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RE-ASSESSMENT OF THE NEW GEOLOGICAL MAP OF BELGIUM: EARLIEST OLIGOCENE DINOFLAGELLATE CYST-BASED AGES IN THE LEUVEN AREA (SHEET 24 AARSCHOT)

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(3 figures, 1 table and 2 plates)

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ABSTRACT. The dinoflagellate cyst (dinocyst) assemblages of two samples from a temporary outcrop in the vicinity of Haacht (Leuven) have been analysed. The co-occurrence of *Areosphaeridium diktyoplokum*, *Cerebrocysta bartonensis*, *Glaphyrocysta semitecta*, *Rombodinium perforatum* and *Thalassiphora reticulata* allows correlation with the North Sea Oligocene-1 zone. As a consequence, the considered unit has a latest Eocene to earliest Oligocene age, equivalent to the age of the marine Tongrian. Comparison of the studied area with the recent 1:50 000 geological map (sheet 24 Aarschot) shows that the current lithostratigraphic interpretation of the analysed section, i.e. the Middle Eocene Maldegem Formation, can no longer be uphold.

KEYWORDS: Oligocene, dinoflagellate cysts, biostratigraphy, Tongrian, Belgium

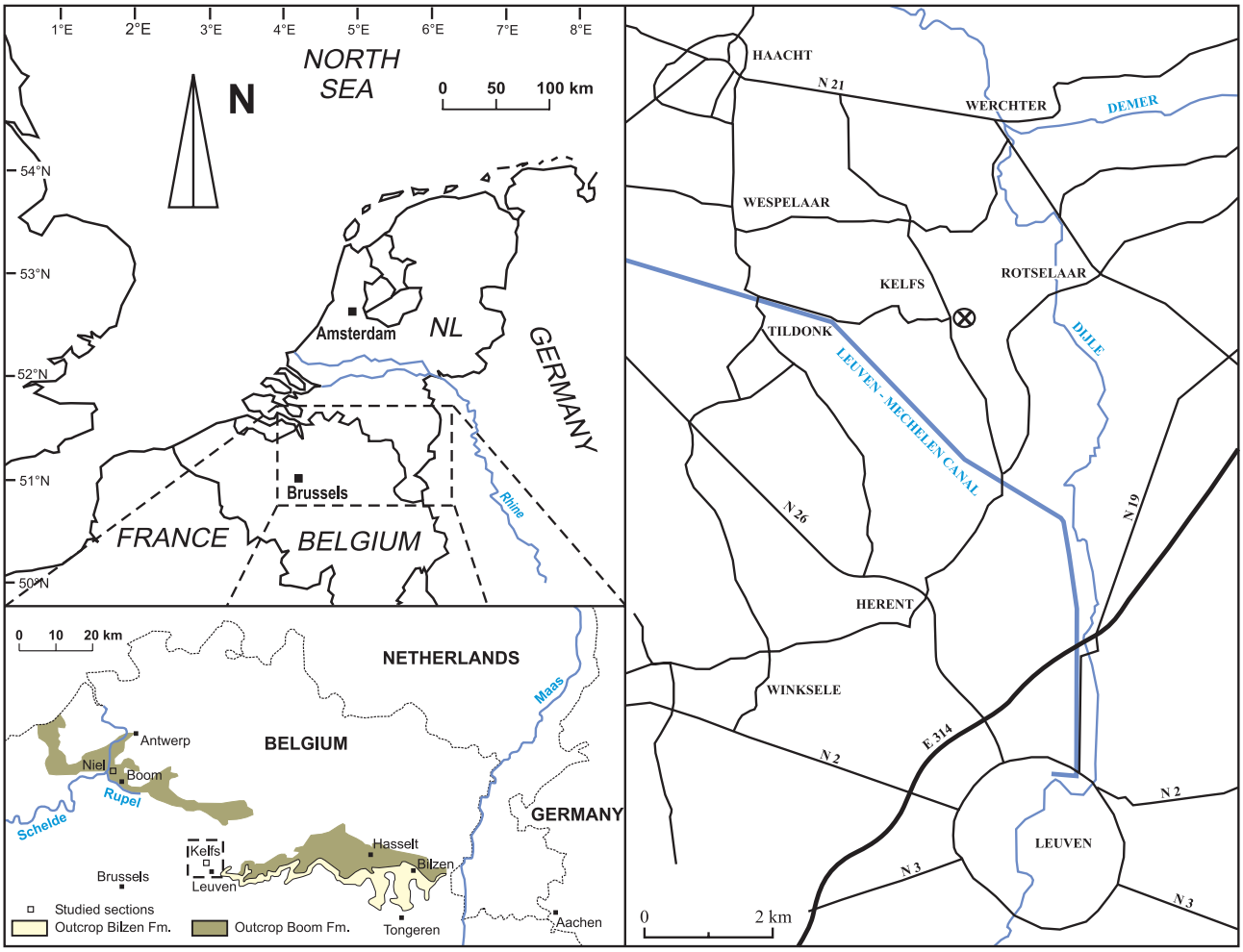

Figure 1: Location of the studied sections. The temporary Kelfs section is indicated with x.

