DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 1997/101

Palynological analysis of the Lower Cretaceous of the Iris-1 well

- a contribution to the EFP-93 project: Lower and Upper Cretaceous stratigraphy in the Central Trough

Karen Dybkjær

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF ENVIRONMENT AND ENERGY

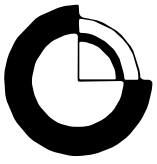
GEUS

DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 1997/101

Palynological analysis of the Lower Cretaceous of the Iris-1 well

- a contribution to the EFP-93 project: Lower and Upper Cretaceous stratigraphy in the Central Trough

Karen Dybkjær



GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF ENVIRONMENT AND ENERGY

GEUS

Contents

1. INTRODUCTION

As part of the EFP-93 Cretaceous Stratigraphy Project, a palynological investigation of the uppermost Farsund Formation and the Valhall Formation (Ryazanian - Hauterivian) in the Iris-1 well was undertaken to produce a chronostratigraphic break-down of the interval. The results are presented below. The subdivision of the investigated interval is based on the occurrence of dinoflagellate cysts. The recorded dinoflagellate cyst assemblages have been compared to the zonation erected by Davey (1979, 1982) and dated in accordance with those papers and other north European litterature on dinoflagellate cyst distribution.

1.1 MATERIALS AND METHODS

The studied interval comprises the succession covering the interval from 13250´ to 11260´. According to Nielsen & Japsen (1991) the interval from 13250´ to 12886´ is referred to the Farsund Formation and the interval from 12886´ to 11260´ is referred to the Valhall Formation. In total 64 samples have been analysed; of these 54 were ditch cuttings samples (dcs), 8 were sidewall cores (swc) and 3 were core samples (ccs). All the core samples and 5 of the sidewall core samples are located below 12850´; most of the studied interval is therefore represented by ditch cuttings samples only. The samples were prepared using conventional palynological preparation techniques (e.g. Poulsen *et al*, 1990). The samples were analysed quantitatively and qualitatively. A full sample list is given in Appendix 3.2. Microscope slides are stored in the palynological slide collection at GEUS.

1.2 ZONATION

As most of the investigated interval is covered only by ditch cuttings samples, a comparison with the published zonation, which is mainly based on first appearances, is somewhat problematic. However, some of the recorded first appearances occur suddenly and with relatively high amounts of specimens, indicating that they are true first appearences and not the result of caving. Based on such events, combined with the stratigraphically important last occurrences, a comparison with Davey´s (1979, 1982) dinoflagellate cyst zonation (Fig. 1) has been made. Davey´s zonation is based on material from the ammonite-bearing Speeton section; his zones can therefore be correlated with ammonite zones.

