

17. DINOFLAGELLATE CYSTS

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INTRODUCTION

Dinoflagellate cyst analysis was carried out on three cores (Brastad, Moltemyr and Solberga) taken in south-western Sweden to assist in an attempt to establish a stratotype section for the Pleistocene/Holocene boundary. Unfortunately the recovery of dinoflagellate cysts was in general so poor as to make the interpretation of the results rather difficult.

A total of one hundred and seventy-two samples were submitted and subjected to normal palynological processing techniques. These techniques included the digestion of the sediments in hydrochloric and hydrofluoric acids and the concentration of the cysts by sieving but no oxidation. After mounting and examination, in which one slide/sample was counted to give the proportions of the contained cysts, all the slides were deposited in the MPA palynological collections of the Institute of Geological Sciences, Leeds, United Kingdom. A full list of all the dinoflagellate cyst species recovered is appended (p. 216), giving both their palaeontological (cyst) and equivalent thecate names where known.

BRASTAD

DATA

Forty-three samples from the Brastad core were submitted and analysed. The results of this analysis are set out in Table 17:1. The relative proportions of the three major species and/or cyst groups *i.e.* *Operculodinium centrocarpum*, *Bitectatodinium tepikiense* summed with *Spiniferites* spp., and *Protoperidinium* spp. together with the number of individuals counted per sample are shown in Figure 20:1b (Chapter 20). The results are poor with only the samples at 6.5, 11.5 and 13.5 m core depth giving counts of over one hundred specimens. The following subdivision of the core into four units must, therefore, be regarded with some caution.

Unit D, 11.00–15.15 m depth – Characterised by high percentages of *O. centrocarpum* with some *B. tepikiense* and minor amounts of both *Spiniferites* and *Protopteridinium* cysts. There is some suggestion of a change at the base of this unit with a downhole increase of *Protopteridinium* cysts, but the evidence is too slight for further comment. Recovery good.

Unit C, 6.50–10.55 m depth – Dominated by *O. centrocarpum* but with greater percentages of *B. tepikiense* than in Unit D. *B. tepikiense* tends to increase in proportion in the upper part of the unit whilst the total *Spiniferites* spp. tends to increase downhole. The proportion of *Protopteridinium* cysts increases dramatically in the lower part of the unit. This unit contains *S. elongatus*, *S. ramosus* and the two *Multispinula* species, *M. minuta* and *M. quanta*. Recovery good.

Unit B, 2.00–6.05 m depth – Dominated by *Protopteridinium* cysts with significant proportions of *O. centrocarpum* but with poor *B. tepikiense* and *Spiniferites* spp. *B. tepikiense* occurs only in the lower part of this unit. Recovery poor.

Unit A, 1.00–1.55 m depth – This unit is essentially characterised by an assemblage virtually monospecific for *O. centrocarpum*. Recovery good.

INTERPRETATION

The poor productivity of the samples makes the diagram difficult to interpret. The species present do, however, characterise north-temperate environments although perhaps the productivity indicates a rather poor climatic regime. The environmental requirements of most of the species mentioned are not known in any detail and so this interpretation must remain largely tentative.

Unit D – *O. centrocarpum* is a cosmopolitan cyst species, Wall *et al.* (1977), which judging by the lack of many accompanying species may be indicative of poor climate and/or less than fully marine conditions. Reid and Harland (1977) described one cyst assemblage that is comparable with the present assemblage and that is their Norwegian Shelf Assemblage, but it differs in having common *Protopteridinium* cysts.

Unit C – This assemblage is more diverse than that below and can be compared to the Intermediate Neritic Assemblage of Reid and Harland (1977). The distribution of *B. tepikiense*, *Spiniferites* spp. and *Protopteridinium* spp. possibly indicates a slightly more ameliorative environment of deposition early in Unit C, than in the later sediments of the unit.

Unit B – A comparable *Protoperidinium* dominated assemblage is found today in the southern North Sea (see Reid and Harland 1977) and this may indicate the presence of a similar type of water mass at Brastad at this time. The nature of the *Protoperidinium* curve on Figure 20:1b, (Chapter 20) does seem to suggest an increasingly ameliorative climate. Wall *et al.* (1977) regard grouped *Protoperidinium* cysts as cosmopolitan estuarine-neritic species.