1. Introduction

Road works created temporary outcrops in the hamlet of Kelfs (in the vicinity of Haacht, Leuven area, Fig. 1), exposing fine to medium grained, glauconite rich, clayey sands just below the Quaternary fluviatile sediments. As the stratigraphic position of these sands was poorly understood, and calcareous microfossils were not preserved, only organic-walled microfossils could provide the most convincing constraints on the age of these deposits. Two samples from the Kelfs area and four reference samples from the Niel borehole have been analysed (Fig. 1), and their stratigraphic range is here compared to the recent 1:50 000 geological map of the area (sheet 24 Aarschot). The referred area near Kelfs is currently mapped as the Ursel Member of the Middle Eocene Maldegem Formation (Fig. 2).

2. Material and Methods

Two samples from a temporary outcrop in Kelfs (Kelfs 3 and Kelfs 7, Fig. 1, Tab. 1) were palynologically analysed in order to clarify the stratigraphic position of the glauconitic sands, disconformably underlying the Quaternary. Four reference samples from the Niel 43W-270 borehole (N29.9, N28.5, N25.5 and N23.5, Fig. 1, Tab. 1) were investigated for comparison, covering respectively the Watervliet Member, the Wintham Member and the stratotype of the Ruisbroek Member (sensu Steurbaut, 1986) (Tab. 1). This borehole encompasses the Eocene-Oligocene transition and has been previously investigated only on a qualitative basis by De Coninck (1999).

Samples of approximately 40 g of sediment were processed using standard palynological techniques. After careful cleaning of the sample surfaces, processing involved an initial treatment in hydrochloric acid (25%) to dissolve carbonates, followed by a treatment of hydrofluoric acid (40%) to dissolve silicates. Silicofluoride gels were removed by repeated hot baths (80°C) of 25% HCl. No oxidation, heavy liquid separation or ultrasonic treatment was applied. All residues were homogenised by stirring and sieved on nylon filters with a mesh size of 20 µm. The fraction bigger than 20 µm was stained with Safranin O and mounted with glycerine jelly. Three slides of each sample were scanned for aquatic palynomorphs using a plain transmitted light microscope. Relative abundances were calculated from 200 specimen counts from the 20 µm slides. Photographs were taken on a ZEISS Axioskop-2 light microscope equipped with a Sony DSC-S75 camera. All slides are lodged in the palynological collection of the department Historical Geology, University of Leuven.

3. Biostratigraphic interpretation

Both Kelfs samples contain rich assemblages of well-preserved palynomorphs. In general, the assemblages are dominated by organic-walled dinocysts and bisaccate pollen. The dinocyst association is characterised by high numbers of the *Spiniferites-Achomosphaera* complex and *Cleistosphaeridium* spp., other dominant groups are

