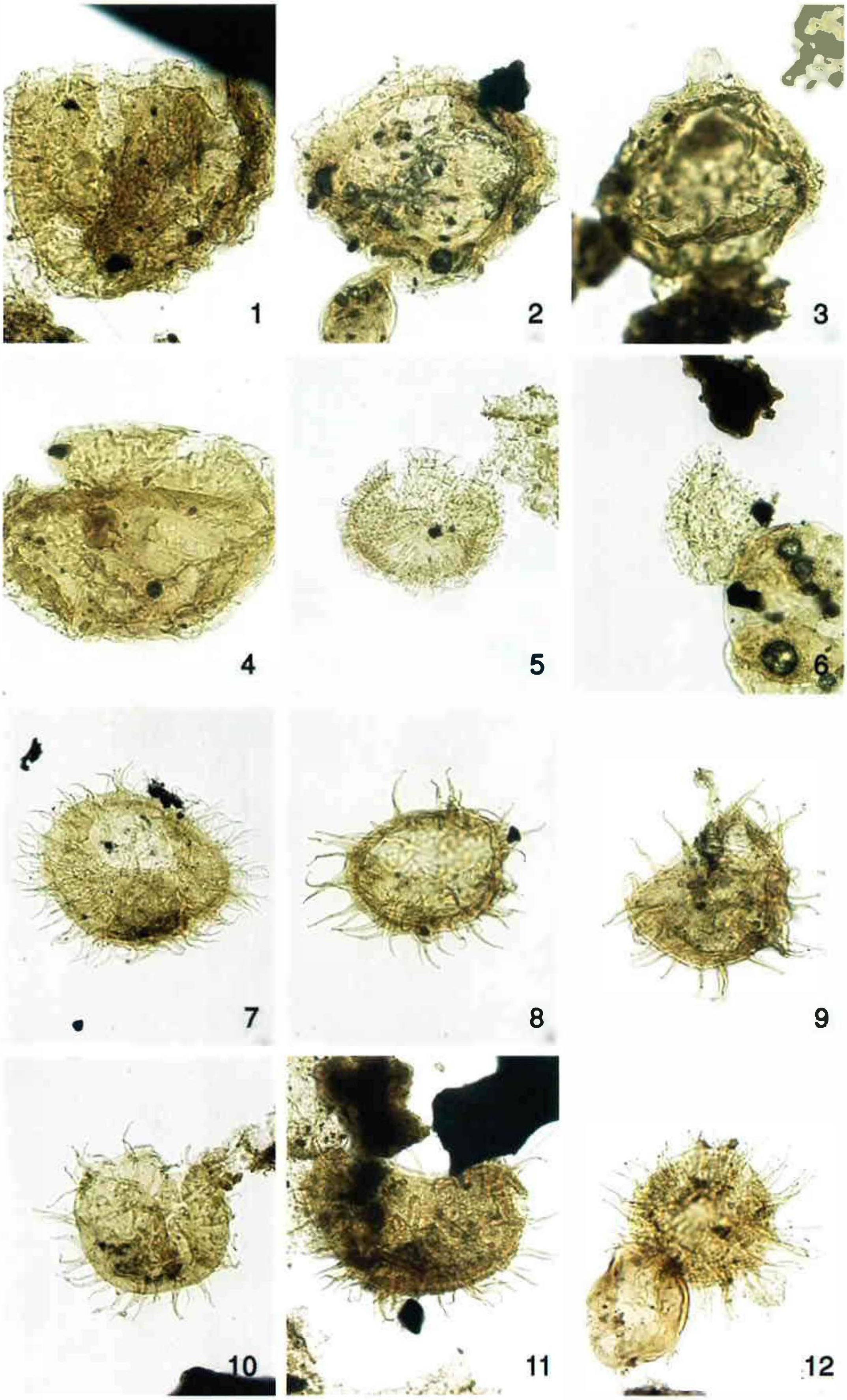

20 µm

Plate 15 Svartenhuk

Fig. 1. *Chlamydophorella*? sp. 4 HNH, GGU 400712-14-4; 48.2-105.7; LVR 1.1635; MI 1093