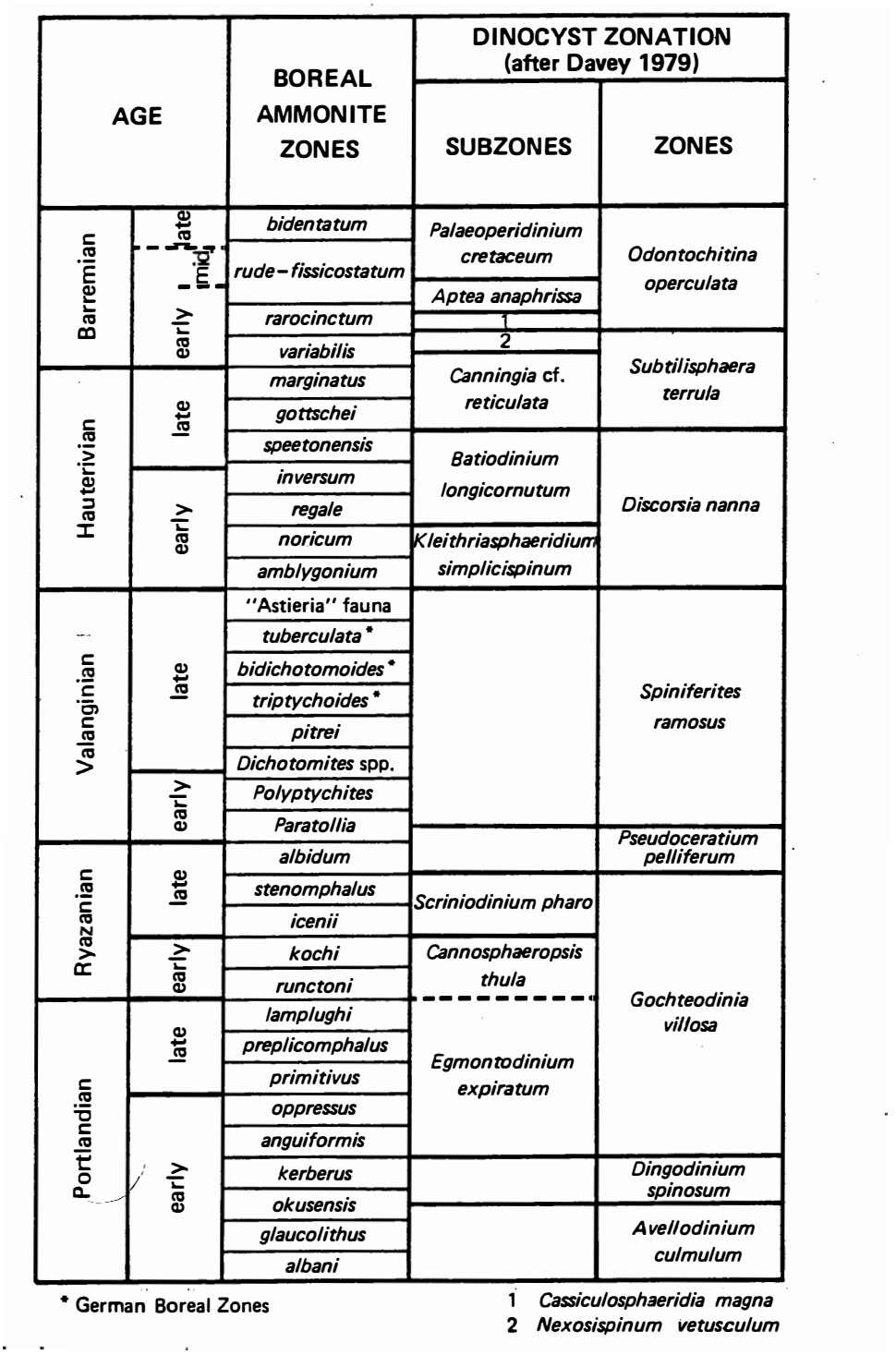


Fig. 1. Davey´s (1979, 1982) dinocyst zonation, used in the present study.

2. BIOSTRATIGRAPHIC SUMMARY

All depths are given in feet and inches. The stratigraphic distribution of dinoflagellates in the Iris-1 well is presented in Enclosure 1. The dinoflagellate cyst zonation established by Davey, (1979) and referred to below, is shown in figure 1.

2.1 IRIS-1

Dinoflagellate biostratigraphy of the interval 11260´- 13250´

11260´- 11470´: Late Hauterivian

The consistent record of *Coronifera oceanica* from 11470´ and upwards and of *Muderongia tetracantha* from 11290´ and upwards probably indicate the presence of the *Subtilisphaera terrula* Zone, although the nominal species has not been recorded in the present study. The *S. terrula* Zone is referred to the late Hauterivian. Some species which normally range throughout the Hauterivian (e.g. *Muderongia neocomica* and *Muderongia sim plex*) apparently have their last occurrence in the dcs at 11290´ and 11320´, respectively. This may be due to the rather poor sample quality of the uppermost two samples, showing very low diversities.

11470´- 11740´: Early-late Hauterivian

The first appearance of the species *Batioladinium longicornutum* at 11840´ indicates the presence of the *Batioladinium longicornutum* Subzone of the *Discorsia nanna* Zone. The consistent record of *Cymososphaeridium validum* from the same level, and more sporadic occurrences of *Hystrichodinium furcatum* from 11750´ and upward, is in agreement with this interpretation. However, the last occurrences of *Tehamadinium daveyi* and *Surculosphaeridium* sp. III at 11740´ indicate that the lowermost record of *B. longicornutum* and *C. validum* (below 11740´) are probably due to caving and that the *B. longicornutum* Subzone is restricted to the interval between 11470´and 11740´.

This zone comprises the lower Hauterivian and probably the lower part of the upper Hauterivian. The last occurrences of *Lagenorhytis delicatula*, *Isthmocystis distincta*, and *Muderongia extensiva* at about 11740´, and the consistent occurrences of *Oligosphaeridium perforatum perforatum* and *Oligosphaeridium* sp. 1 of Heilmann-Clausen (1987) from 11710´ and 11670´ respectively, and up to 11340´, further support a Hauterivian age for this interval (R. Davey, pers. commun., 1995).

11740´: A major unconformity seems to be located at or close to 11740´, comprising a time interval from the early Valanginian to the early Hauterivian.

11740´- 12700´: Early Valanginian

The consistent occurrence of *Spiniferites ramosus* Group from 12700´ and upwards indicates the presence of the *Spiniferites ramosus* Zone which is referred to the early Valanginian. This is supported by the presence of *Surculosphaeridium* sp. III of Davey (1982) up to 11740´. The last occurrence of *Endoscrinium pharo* at 11510´ indicates that this species ranges a little higher than earlier recorded or it may be due to reworking.

12700´- 12990´: earliest Valanginian - latest Ryazanian

Pseudoceratium pelliferum (including the short horned variant) has a distinct first occurrence in the ditch cuttings samples at 12990´, indicating the base of the *Pseudoceratium pelliferum* Zone. The top of this zone is located at 12700´ based on the consistent occurrence of the *Spiniferites ramosus* Group and *Oligosphaeridium complex* above this level. The interval from 12990´ to about 12700´ is thus referred to the *P. pelliferum* Zone, of latest Ryazanian to earliest Valanginian age. The consistent record of *Surculosphaeridium* sp. III of Davey (1982) from the lower part of this interval and upwards, supports an early Valanginian age (see Heilmann-Clausen, 1987).

12990´- 13050´: Late Ryazanian

The common occurrence of *Dingodinium*? *spinosum* and *Gochteodinia villosa villosa* in the sidewall core sample at 13050´ and up to (and including) the core sample at 13006´9´´ and of *Gonyaulacysta* sp. A of Davey (1979) in the core sample at 13018´ indicate that the interval from 13050´ to 12990´ is referable to Davey´s *Egmontodinium pharo* Subzone. Up to the top of this interval the species *Dichadogonyaulax culmula*, *Dingodinium*? *spinosum*, *Circulodinium comptum*, and *Kleithriasphaeridium porosispinum* all occur frequently in all samples, while they occur more sporadically above this level, probably due to reworking. The *E. pharo* Subzone is referred to the late Ryazanian.