	N29.9	N28.5	N25.5	N23.5	Kelfs 7	Kelfs 3
Achilleodinium biformoides		<1	2,3	<1		
Areoligera semicirculata			<1	<1		
Areosphaeridium diktyoplokum	5,8	3,6			X	X
Areosphaeridium michoudii	1,3	<1			X	X
Caligodinium amiculum	<1	<1	<1	<1		
Cerebrocysta bartonensis	<1	<1			X	X
Charlesdowniea clathrata	1,9	<1			X	X
Charlesdowniea coleothrypta rotundata	<1	1,0			X	X
Charlesdowniea faciata		5,1				
Cleistosphaeridium spp.	2,6	2,0	1,7	3,2	X	X
Corrodinium incompositum	<1	1,5	<1			X
Cymatiosphaera bujakii			<1	<1		
Dapsilidinium pseudocolligerum	3,2	2,0	3,5	5,0	X	X
Deflandrea phosphoritica	5,2	5,1	2,3	2,3	X	X
Dinopterigium cladoides	3,9	2,0	<1	<1	X	X
Distatodinium paradoxum	<1	<1	<1	1,3	X	X
Elytrocysta brevis		2,0	1,1	1,3		
Enneadocysta pectiniformis	2,6	14,4	4,0	2,7	X	X
Gerdiocysta conopea			1,1	<1		
Gerlachidium aechmophorum			<1	<1		
Glaphyrocysta inculta		<1			X	X
Glaphyrocysta aff. *inculta* in DC 1986	<1	<1			X	X
Glaphyrocysta semitecta	<1	1,0	2,3	1,3	X	X
Heteraulacysta porosa	1,3	<1			X	X
Histiocysta spp.	<1		2,8	2,7		
Homotryblium spp.	7,1	5,1	1,1	3,2	X	X
Horologinella pentagonalis			<1	<1		
Hystrichokolpoma cinctum	<1	<1				
Hystrichokolpoma grimmertingenensis		<1				
Hystrichokolpoma rigaudiae	<1	<1	1,1	2,3	X	X
Hystrichokolpoma salacia	<1			<1		X
Impagidinium spp.	<1	<1	<1	<1		
Lejeunecysta tenella					X	X
Lingulodinium machaerophorum	1,3	1,5	<1	3,6	X	X
Membranophoridium aspinatum	1,3	<1	1,7	2,3	X	X
Nematosphaeropsis spp.	<1	<1	<1			
Operculodinium eisenackii	1,3	<1			X	X
Operculodinium spp.	9,7	5,6	1,7	<1	X	X
Paralecaniella indentata		1,0	4,6	<1		
Palaeocystodinium golzowense	<1		1,7		X	X
Phthanoperidinium comatum	3,9	1,5	8,0	11,9	X	X
Phthanoperidinium filigranum			<1	<1		
Reticulatosphaera actinocoronata	1,3	1,0	4,0	6,4	X	X
Rhombodinium draco	<1	<1				X
Rhombodinium perforatum	1,3	<1				X
Rottnestia borussica	1,3	<1				
Samlandia chlamydophora	<1	<1	<1	<1	X	X
Selenopemphix armata		<1	<1			
Selenopemphix nephroides	<1	<1	<1		X	X
Selenopemphix selenoides			1,1	1,3	X	X
Spiniferella cornuta	<1	<1	<1		X	X
Spiniferites-Achomosphaera complex	37,6	34,0	28,7	17,4	X	X
Tectatodinium pellitum	<1	<1	1,1	<1		X
Thalassiphora fenestrata	<1	<1	<1		X	X
Thalassiphora patula	<1	<1			X	X
Thalassiphora pelagica	<1	<1	<1	2,7	X	X
Thalassiphora reticulata		<1				X
Thalassiphora? spinifera	<1	1,5	<1	<1		
Tityrosphaeridium cantharellus	1,3	<1	1,7	3,2	X	X
Tuberculodinium vancampoae		<1			X	X
Vozzhennikovia spp.			7,5	11,9		
Wetzeliella symmetrica complex			<1	2,7		

Table 1: Quantitative and qualitative dinocyst distribution of selected species within samples from Kelfs and the Niel 43W-270 borehole. Numbers represent percentages, X = present in sample.