Fig. 2. Dinocyst sp. 8 HNH, GGU 400712-17-4; 48.8 110.4; LVR 1.1726; MI 1182

Fig. 3. Dinocyst sp. 3 HNH, GGU 400708-12-5; 25.2 103.1; LVR 1.1310; MI 813

Fig. 4. Dinocyst sp. 2 HNH, GGU 402601-4, HNH920806/1; 33.8 95.8; LVR 1.1165; MI 684

Fig. 5. Dinocyst sp. 9 HNH, GGU 400712-25-4; 51.4 100.7; LVR 1.1820; MI 1271

Fig. 6. *Spiniferites* sp., GGU 402680-4, HNH920822/5; 53.0-106.0; LVR 1.1196; MI 714

Fig. 7. Chorat sp. 15 HNH, GGU 400711-6-7; 30.5 97.7; LVR 1.1503; MI 980

Fig. 8. Chorat sp. 2 HNH, GGU 400709-18-4; 34.4 98.0; LVR 1.817; MI 490

Fig. 9. Chorat sp. 4 HNH, GGU 400709-10-5; 33.1 105.2; LVR 1.1137; MI 656

Fig. 10. Chorat sp. 4 HNH, GGU 402601-4, HNH920806/1; 40.0-105.7; LVR 1.1167; MI 686

Fig. 11. Chorat sp. 4 HNH, GGU 402610-4, HNH920806/1; 46.8-101.7; LVR 1.1171; MI 689

Fig. 12. Chorat sp. 4 HNH, GGU 402664-4, 400712; 51.5-107.3; LVR 1.1609; MI 1068

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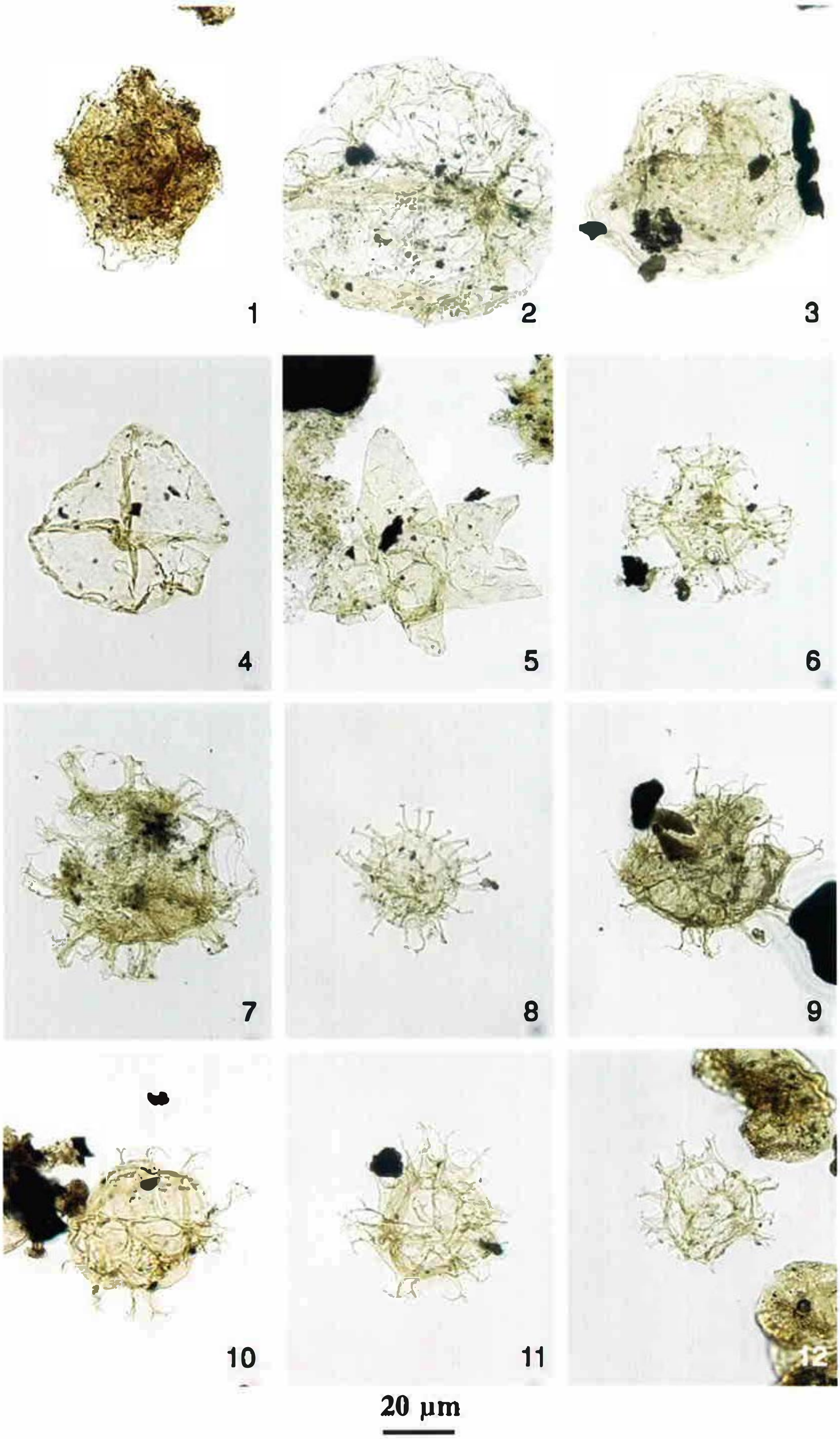