13050´- 13250´: Early Ryazanian- ?late Ryazanian

The lowermost part of the interval, up to the sample at 13050´ may be referred to the *Cannosphaeropsis thula* Subzone of Davey (1979, 1982) (early Ryazanian). However, the sporadic occurrence of the nominal species up through most of the investigated section makes it impossible to point out a reliable top occurrence of the species and thus of the subzone. Part of the interval may therefore belong to the *E. pharo* Subzone.

2.2 REWORKING

The sporadic occurrences of species such as *Cannosphaeropsis thula*, *Amphorula expirata* and *Systematophora daveyi* up through most of the investigated interval strongly indicate continuous reworking from Late Volgian to early Late Ryazanian deposits throughout the investigated succession.

3. REFERENCES

Costa, L.I. & Davey, R.J. 1992: Dinoflagellate cysts of the Cretaceous System. *In* Powell, A. J. (ed.) *A stratigraphic index of dinoflagellate cysts*, 99-154. London: Chapman and Hall.

Davey, R.J. 1979: The stratigraphic distribution of dinocysts in the Portlandian (latest Jurassic) to Barremian (Early Cretaceous) of northwest Europe. *American Association of Stratigraphic Palynolynologists Foundation, Contribution Series* 5B, 49-81.

Davey, R.J. 1982: Dinocyst stratigraphy of the latest Jurassic to Early Cretaceous of the Haldager No. 1 borehole, Denmark. *Geological Survey of Denmark, Series B* 6, 57 pp.

Duxbury, S. 1977: A palynostratigraphy of the Berriasian to Barremian of the Speeton Clay of Speeton, England. *Palaeontographica*, Abt. B **160**, 17-67.

Dybkjær, K. 1991: Palynological zonation and palynofacies investigation of the Fjerritslev Formation (Lower Jurassic-basal Middle Jurassic) in the Danish Subbasin. *Geological Survey of Denmark, Series A* **30**, 150 pp.

Heilmann-Clausen, C. 1987: Lower Cretaceous dinoflagellate biostratigraphy in the Danish Central Trough. *Geological Survey of Denmark, Series A* **17**, 89 pp.

McIntyre, D.J. & Brideaux, W.W. 1980: Valanginian miospore and microplankton assemblages from the northern Richardson Mountains, District of Mackenzie, Canada. *Geological Survey of Canada Bulletin* **320**, 1-57.

Nielsen, L.H. & Japsen, P. 1991: Deep wells in Denmark 1935-1990. *Geological Survey of Denmark, Series A* **31**, 179 pp.

Poulsen, N.E., Gudmundsson, L., Hansen, J.M. & Husfeldt, Y. 1990: Palynological preparation techniques, a new Macerationtank-method and other modifications. *Geological Survey of Denmark, Series C* **10**, 23pp.

4. APPENDICES

4.1 LIST OF SAMPLES ANALYSED FOR PALYNOLOGY

Iris-1.

Depth (ft)	Sample type
11260´	dcs
11290´	dcs
11320´	dcs
11340´	dcs
11390´	dcs
11430´	dcs
11470´	dcs
11490´	dcs
11510´	dcs
11550´	dcs
11590´	dcs
11630´	dcs
11670´	dcs
11710´	dcs
11740´	swc
11750´	dcs
11790´	dcs
11840´	dcs
11870´	dcs
11910´	dcs
11950´	dcs
11990´	dcs
12030´	dcs
12070´	dcs
12110´	dcs
12150´	dcs
12190´	dcs
12230´	dcs
12270´	dcs
12310´	dcs
12350´	dcs
12390´	dcs
12410´	dcs

12426´	swc
12450´	dcs
12490´	dcs
12530´	dcs
12570´	dcs
12620´	dcs
12660´	dcs
12700´	dcs
12730´	dcs
12760´	dcs
12790´	dcs
12820´	dcs
12850´	swc
12850´	dcs
12888´	swc
12900´	dcs
12940´	dcs
12960´	dcs
12962´	swc
12970´	swc
12990´	dcs
13006´9´´	ccs
13010´	dcs
13013´3´´	ccs
13018´	ccs
13030´	dcs
13050´	swc
13060´	dcs
13080´	dcs
13110´	dcs
13250´	swc

Total number of samples: 64

4.2 SPECIES LIST

Palynomorphs from the Iris-1 well. Most of the dinoflagellate cyst species are fully referenced in Lentin & Williams (1993), others are referenced herein. For references concerning the spores and pollen, see Dybkjær (1991).