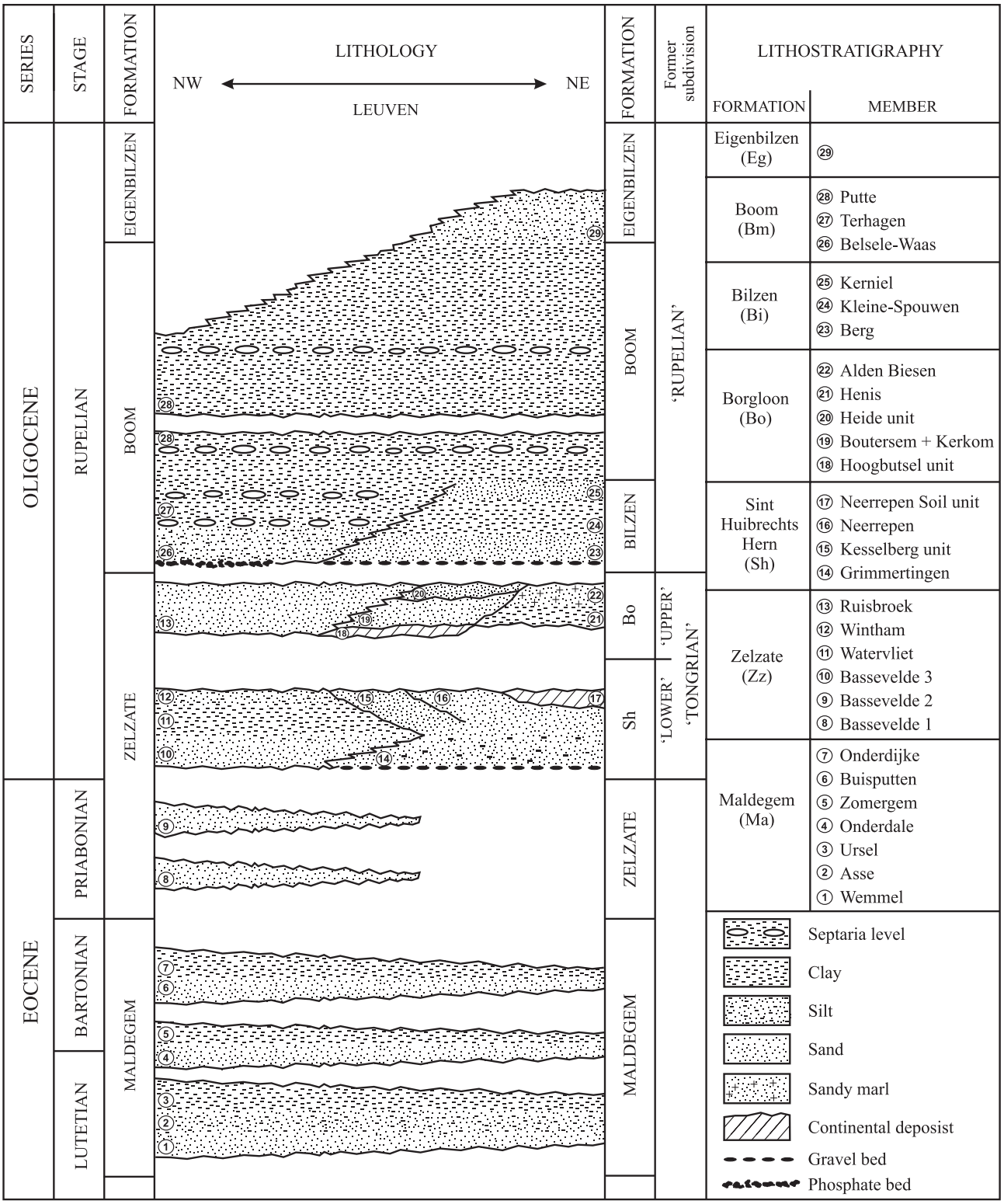

Figure 2: Schematic cross section of the Middle Eocene to Lower Oligocene sediments in the Leuven area. Lithostratigraphy modified after Laga *et al*., 2001.

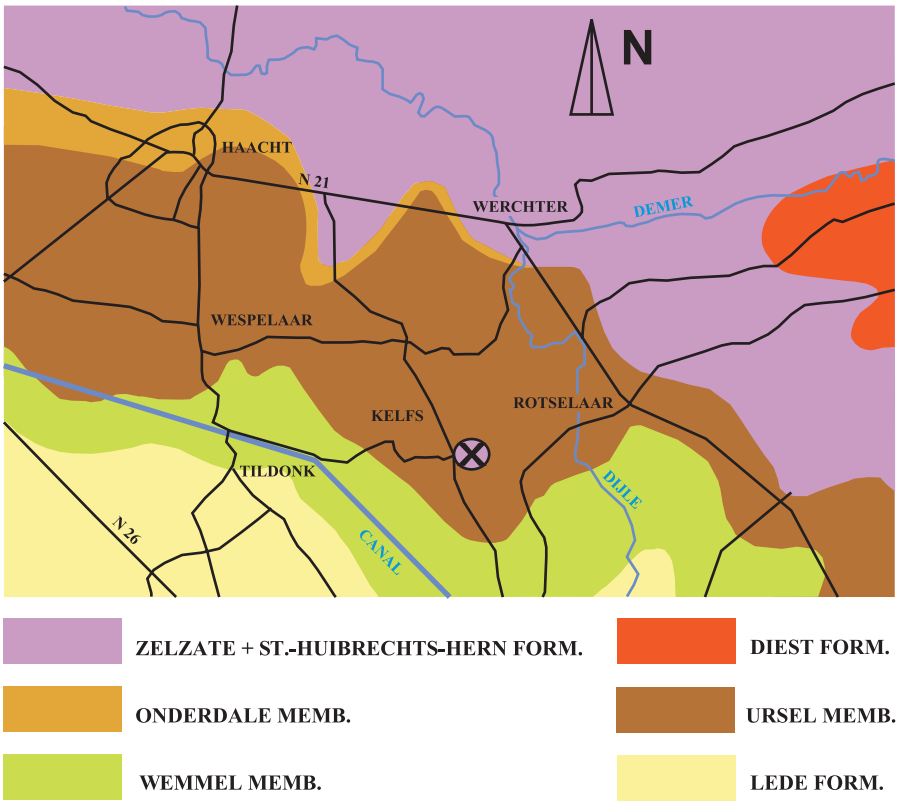

Figure 3: Geological map of the Haacht area (after the new 1:50.000 geological map, sheet 24 Aarschot). The temporary Kelfs section is indicated with x.