Plate 16 Svartenhuk

Fig. 1. Chorat sp. 5 HNH, GGU 402678-7, HNH920822/5; 52.8-94.8; LVR 1.1181; MI 699

Fig. 2. Chorat sp. 5 HNH, GGU 402625-7, HNH920809/1; 27.9-107.3; LVR 1.1230; MI 747

Fig. 3. Chorat sp. 5 HNH, GGU 402628-4, HNH920809/1; 23.2-109.9; LVR 1.1239; MI 756

Fig. 4. Chorat sp. 5 HNH, GGU 400708-20-3; 25.4-100.8; LVR 1.1282; MI 788

Fig. 5. Chorat sp. 5 HNH, GGU 402664-9, 400712; 49.4-112.6; LVR 1.1625; MI 1084

Fig. 6. Chorat sp. 5 HNH, GGU 400712-23-3; 47.6-110.0; LVR 1.1757; MI 1211

Fig. 7. Chorat sp. 5 HNH, GGU 400712-24-3; 24.4-111.7; LVR 1.1773; MI 1226

Fig. 8. Chorat sp. 5 HNH, GGU 400712-25-4; 17.1-111.4; LVR 1.1798; MI 1251

Fig. 9. Chorat sp. 7 HNH, GGU 402615-8, HNH920806/1; 40.4-94.9; LVR 1.1178; MI 696

Fig. 10. Chorat sp. 8 HNH, GGU 402680-7, HNH920822/5; 21.0-109.6; LVR 1.1214; MI 732

Fig. 11. Chorat sp. 9 HNH, GGU 402680-7, HNH920822/5; 28.0-96.3; LVR 1.1217; MI 735