Dinoflagellate cysts, other marine algae and acritarchs

Acanthaulax granuligera
Acanthomorph acritarchs
Achomosphaera neptunii
Aldorfia sp. A Davey, 1982
Ambonosphaera staffenensis
Amphorula expirata
Aptea polymorpha
Apteodinium granulatum
Apteodinium sp. A Davey, 1982
Apteodinium spongiosum
Batioladinium? pelliferum
Batioladinium cf. *varigranosum* sensu Davey, 1982
Batioladinium longicomutum
Batioladinium pomum
Batioladinium radiculatum
Batioladinium sp. 1 Davey, 1982
Batioladinium varigranosum
Botryococcus spp.
Bourkidinium granulatum
Cannosphaeropsis thula
Cassiculosphaeridia magna
Cassiculosphaeridia reticulata
Cepadinium ventriosum
Chlamydophorella membranoidea
Chlamydophorella trabeculosa
Chytroeisphaeridia cerastes
Circulodinium comptum
Coronifera oceanica
Cribroperidinium sepimentum
Cribroperidinium spp.
Ctenidodinium elegantulum
Cymatiosphaeraceae spp.
Cymososphaeridium validum
Dapsilidinium multispinosum
Dichadogonyaulax? pannea
Dichadogonyaulac culmula
Dingodinium cerviculum

Dingodinium? *spinosum*
Discorsia nanna
Egmontodinium torynum
Endoscrinium campanula
Endoscrinium pharo
Epiplosphaera areolata
Florentinia mantellii
Foraminiferal test-linings
Fromea amphora
Gochteodinia villosa multifurcata
Gochteodinia villosa villosa
Gonyaulacysta chladophora sensu Duxbury, 1977
Gonyaulacysta fastigiata
Gonyaulacysta helicoidea
Gonyaulacysta sp. A Davey, 1979
Gonyaulacysta sp. B Davey, 1982
Heslertonia heslertonensis
Heslertonia pellucida
Hystrichodinium furcatum
Hystrichodinium voigtii
Hystrichosphaeridium cf. *recurvatum*
Hystrichosphaerina schindelwolfii
Isthmocystis distincta
Kleithriasphaeridium corrugatum
Kleithriasphaeridium eoinodes
Kleithriasphaeridium fasciatum
Kleithriasphaeridium porosispinum
Kleithriasphaeridium simplispinum
Kleithriasphaeridium sp. 1 Heilmann-Clausen, 1987
Lagenorhytis delicatula
Large spheres
Mendicodinium groenlandicum
Mendicodinium reticulatum
Mendicodinium spp.
Muderongia extensiva
Muderongia neocomica
Muderongia microperforata
Muderongia simplex
Muderongia spp.
Muderongia tabulata
Muderongia tetracantha
Nelchinopsis kostromiensis
Nematosphaeropsis scala
Nematosphaeropsis spp.
Occisucysta tentorium

Odontchitina operculata
Oligosphaeridium? asterigum
Oligosphaeridium complex
Oligosphaeridium diluculum
Oligosphaeridium perforatum perforatum
Oligosphaeridium pulcherrimum
Oligosphaeridium sp. 1 Heilmann-Clausen, 1987
Oligosphaeridium sp. GE McIntyre & Brideaux, 1980
Pareodinia ceratophora
Pareodinia spp.
Perisseiasphaeridium insolitum
Perisseiasphaeridium spp.
Prolixosphaeridium parvispinum
Prolixosphaeridium spp.
Protoellipsodinium spinosum
Pseudoceratium pelliferum
Pseudoceratium sp. 1 Heilmann-Clausen, 1987
Pterodinium aliferum
Pterospermella spp.
Sentusidinium spp.
Sirmiodiniopsis frisia
Sirmiodinium grossii
Spiniferites? *dentatus*
Spiniferites ramosus Group
Spiniferites primaevus
Spiniferites twistringiensis
Stiphrosphaeridium anthophorum
Stiphrosphaeridium arbustum
Stiphrosphaeridium dictyophorum
Surculosphaeridium sp. II Davey, 1982
Surculosphaeridium sp. III Davey, 1982
Systematophora cf. *areolata* sensu Davey, 1982
Systematophora? *daveyi*
Systematophora palmula
Systematophora scoriacea
Tanyosphaeridium regulare
Tasmanites spp.
Tehamadinium daveyii
Tenua hystrix
Trabeculidium spp.
Trichodinium castanea
Tubotuborella apatela
Wallodinium anglicum
Wallodinium cylindricum
Wallodinium krutzschii

Wallodinium spp.

Spores and pollen

Bisaccate pollen spp.
Callialasporites dampieri
Callialasporites spp.
Callialasporites turbatus
Callialasporites trilobatus
Cerebropollenites macroverrucosus
Chasmatosporites spp.
Chomotriletes minor
Cicatricosisporites spp.
Concavissimisporites variverrucatus
Corollina echinatus
Corollina torosus
Corollina torosus, tetrad
Deltoidospora australis
Deltoidospora toralis
Densoisporites velatus
Gleicheniidites cercinidites
Gleicheniidites conspiciendus
Gleicheniidites senonicus
Ischyosporites variegatus
Manumia delcourtii
Pilosisporites trichopapillosus
Sestrosporites pseudoalveolatus
Staplinisporites caminus
Trilobosporites apiverrucatus

5. ENCLOSURES

1. PALAEONTOLOGICAL DISTRIBUTION CHART; IRIS-1 WELL

Grey shading of rows indicates biostratigraphic important taxa.

PRoven 13.030' Mangler i Range-chartet!