Operculodinium spp. and *Homotryblium* spp. Typical oceanic taxa (e.g. *Nematosphaeropsis* spp. and *Impagidinium* spp.) are very rare throughout the section, reflecting the shallow marine setting during the deposition of the greensands. The diverse and rich dinocyst association (over 41 taxa in Kelfs 3) allows confident comparison of our material with published dinocyst distribution patterns from the southern North Sea Basin (i.e. Köthe, 1990; Stover & Hardenbol, 1994; De Coninck, 1995, 1999, 2001; Vandenberghe *et al.*, 2003; Van Simaeys *et al.*, 2005).

The stratigraphic most significant dinocysts are *Areosphaeridium diktyoplokum*, *Cerebrocysta bartonensis*, *Charlesdowniea clathrata*, *Charlesdowniea coleothrypta rotundata*, *Glaphyrocysta semitecta*, *Rhombodinium perforatum* and *Thalassiphora reticulata*. The co-occurrence of these dinocysts allows correlation with the dinocyst North Sea Oligocene-1 zone (NSO-1) after Van Simaeys *et al.* (2005). As a consequence, both Kelfs 3 and Kelfs 7 samples have a latest Eocene to earliest Oligocene age.

So far, the NSO-1 zone is recognised in the upper part of the Bassevelde Member, the Watervliet Member and the Wintham Silt (all belonging to the Zelzate Formation) in NW Belgium and in both the Grimmertingen and Neerrepen Members (both belonging to the Sint-Huibrechts-Hern Formation) in NE Belgium (Van Simaeys *et al.*, 2005). This zone is identical to the D12nc zone (Köthe, 1990) and is calibrated to the upper part of NP21 (Van Simaeys *et al.*, 2005).

In the Niel borhole, a major change in the dinocyst assemblage is noted at the transition from the Wintham Member to the overlying Ruisbroek Member (i.e. last occurrences of *Areosphaeridium diktyoplokum*, *Cerebrocysta bartonensis* and *Rhombodinium perforatum*; first occurrences of *Areoligera semicirculata*, *Gerdiocysta conopea* and *Wetzeliella symmetrica* complex). This change in dinocyst assemblage, together with a distinct change in lithology, has been interpreted as a major glacio-eustatic driven unconformity (Van Simaeys, 2004), correlated to the Oi-1 event (De Man *et al.*, 2004). The occurrence of the Arctic dinocyst species *Svalbardella* spp. at the base of the Ruisbroek Member (De Coninck, 1999), further supports the marked cooling at the transition from the Wintham Member to the overlying Ruisbroek Member.

4. Discussion & Conclusion

From this study, it appears that the upper part of the considered unit just below the Quaternary in the Kelfs area belongs to the 'lower' or 'marine' Tongrian sequence of latest Eocene to earliest Oligocene age (sensu Vandenberghe *et al.*, 2004). This Tongrian sequence unconformably overlies the Maldegem Formation as can be observed on profiles 2 and 3 of the new geological map, respectively in the Haacht-Wespelaar-Tildonk area to the west of the area discussed in this paper and in the Betekom area to the northeast (Schiltz *et al.*, 1993). The regional extension of this unconformity is also apparent from the profile through Putte and Betekom in Saeys *et al.*, 2004. The unconformity subcrop line limiting the occurrence of the Zz Zelzate (Bassevelde 3) - Sh Sint-Huibrechts-Hern (marine Tongeren) map unit should therefore be extended southwards of Haacht, probably south of Wespelaar and Kelfs (Fig. 3). The precise remapping requires however a detailed re-examination of boreholes and available samples in the area.

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Appendix 1: Identified taxa

The taxa included in the present study are listed alphabetically below. Selected taxa, marked with an asterisk, are illustrated on Plates 1 and 2. Taxonomy follows the Fensome & Williams index of fossil dinoflagellates 2004 edition.

Dinoflagellate cysts

Achilleodinium biformoides (Eisenack 1954) Eaton 1976
Areoligera semicirculata (Morgenroth 1966) Stover & Evitt 1978
**Areosphaeridium diktyoplokum* (Klumpp 1953) Eaton 1971
Areosphaeridium michoudii Bujak 1994
Caligodinium amiculum Drugg 1970
Cerebrocysta bartonensis Bujak in Bujak *et al.*, 1980
Charlesdowniea clathrata (Eisenack 1938) Lentin & Vozzhennikova 1989
Charlesdowniea coleotrypta rotundata (Châteauneuf & Gruas-Cavagnetto) Lentin & Vozzhennikova 1989
Charlesdowniea faciata (Rozen 1965) Lentin & Vozzhennikova 1989
Cleistosphaeridium spp.
- *Cleistosphaeridium diversispinosum* Davey *et al.* 1966
- *Cleistosphaeridium placacanthum* (Deflandre & Cookson 1955) Eaton *et al.* 2001