Fig. 12. Chorat sp. 11 HNH, GGU 400711-12-4; 51.7-95.0; LVR 1.1406; MI 893

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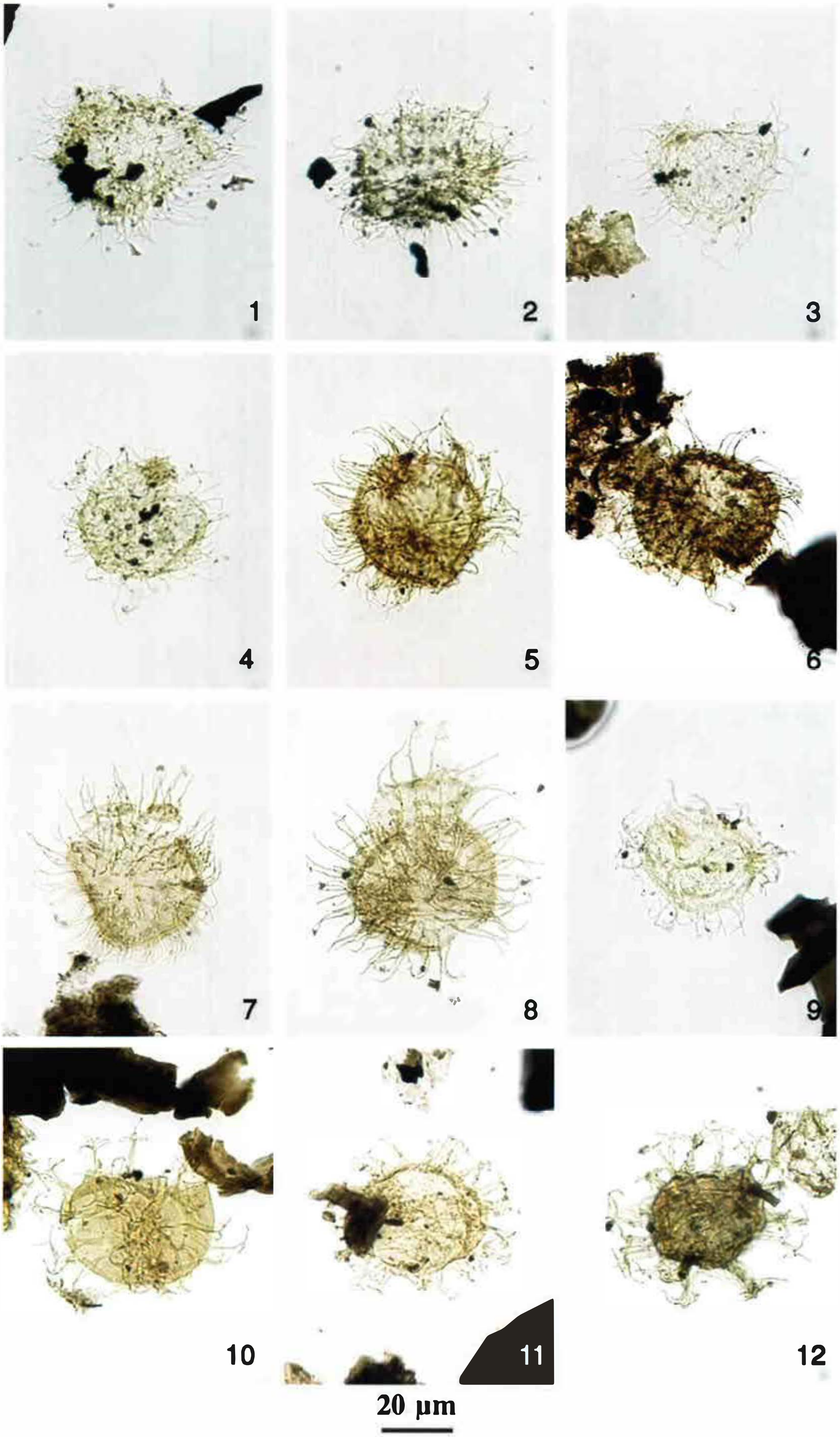