Iris-1 Palynomorph distribution chart

	late Hauterivian							early-late Hauterivian															early Valanginian																	earliest Valanginian - latest Ryazanian														late Ryazanian						early-?late Ryazanian		
Depth	11260'	11290'	11320'	11340'	11390'	11430'	11470'	11490'	11510'	11550'	11590'	11630'	11670'	11710'	11740'	11750'	11790'	11840'	11870'	11910'	11950'	11990'	12030'	12070'	12110'	12150'	12190'	12230'	12270'	12310'	12350'	12390'	12410'	12426'	12450'	12490'	12530'	12570'	12620'	12660'	12700'	12730'	12760'	12790'	12820'	12850'	12880'	12900'	12940'	12960'	12962'	12970'	12990'	13006'	13010'	13013'	13018'	13050'	13060'	13080'	13110'	13250'
DINOFLAGELLATE CYSTS																																																														
Acanthaulax granuligerum																																													3															
Acanthomorph acritarchs																			1							2	2	3	2	2		1	1				1			2		1	1	2			2							1	2	1	3		2	1	2	4	
Achomosphaera? neptunii		1	3	7	8	4	2	3	6	5	4	4	3	6	1	4	8	9	7	3	8	7	11	6	3	2	3	4	2	4	6		3	5	2	2	3	3	2	2	3	2	2	2	2	5		4	2	2			3					2				
Aldorfia sp. A																1							1	3				1	1	1	2		1				1		2																								
Aldorfia spongiosa															2							1					1		2									1	1	2	2		2		1	4	1	3		2			2									
Ambonosphaera staffenensis																								2	1	2	3	1	2	2	1	1	3		2	3	2	2	1	2	3	2	3	2	6	4		3	2	1									3		1	2	
Amphorula expirata												1																																			1	2				1						2		2				1	
Aptea polymorpha				3	1	1																																																								
Apteodinium granulatum															1																																															
Apteodinium sp. A of Davey, 1982																				2	2	4	1			2										1				1		2	2																			
Batioladinium ? pelliferum										1																																																			
Batioladinium cf. varigranosum sensu Davey, 1982																											1													1															1					
Batioladinium longicornutum		1					1		1			2		1			1	1																																										
Batioladinium pomum																																									1					1		1					2	4	2		2	3	2		1
Batioladinium radiculatum																																											1			1							1			1		1			
Batioladinium sp. 1 of Davey, 1982																	1	3	2	1		1		2	1	2	1	1	2			3	1							2	2	3		1	1																		
Batioladinium varigranosum										1	1						2	1	2	1		1				2					2						1					1																			
Botryococcus spp.																1		1																																												
Bourkidinium granulatum		1	2	1	1	3	2	2	3	1	5	2	3	2					1	1	2			1			2	1	2	1	2	1			1		1	1	2			1		1	3	3		2	1	2			1	1	2	2	1	3	2	1		3
Cannosphaeropsis thula																										1																2		1		1		3					2						3		3	
Cassiculosphaeridia magna			1	2	2		1	1	1	1	3	1	2	3	1	6	8	4	4	4	4	5	8	3	4	2	2	4	3	4	3	2	3	2	4	4	2	4	2	1	2	3	3	3	3	8	2	4	3	2	2		2	1			2	3	4	3	1	
Cassiculosphaeridia reticulata	3		3	4	2	2	1	4	1	1	2	3	2	2		1	4	4	1	5	4	6	7	3	4	4	2	4	6	5	3	9	3		6	5	3	7	2	5	2	3	3	4	3	2		4	4				1					1	1			
Cepadinium ventriosum		2	2	8	9	1	2		1	3	1	4	2	1		1	1	2	2																																								1			
Chlamydophorella membranoidea	1	1	7	3	10	20	8	2	9	7	13	11	8	8		1	11	20	12	15	10	11	8	5	9	10	10	10	15	8	10	5	12		5	10	5	13	10	5	4	8	7	6	11	11		8	12	8			10	7	6	7	2	17	6	7	11	
Chlamydophorella trabeculosa		2	6	3	3	4		1	1	3	1	2	2	2		3	2	1	1	1					1	4		1																																			
Chytroeisphaeridia cerastes									1	1												1	2	1					1							1	1																										
Circulodinium comptum	2								2	3	1	3	3	1		1	5	3	1	1	3	3	3	3	7	4	3	4	3	3	4	7	7	3	6	3	4	2	3	2	3	6	4	3	3	14	12	2	2		10	3	3	10	14	15	14	11	15	14	9	
Coronifera oceanica	2	1	2	1	3	1	1					2																																																		
Cribroperidinium sepimentum								1	1	1		1		1			2																																												
Cribroperidinium spp.																																																				2								3			
Ctenidodinium elegantulum															3				2	1	2	2	1	3	1	3	3	3	5	2	4	2	2		2	2	4	2	2	7	3	2	5	5	4	2		4	2	4			3		1			2				
Cymatiosphaeraceae spp.																																														1													1	3	2	
Cymososphaeridium validum				1	1	1	4	7	1	3	6	3	3	2	1	1		1																																												
Dapcilidinium multispinosum												2	2	2		2	2	3	1														1		1	2		1	2						2											3			
Dichadogonyaulax ?pannea																																												1																	
Dichadogonyaulax culmula																																										1			1	1	2	2	4		2				7	1	4	6	1	1	4	4	
Dingodinium cerviculum	3	1	4	2	2	4	2		2	3	2	2	4	1	2	2	2	3	2	3	1	4		2	10	10	5	3	4	3	2	2	2		3	5	5	4	3	2	2	3	2	2	4	5		4	2	1			3	3		1	3	6	4	4	3	