Corrodinium incompositum (Drugg 1970) Stover & Evitt 1978
Dapsilidinium pseudocolligerum (Stover 1977) Bujak *et al.* 1980
Deflandrea phosphoritica Eisenack 1938
Dinopterigium cladoides Deflandre, 1935
Distatodinium paradoxum (Brosius 1963) Eaton 1976
Elytrocysta brevis Stover & Hardenbol 1994
Enneadocysta pectiniformis (Gerlach 1961) Stover & Williams 1995
Gerdiocysta conopea Liengjarern *et al.*, 1980
Gerlachidium aechmophorum (Benedek 1972) Benedek & Sarjeant 1981
Glaphyrocysta inculta (Morgenroth 1966) Stover & Evitt 1978
Glaphyrocysta aff. inculta in De Coninck 1986
**Glaphyrocysta semitecta* (Bujak 1980) Lentin & Williams 1981
**Heteraulacysta porosa* Bujak in Bujak *et al.*, 1980
Histiocysta spp.
Homotryblium spp.
- *Homotryblium floripes* (Deflandrea & Cookson 1955) Stover 1975
- *Homotryblium tenuispinosum* Davey & Williams 1966
- *Homotryblium vallum* Stover 1977

Horologinella pentagonalis Heilmann-Clausen & Van Simaeys in press
Hystrichokolpoma cinctum Klumpp 1953
Hystrichokolpoma grimmertingenensis De Coninck 2001
Hystrichokolpoma rigaudiae Deflandre & Cookson 1955
Hystrichokolpoma salacia Eaton 1976
Impagidinium spp.
Lejeunecysta tenella (Morgenroth 1966) Wilson & Clowes 1980
Lingulodinium machaerophorum (Deflandre & Cookson 1955) Wall 1967
Membranophoridium aspinatum Gerlach 1961
Nematosphaeropsis spp.
**Operculodinium eisenackii* Heilmann-Clausen & Van Simaeys in press
Operculodinium spp.
- *Operculodinium centrocarpum* (Deflandre & Cookson 1955) Wall 1967
- *Operculodinium deconinckii* Lentin & Williams 1989
- *Operculodinium divergens* (Eisenack 1954) Stover & Evitt 1978
- *Operculodinium uncinispinosum* (De Coninck 1969) Islam 1983

Palaeocystodinium golzowense Alberti 1961
Phthanoperidinium comatum (Morgenroth 1966) Eisenack & Kjellström 1971
Phthanoperidinium filigranum (Benedek 1972) Lentin & Williams 1976
Reticulatosphaera actinocoronata (Benedek 1972) Bujak & Matsuoka 1986
Rhombodinium draco Gocht 1955
**Rhombodinium perforatum* (Jan du Chêne & Châteauneuf 1975) Lentin & Williams 1977
**Rottnestia borussica* (Eisenack 1954) Cookson & Eisenack 1961
Samlandia chlamydophora Eisenack 1954
Selenopemphix armata Bujak 1980
Selenopemphix nephroides Benedek 1972
Selenopemphix selenoides Benedek 1972
Spiniferella cornuta (Gerlach 1961) Stover & Hardenbol 1994
Spiniferites-Achomosphaera complex
Tectatodinium pellitum Wall 1967
Thalassiphora fenestrata Liengjarern *et al.*, 1980
**Thalassiphora patula* (Williams & Downie 1966) Stover & Evitt 1978
Thalassiphora pelagica (Eisenack 1954) Eisenack & Gocht 1960
**Thalassiphora reticulata* Morgenroth 1966
**Thalassiphora*? *spinifera* (Cookson & Eisenack 1965) Stover & Evitt 1978
Tityrosphaeridium cantharellus (Brosius 1963) Sarjeant 1981
**Tuberculodinium vancampoae* (Rossignol 1962) Wall 1967
Vozzhennikovia spp.
- *Vozzhennikovia cearaichia* Stover & Hardenbol 1994
- *Vozzhennikovia spinula* Stover & Hardenbol 1994

Wetzeliella symmetrica complex
Wetzeliella gochtii Costa & Downie 1976
Wetzeliella symmetrica Weiler 1956