Plate 17 Svartenhuk

Fig. 1. Chorat sp. 12 HNH, GGU 400711-10-4; 26.3-101.9; LVR 1.1436; MI 919

Fig. 2. Chorat sp. 13 HNH, GGU 400711-10-4; 40.8-103.6; LVR 1.1440; MI 922

Fig. 3. Chorat sp. 14 HNH, GGU 400711-6-4; 42.0-111.4; LVR 1.1491; MI 968

Fig. 4. Chorat sp. 16 HNH, GGU 400710-11-8; 38.3-104.8; LVR 1.1535; MI 1007

Fig. 5. Chorat sp. 17 HNH, GGU 400710-11-7; 45.1-110.5; LVR 1.1538; MI 1010

Fig. 6. Chorat sp. 18 HNH, GGU 400712-14-4; 29.0-114.9; LVR 1.1652; MI 1110

Fig. 7. Chorat sp. 21 HNH, GGU 400712-23-3; 46.0-102.2; LVR 1.1756; MI 1210

Fig. 8. Chorat sp. 22 HNH, GGU 400712-24-3; 28.0-109.2; LVR 1.1778; MI 1231

Fig. 9. Chorat sp. 22 HNH, GGU 400712-24-3; 49.3-96.6; LVR 1.1779; MI 1232

Fig. 10. Chorat sp. 23 HNH, GGU 400712-24-3; 28.0-94.5; LVR 1.1782; MI 1235

Fig. 11. Chorat sp. 24 HNH, GGU 400712-25-4; 35.6-93.8; LVR 1.1811; MI 1263

Fig. 12. Chorat sp. 25 HNH, GGU 400577-9, GKP; 30.5-104.6; LVR 1.1979; MI 1407

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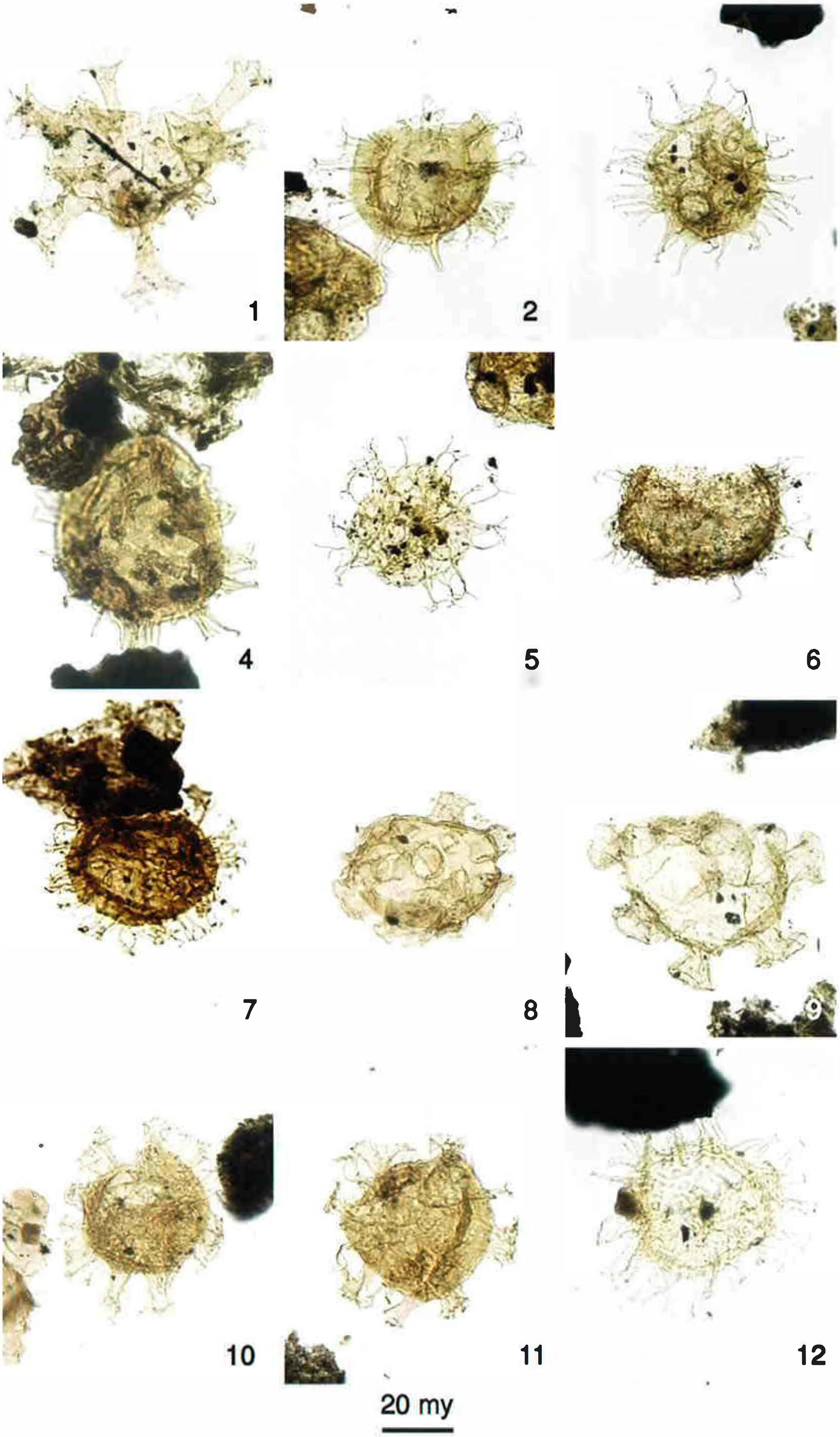