Dingodinium spinosum																						1							1									1		1		1		1		1	2	1		2				11	2	11	6	2	7	10	10	
Discorsia nanna						1																																																								
Dracodinium spp.																				1																																										
Egmontodinium torynum																							1	2					1	1		1	1	1	1	1		2			1	1	1	1		2	1		1	1							2		1			
Endoscrinium campanula				2			1		1	1	2	2	2	2	2	4	3	2	3	2	7	3	2	2	2	3	2	2	2	3	2	4	4	2	5	11	7	7	6	2	3	7	5	4	5	9		10	7	7			7	1				3				
Endoscrinium pharo									1						1						1	1		2	1	3	2	1	3	1	1	1	2		2	2	2	3	2	2	2	2	2	1	3	3	1	2	2	2		1	3	7	3	2		2	3	1	1	
Epiplosphaera areolata																																																								1							
Florentinia mantellii	6	1	3	2	3	2	1	2		2		1	6	2		2	1	1	1		1	1	2																	1																					
Foraminiferal test-linings														1					1	2	2	1	1	2		1	2		1	2	2		1			2	2	2	2	2	2	1	2	1	1	7	1	3	2	1	2		3	7	7	8	2	2	6	2	4	
Fromea amphora	1		2	1	2	2	1	1	1	2			1	1		2	1	3	2	1	3	2	4	2				1	1	4	1	1	2		1		2	2	1	1	1	2	1	1	1	2		1		1				1	1	2	4					
Gochteodinia villosa subsp. multifurcata							1	1	1	2											2	1	2		1	1	1	1	2	2	2	1		1	1	2	2	1	1	1	2			2	2		1	2	1			2	1								
Gochteodinia villosa villosa												1	1		3								2											2	2	1			1		2	2	1	2	5	3	1	2				1	2	4	4	3	2	2	3	5	
Gonyaulacysta chladophora sensu Duxbury, 1977		1	2	1	3	1	2		2	3	1	2	2	1	1	1		1		2	1																																									
Gonyaulacysta fastigiata																	1																																			2		1			1			1	
Gonyaulacysta helicoidea	1	2	2	1	2	4	2	2	3	2	2	2	5	3	3	5	3	6	2	11	3	5	19	4	5	14	3	9	5	4	5	3	5	1	8	5	11	11	8	8	8	6	10	5	4	12	3	11	2	3	1		6	2	2	2	1	6	3	2	3	
Gonyaulacysta sp. A of Davey, 1979															1																										2		2	2	2	4		1		1			1	2		1	3	4	6	8	2	
Gonyaulacysta sp. B of Davey, 1982																																				1		2		1																					
Heslertonia heslertonensis				2			3	1		2	3	4	1	3	1	2	2	2	2	2	1	3	3		5	1	4	2		2	2	3	1		2	2	3	3	2	2	2		2	2	1	1		1														
Heslertonia pellucida						3	2	1	1	1	2	1		3	4				1	1	2		3	3	5	5	4	1	2	1	1		5		3	3	4	2	3	2	5	2	3	2	4	5	1	4	5	3			5					7	1	1	2	
Hystrichodinium furcatum						1						1		1		1																																														
Hystrichodinium pulchrum	3		1	5	3	1				2	4	6	4	8	3	7	4		2	6	2	7	3	5	4	4	1	4	5	2	5	4	5	3	4	5	2	4	3	5	3	5	3	3	9	7	3	2	2	3	1		1	11		11	11	5	5	1	2	
Hystrichodinium voigtii	6	5	15	13	23	24	8	19	17	16	21	41	22	28	2	20	18	13	11	22	14	18	11	14	18	17	18	21	18	15	14	15	12		9	17	16	10	8	21	17	13	17	16	13	14		21	17	20			7	8	14	7	4	17	12	8	13	6
Hystrichosphaeridium cf. recurvatum												2	1	1	1		1																																													
Hystrichosphaerina schindewolfii												1						1				1				1			1																																	
Isthmocystis distincta				1											1	1	1	2	1	1		3	2	5	2	3	2		1	2	2	2	2		2	3	3	2	3	3	3	2	2	3	2	3		2	1	2			2			1	1	1		1		
Kleithriasphaeridium corrugatum	1		2	3	1		1		1	1		1	1	1	2	1	1	6	2	4	4	5	7	2	3	4	1	2	2	6	1	5	3	6	6	5	3	4	4	7	3	5	3	4	4	12	3	7	4	6			4					2	1			
Kleithriasphaeridium eoinodes	8	4	4	6	6	4	9	4	5	9	7	10	8	11	1	21	11	5	4	9	4	6	3	3	2	2	3	3	1	2	4	3	3	4	2					1						1								1			1				4
Kleithriasphaeridium fasciatum						1	1		1	1	1	1	1	3	1	5		3	3	4	2	2	3	2	4	3	2	2		3	2	4	3		2	9		4	3	2	2	1	4	5	3	4		3	1	1			3				8	4	1			
Kleithriasphaeridium porosispinum				1											1					1		1			2					2			1		1	2		1	2			2		1		1		2		1			2	10	4	11		2	2	5	5	
Kleithriasphaeridium simplispinum																1				2																																										
Kleithriasphaeridium sp. 1 of H.-C., 1987			1	1	1	1	3	1	1			1																																																		
Lagenorhytis delicatula															1		1	2	3	1	2	5	3	5	1	3	4	2	3	3	5	4	2	1	1	4	5	4	2	2	3	4	2	3	2	3		4	3	3			4					2				
Large spheres																																			1		1								1	13	5	2	1	2	3		4	4	6	4	4		5	9	5	23
Mendicodinium groenlandicum																							1	1		1			1		1		1		1			1		2	1		2	2		1			1	2				2	5	4	2		2	2	3	
Mendicodinium reticulata																	3																																													
Mendicodinium spp.																		1	2																																											
Muderongia microperforata																								2					1	2	3	4	4	2	2	2	2	2		1			1																				
Muderongia extensiva																	2	3	2	2	2	1	1	1								2		3		1																									
Muderongia neocomica		1	2	2	2	3	1		2	1		2			4	1																																													
Muderongia simplex			2	1	1					1					1	1		3	4	13	10	10	12	9	8	8	7	3	5	10	4	2	2		3	3	4	7	2	4	1	3	4	3	3	5	1	3	4	2			5					3				