Acritarchs

Cymatiosphaera bujakii De Coninck 1986

Paralecaniella indentata (Deflandre & Cookson 1955) Cookson & Eisenack 1970

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PLATE 1

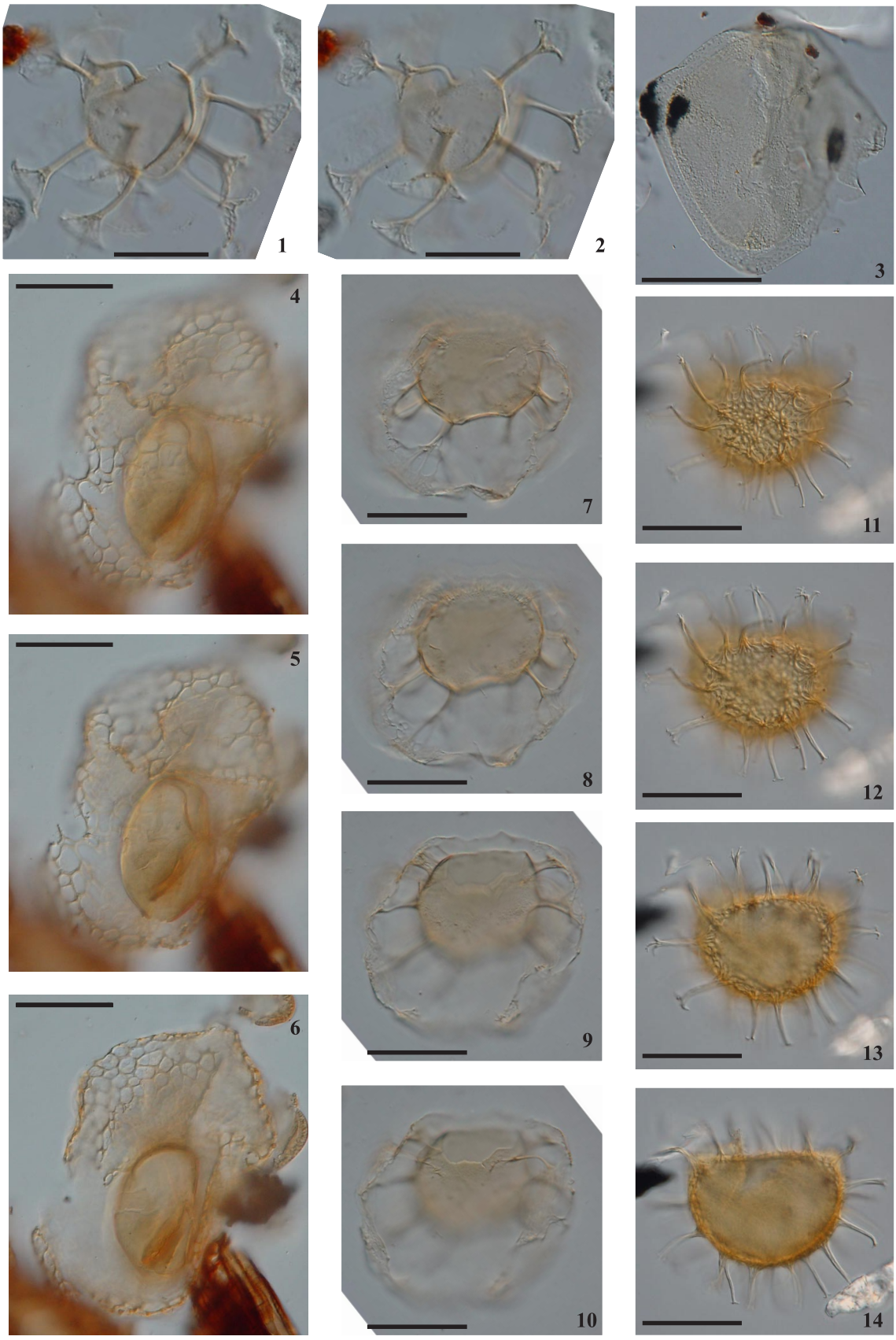

Fig. 1-2: *Areosphaeridium diktyoplokum* / Sample/slide: Niel 29.9-1 [T46/2] / Same specimen, differing high foci
Fig. 3: *Rhombodinium perforatum* / Sample/slide: Niel 28.5-1 [N44/4]
Fig. 4-6: *Thalassiphora reticulata* / Sample/slide: Kelfs 3-1 [R56] / Same specimen, from high to low focus
Fig. 7-10: *Glaphyrocysta semitecta* / Sample/slide: Kelfs 3-1 [N68/1] / Same specimen, from high to low focus
Fig. 11-14: *Operculodinium eisenackii* / Sample/slide: Niel 28.5-2 [K44/2] / Same specimen, differing high foci Bar = 50 µm