Plate 18 Svartenhuk

Fig. 1. *Desmocysta plekta*, GGU 402601-4, HNH92086/1; 34.8-92.5; LVR 1.1166; MI 685

Fig. 2. *Desmocysta plekta*, GGU 400711-12-5; 30.0-105.7; LVR 1.1411; MI 898

Fig. 3. *Desmocysta* aff. *plekta*, GGU 400710-9-9; 27.9-101.9; LVR 1.2791; MI 2078

Fig. 4. *Dinogymnium* cf. *sibiricum*, GGU 251506-8, JGL; 48.8-100.4; LVR 1.705; MI 388

Fig. 5. *Dinogymnium* cf. *sibiricum*, GGU 251507-4, JGL; 52.3-105.5; LVR 1.713; MI 394

Fig. 6. Dinocyst sp. 7 HNH, GGU 400710-15-4; 44.2-91.7; LRV 1.1525; MI 997

Fig. 7. *Fromea fragilis*, GGU 400709-26-3; 43.5-102.5; LVR 1.731; MI 410

Fig. 8. *Fromea amphora*, GGU 400711-12-4; 47.0-96.5; LVR 1.1408; MI 895

Fig. 9. *Wallodinium anglicum*, GGU 400712-23-3; 27.4-103.0; LVR 1.1745; MI 1201

Fig. 10. *Palaeotetradinium silicorum*, GGU 402673-4, HNH920822/3; 34.7-104.7; LVR 1.677; MI 361

Fig. 11. *Trigonopyxidia ginella*, GGU 400709-24-3; 27.4-110.9; LVR 1.755; MI 432