Iris-1 Palynomorph distribution chart

	late Hauterivian							early-late Hauterivian							early Valanginian																											earliest Valanginian - latest Ryazanian												late Ryazanian					early-?late Ryazanian			
Depth	11260'	11290'	11320'	11340'	11390'	11430'	11470'	11490'	11510'	11550'	11590'	11630'	11670'	11710'	11740'	11750'	11790'	11840'	11870'	11910'	11950'	11990'	12030'	12070'	12110'	12150'	12190'	12230'	12270'	12310'	12350'	12390'	12410'	12426'	12450'	12490'	12530'	12570'	12620'	12660'	12700'	12730'	12760'	12790'	12820'	12850'	12888'	12900'	12940'	12960'	12962'	12970'	12990'	13006'	13010'	13013'	13018'	13050'	13060'	13080'	13110'	13250'
DINOFLAGELLATE CYSTS																																																														
Muderongia spp.																																																														
Muderongia tabulata			2	1	1	1	1	1		3	5	4	11	11	3	4	15	4	10	14	8	16	16	11	18	16	7	15	8	20	13	13	15	4	10	13	5	7	9	10	10	10	6	9	14	14		9	4	5			5					5	1	1		
Muderongia tetracantha	2	1							1																																																					
Nelchinopsis kostromiensis			3	1	2			1	1	1	1																																												1							
Nematosphaeropsis scala					2	1		1		3	2	2		2		2	3												1																																	
Nematosphaeropsis spp.																																			1																											
Occisucysta tentoria	1	1	4	2	2	1	1	1	2	1	2	2	2	1	2	3	1		2	2	1	2	2	2	2	2	2	3	3	2	2		5		1	3	4	6	2	2	2	2	2	3		3		4	3	1			2					1				
Odontochitina operculata	9	1	8	5	7	7	1	2	6	9		4	7	2	2	1	2	3	1	1	2	1	1	1	1		1	2		2	1	1		3			1	1	2						1	2		2	3				2									
Oligosphaeridium asterium	6	1	9	8	8	11	15	13	5	5	1	3	2	1	1	1	3	1	2	6	4	4	4	6	4	2	3	2	4	4	3	5	5	1	2	3	4	5	2	3	4	6	3	3	3	7	2	4	4	5			5					6				
Oligosphaeridium complex	5	1	2	3	7	7	5	26	14	13	17	14	21	5		7	12	8	3	3	3	4	2	4	1	3	2	2	6	4	2	1				2		1	2																							
Oligosphaeridium dirculum																																	1				2	1	1	2			2			3	2	1		2			1	2		3	4	1				
Oligosphaeridium perforatum perforatum				1	1	1	3	3		2	1	1	1	2																																																
Oligosphaeridium pulcherrimum																								1				1																																		
Oligosphaeridium sp. 1 of Heilmann-Clausen, 1987				6	9	3	1	1	1	4	2	3	1				1				1	1				1																																				
Oligosphaeridium sp. GE of McI. & B., 1980									1			1					1		1	1				2		1		1	1																																	
Pareodinia ceratophora																																										2		2					1				1			2	2					
Pareodinia spp														1						1				1																	2																					
Perrisiasphaeridium insolitum																																										2				1																
Perrisiasphaeridium spp.																							1												1																											
Prolixosphaeridium parvispinum												1			1				1										1							2		3	1	2	1		2			1		1	2	1			1					2				
Prolixosphaeridium spp.																							1																																							
Protoellipsodinium spinosum											1																																																			
Pseudoceratium pelliferum	1	2	2	1	3	3			1	2		3			2		4	6	2	2	1	4	4	2	2	2	1	1	2	4	2	2	2		2	2	1	3	1	2		3	2		1	2		2	2	2			2									
Pseudoceratium sp.1 of Heilmann-Clausen, 1987										1		1	1	3		3	3	2	7	5	3	4	6	3	2	5	1	[illegible]	8	10	5	14	8		9	9	13	5	7	9	7	9	9	13	14	9		9	8	6			6					4				
Pterospermella spp.			2	1					1			2												1							1				1						1					8		1	1			1			7	4	1		16	16	15	20
Sentusidinium spp.																																																							1							1
Sirmiodiniopsis frisia															3																																															
Sirmiodinium grossii	5	1	5	3	1	1	2	2	1	2	4	3	5	5	4	3	10	9	20	18	21	22	21	13	8	4	12	7	9	13	16	8	13	1	16	8	9	8	10	8	9	11	8	11	10	11	2	10	6	12			12	13	8	6	9	9	6	5	14	
Spiniferites dentatus	3	3	6	9	6	3	2						1			2	4																																													
Spiniferites ramosus Group	4	2	16	15	13	15	3	6	13	4	6	12	7	8		7	6	5	5	11	8	7	8	2	4	3	2	4	2	2	5	2	3		1	2			1	1	2				1																	
Spiniferites ramosus primaevus																	2	2			1	1	3	3	1	1	1		2	2			1			1	1	2	1	1		2		1	1	2		1	2													
Stiphrosphaeridium anthophorum																1				1																																										
Stiphrosphaeridium arbustum																			1								1													1		1				2							2	4	4	4	3		2	3	2	
Stiphrosphaeridium dictyophorum																																1								1	2		2	1	1	2		2		1				1	4			1	2	3	8	