PLATE 2

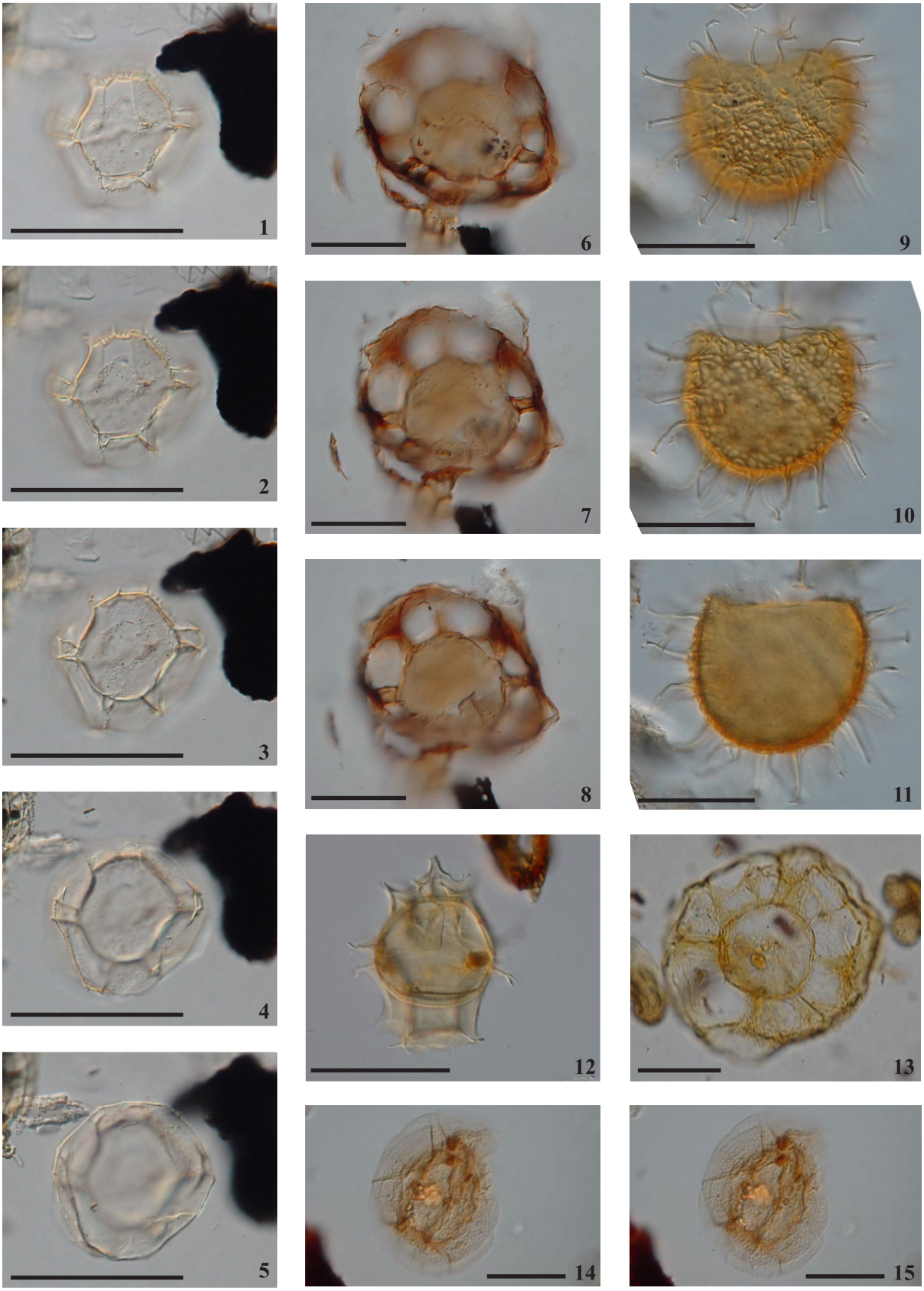

Fig. 1-5: *Thalassiphora*? *spinifera* / Sample/slide Niel 28.5-3 [X56] / Same specimen, from high to low focus
Fig. 6-8: *Tuberculodinium vancampoae* / Sample/slide: Kelfs 3-1 [S52/1] / Same specimen, from high to low focus
Fig. 9-11: *Operculodinium eisenackii* / Sample/slide: Niel 29.9-1 [M48/3] / Same specimen, differing high foci
Fig. 12: *Rottnestia borussica* / Sample/slide: Niel 28.5-2 [M61] / Optical section
Fig. 13: *Thalassiphora patula* / Sample/slide: Kelfs 3-1 [U47] / Optical section
Fig. 14-15: *Heteraulacysta porosa* / Sample/slide: Kelfs 7-2 [X66] / Different optical sections Bar = 50 µm