Fig. 12. *Trigonopyxidia ginella*, GGU 400709-22-3; 31.7-98.7; LVR 1.782; MI 458

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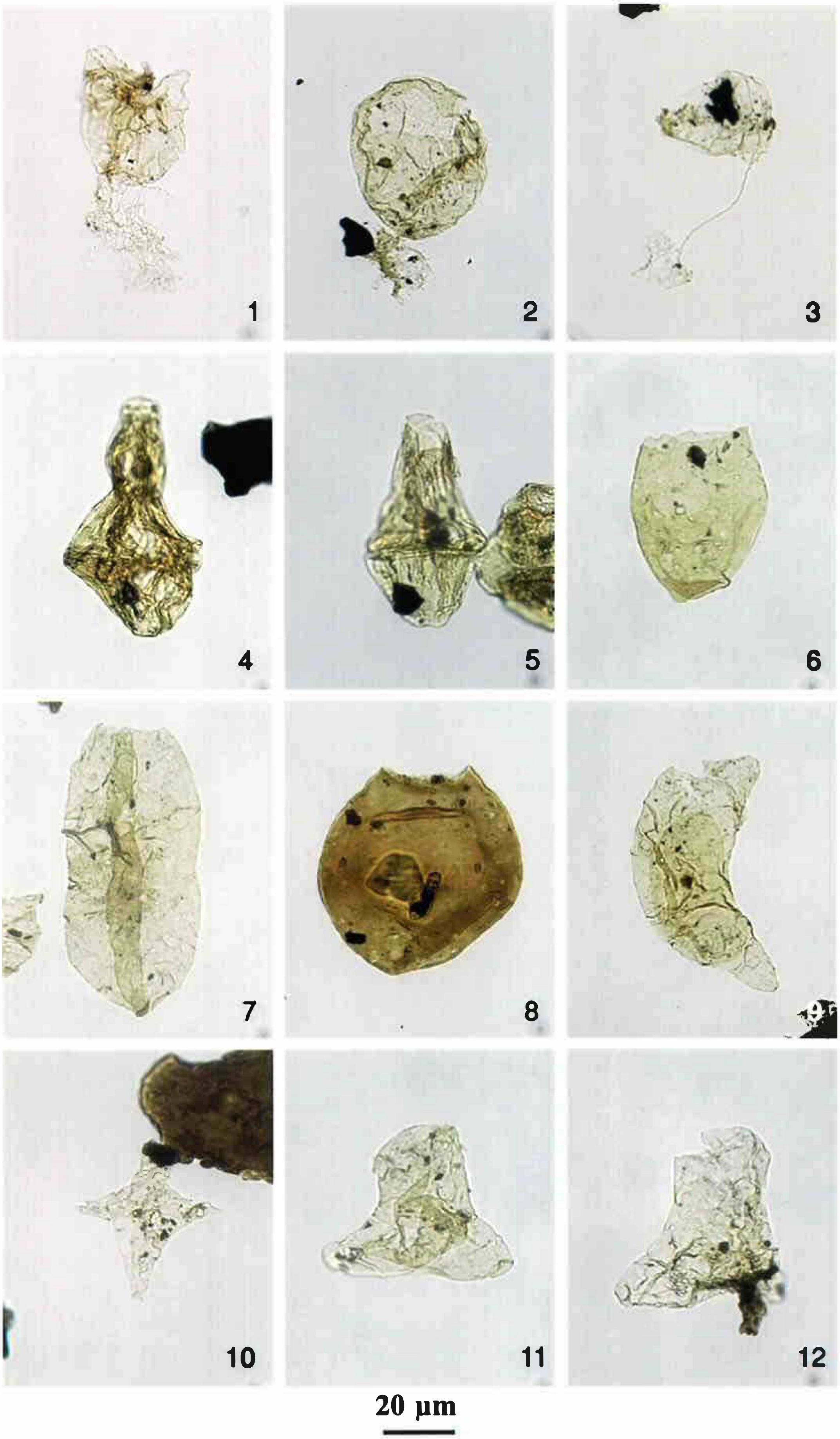

20 µm

Plate 19 Svartenhuk

Fig. 1. *Veryhachium cruciatum*, GGU 400708-20-4; 28.2-107.8; LVR 1.1287; MI 793

Fig. 2. *Veryhachium cruciatum*, GGU 400711-12-4; 33,0-106.7; LVR 1.1386; MI 876

Fig. 3. Acritarch sp. 3 HNH, GGU 400711-12-4; 30.3-112.8; LVR 1.1385; MI 875

Fig. 4. Acritarch sp. 1 HNH, GGU 400709-24-3; 47.9-96.3; LVR 1.765; MI 442

Fig. 5. Acritarch sp. 4 HNH, GGU 400710-15-7; 22.4-107.8; LVR 1.1529; MI 1001

Fig. 6. Acritarch sp. 5 HNH, GGU 400712-15-4; 50.7-94.3; LVR 1.1682; MI 1139

Fig. 7. *Palambages* sp., GGU 402601-7, HNH920806/1; 52.9-96.7; LVR 1.1170; MI 688

Fig. 8. *Apendicisporites* sp. 1 HNH, GGU 402628-8, HNH920809/1; 25.1-94.9; LVR 1.1257; MI 771

Fig. 9. *Apendicisporites* sp. 2 HNH, GGU 400708-22-6; 44.2-101.3; LVR 1.1280; MI 787

Fig. 10. Fungal sp. 1 HNH, GGU 402628-4, HNH920809/1; 27.2-109.9; LVR 1.1240; MI 757

Fig. 11. Fungal sp. 3 HNH, GGU 402628-4, HNH920809/1; 50.8-105.2; LVR 1.1244; MI 760