Unit A – This unit may be interpreted the same as for unit D. *O. centrocarpum*, because of its tolerance, may be expected as a “pioneer” species in certain difficult environmental circumstances.

MOLTEMYR

DATA

Forty samples were submitted for analysis from the Moltemyr core. The results of this analysis are set out in Table 17:2. The data are displayed in Figure 20:2b (Chapter 20) and shows the changing proportions of the major cyst groups and the number of individuals counted per sample. Assemblages of over one hundred specimens come from levels at about 5.6 and 5.7 m core depth, but otherwise recovery was poor. The core has been tentatively subdivided into a number of units and these are discussed below.

Unit D, 6.10–6.50 m depth – Dominated by *Protoperidinium* cysts with subsidiary *O. centrocarpum*. Recovery poor.

Unit C, 5.10–6.10 m depth – Characterised by high *O. centrocarpum* with subsidiary *Protoperidinium* and *Spiniferites* cysts (for example *S. elongatus* and *S. ramosus*) together with some *B. tepikiense*. Recovery good.

Unit B, 2.90–5.03 m depth – Characterised by *Protoperidinium* cysts with subsidiary *O. centrocarpum* but very few *Spiniferites* cysts or *B. tepikiense*. The only specimens of *Stelladinium stellatum* were recovered from this unit, and also *M. quanta* was present throughout.

Unit A, 2.50–2.82 m depth – Dominated by *O. centrocarpum* with occasional *B. tepikiense* and *Spiniferites* cysts at the base.

INTERPRETATION

The interpretation for the Moltemyr core is much the same as for Brastad. All the cysts recovered are north temperate species and the generally poor recovery suggests difficult environmental conditions.

Unit D is dominated by *Protopteridinium* cysts. The poor recovery and low diversity suggest poor conditions possibly in a nearshore environment. Unit C, however, indicates some amelioration in the increased productivity and diversity and the dominance of the cosmopolitan species *O. centrocarpum*. This species can also indicate an increased influence of North Atlantic water. The overlying subdivision, Unit B, may indicate some increased amelioration in a nearshore situation with a possible lowering of salinity. The final unit, A, is, like that of Brastad, an almost monospecific assemblage of *O. centrocarpum* probably indicative of a special environment, capable of supporting "pioneer" species only.

SOLBERGA

DATA

Ninety-four samples were submitted and analysed for dinoflagellate cysts. The results of this analysis are set out in Table 17:3. These data have been displayed in Figure 20:3b (Chapter 20) to show the changing proportions of the three major species and/or cyst groups together with the number of individuals counted per sample. This core yielded even fewer specimens than the Brastad or Moltemyr cores and it is doubtful if much of the sediment was deposited in favourable conditions. Good assemblages of over one hundred specimens came only from the levels at 19.45, 19.55 and 20.00 m core depth. An attempt has been made, however, to subdivide the core into five dinoflagellate units and these are described below.

Unit E, 21.50–27.30 m depth – Characterised by high percentages of *Protopteridinium* cysts and a lesser amount of *O. centrocarpum*. *Spiniferites* cysts occur in the lower and upper parts of the unit with *B. tepikiense* occurring in the lower sediments. Poor recovery.

Unit D, 18.50–21.05 m depth – Dominated by *O. centrocarpum* with subsidiary *Protopteridinium* cysts and minor *Spiniferites* cysts, including reasonable numbers of *S. ramosus*. The presence of *Stelladinium stellatum* is particularly noteworthy. Good recovery.

Unit C, 16.20–18.45 m depth – Characterised by *Protopteridinium* cysts with subsidiary *O. centrocarpum* and *B. tepikiense*. The presence of *M. quanta* is noteworthy. Good recovery.

Unit B, 11.50–16.05 m depth – Dominated by *Protopteridinium* cysts with minor amounts of *O. centrocarpum*, *M. minuta* and *M. quanta*. Poor recovery.

Unit A, 2.50–11.05 m depth – Characterised by *O. centrocarpum* and *Protopteridinium* cysts. Poor recovery.

INTERPRETATION

The general paucity of cysts throughout the sequence makes any interpretation difficult, and only units D and C are commented upon.