Surculosphaeridium sp. II of Davey, 1982																															1																															
Surculosphaeridium sp. III of Davey, 1982															1		1	3	2	4	4	2	6	4	3	4	2	3	2	1	3	3	2	2		3			3	2	2	2	3	1	1	3		2	1													
Systematophora cf. areolata										1					2																															3		1														
Systematophora daveyi																	1																		1						1			2		2		2					1					1	2	2		
Systematophora palmula															3									2							1		1			3	1	2	1	2	1		3	3		9		1		2			1	3	9	2	3	1	3	3	3	
Systematophora scoriacea						1							1		2	1		3	2		1	2	1	4	1	2	1	1	1	1	2	1	2	1		2	1	4	1				2	2	1	1		1	2	1												
Tanyosphaeridium regulare							1	2																																																						
Tasmanites spp.	1					1																					1										1	1					1			3	1			1	1				1	1			5	2		1
Tehamadinium daveyi															1															1	2					1		2		2	1	1	1	1	2	2		1					1	2		2						
Tenua hystrix		6	11	9	12	6	3	5	12	4	3	5	3	1	1	5	9	2	1	2	3	2	4		2	2			3	2	2	1	2		1	3	1	2	1	1	2	4	1	2	2	1		1	2	3			2									
Trabeculodinium spp.																		1																																												
Trichodinium castanea			2	2	1	4		1	1		2	2	1	2		7	6	10	7	18	22	17	18	4	4	9	4	7	9	9	9	9	10	3	8	6	7	7	5	5	6	8	9	7	13	11		11	6	8			6	2	6	3		8	7	2		1
Tubotuberella apatela				1						1					4	1			1	2	1	1	2	2	2	3	4	1	2	4	2	2	4		3	4	5	3	1	2	2	3	4	2	6	5		3	2	2			4	2	3	2	8	2	3	2	3	
Wallodinium anglicum																														1	1									1			1		2			1														
Wallodinium cylindricum																										1										1		1																				1				
Wallodinium krutzschii			1													1			2			1				1				1			1	1		1	1																	3		2	2	2	1	1	4	
Wallodinium spp.															1																																															
SPORES AND POLLEN																																																														
Bisaccate pollen spp.	18	8	23	22	9	11	22	2	30	12	2	13	26	21	4	12	7	8	3	11	6	8	12	5	7	4	7	7	3	4	4	3	4		5	3	5	5	4	7	5	4	6	5	3	5	6	2	5	7	1		7	9	6	10	5	9	15	10	11	
Callialasporites dampieri								1										1	3	1	2	3	1	1			1		1	2	1	1			2			2	2	2	2		4	2	2	2	3	2	1		2		2	2			1	1	1	1		
Callialasporites spp.																																1															1															
Callialasporites trilobatus			1	1									1			1	1					1				1																	1		1																	
Callialasporites turbatus																							1																								1								1							
Cerebropollenites macroverrucosus			1		1		2			2				1				1		2	3	1			1		1	1	1		2					1	2		2	1	2	1	2			3	1	2		1				7	3	2	1	2	5	3	4	
Chasmatosporites spp.																					1																			1																						
Chomotriletes minor																										1																							1													
Cicatricosisporites spp.						1		1			1		1	1			1	1	2	1	2	1		1	3	1	2			2	1		2		1	2	1	1			1	1	1	1	1	4	2	3	1				1		1		1		1			
Concavissimisporites variverrucatus																																											1	1		1		2					1									
Corollina echinatus																																																						3	3	5	2		1	4	4	1
Corollina torosus																										1											1		1		1								1					1	4	2				4	3	1
Corollina torosus, tetrad						1																1	1								1		1						1							1	2			1				1		1	1	1				
Deltoidospora australis								1		1				1					1		1			1		1											1				1				1	4	1	1							1			1	1			
Deltoidospora toralis	7	2	2	5	2	2	2	3	5		3	2	2	2		1	3	2	2	1	2	2	2	1		3	2	3		2	2		2		2	2	2	1	3	1		2	1	1	5	3	6	2		2	3		2	2		1	3	1	1	1	3	
Densoisporites velatus																			1			1	2	2					1						1		1	1			2	1	1		1	2	1	2	2				1				1	1				
Gleicheniidites cercinidites																																								1																					1	
Gleicheniidites conspiciendus																																																													1	
Gleicheniidites senonicus	1		1			1				1												1				1	1								1												1			1			1	2					1		1	
Ischyosporites variegatus																																						1						1		3	1	1		1			1									
Manumia delcourtii																																															1															
Pilosisporites trichopapillosus																				1	2																																									
Sestrosporites pseudoalveolatus																		1						1		2							1		1	1								1		1	2										1					
Staplinisporites caminus																											1		1		1								1					1			3			2				2		1		2	2			
Trilobosporites apiverrucatus																			1	1	1	2	3	1	1		2	1	1		1	3	2		1		2	1				1	1			2	2															

Enclosure 1b