Fig. 12. Fungal sp. 4 HNH, GGU 400712-15-4; 24.9-106.7; LVR 1.1675; MI 1133

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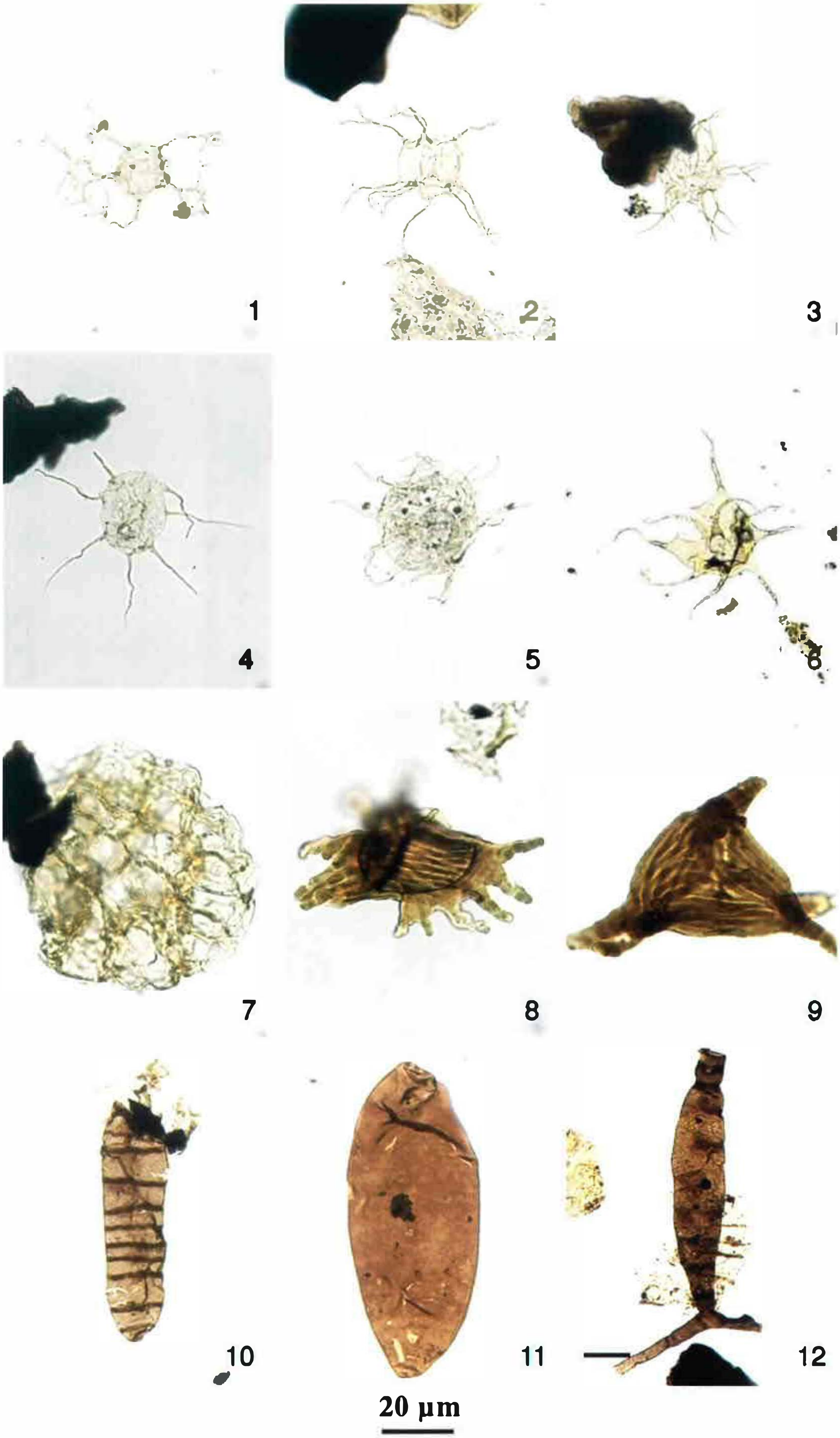

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