Unit D – This corresponds with the first influx of good assemblages of dinoflagellate cysts indicating either a transition to favourable environments or a change in sedimentary conditions. The assemblage is dominated by *O. centrocarpum* with *Protoperidinium* cysts and is quite comparable to that from the Norwegian shelf (Dale 1976) and referred to as the Norwegian Shelf Assemblage by Reid and Harland (1977). This is indicative of a good north-temperate climate and a neritic environment of deposition.

Unit C – Again a rich assemblage but different from above in the dominance of *Protoperidinium* cysts which may mean a further amelioration of climate or some other environmental change possibly with the establishment of a water mass somewhat similar to that in southern North Sea today (Reid and Harland 1977). The rapidly fluctuating proportions of *B. tepikiense* may indicate periods of colder climate or possibly changes in the water-mass configuration. It is a unit closely linked with Unit D as a part of the marine transgression.

CONCLUSIONS

The results of the dinoflagellate cyst analysis on the Brastad, Moltemyr and Solberga cores are disappointing. The cores have, however, been subdivided using the dinocyst evidence and some tentative interpretations made.

In the Brastad and Moltemyr cores the results may suggest a climatic amelioration up to the so-called Pleistocene/Holocene boundary with a number of fairly clearly defined assemblages characterising slightly different water-mass situations. The presence of the cyst species *Stelladinium stellatum* in Moltemyr and Brastad may be of some particular environmental significance and has also been found by B. Dale (pers. comm.) in a similar stratigraphical situation offshore. Further comment on the Solberga core is precluded by the poor recovery except that, during the time of deposition of units E, B and A, conditions were either climatically unfavourable and/or less than fully marine, or sedimentary conditions were unfavourable. None of the species appears to be age diagnostic and so further comment on age is not reasonable. These results should be taken into account together with others described in any discussions on the Pleistocene/Holocene boundary.

APPENDIX

List of Dinoflagellate Taxa recovered from Pleistocene/Holocene Cores
in South West Sweden

CYST NAME	THECATE NAME
Order <i>PERIDINIALES</i> Haeckel 1894	
Family <i>GONYAULACACEAE</i> Lindemann 1928	
<i>Bitectatodinium tepikiense</i> Wilson	<i>Gonyaulax spinifera</i> (Claparède & Lachmann) Diesing
<i>Lingulodinium machaerophorum</i> (Deflandre & Cookson) Wall	<i>Gonyaulax polyedra</i> Stein
<i>Operculodinium centrocarpum</i> (Deflandre & Cookson) Wall	<i>Gonyaulax grindleyi</i> (Reinecke) Von Stosch
<i>Planinosphaeridium choanum</i> (Reid) Wall <i>et al.</i>	<i>Gonyaulax</i> sp. indet.
<i>Spiniferites belerius</i> Reid	<i>Gonyaulax scrippsae</i> Kofoid
<i>Spiniferites elongatus</i> Reid	<i>Gonyaulax spinifera</i> (Claparède & Lachmann) Diesing
<i>Spiniferites lazus</i> Reid	<i>Gonyaulax</i> sp. indet.
<i>Spiniferites membranaceus</i> (Rossignol) Sarjeant	<i>Gonyaulax spinifera</i> (Claparède & Lachmann) Diesing
<i>Spiniferites ramosus</i> (Ehrenberg) Loeblich & Loeblich	<i>Gonyaulax</i> sp. indet.
<i>Spiniferites</i> spp. indet.	<i>Gonyaulax</i> spp. indet.
Family <i>PERIDINIACEAE</i> Ehrenberg 1832	
<i>Brigantedinium simplex</i> (Wall) Reid	<i>Protooperidinium conicoides</i> (Paulsen) Balech
<i>Brigantedinium cariacoensis</i> (Wall) Reid	<i>Protooperidinium avellana</i> (Meunier) Balech
Cyst B of Harland 1977	<i>Protooperidinium</i> sp. indet.
Cyst	<i>Protooperidinium punctulatum</i> (Paulsen) Balech
Cyst indet.	<i>Protooperidinium</i> sp. indet.
<i>Lejeunia paratenella</i> Benedek	<i>Protooperidinium</i> sp. indet.
<i>Multispinula minuta</i> Harland & Reid	<i>Protooperidinium</i> sp. indet.
<i>Multispinula quanta</i> Bradford	<i>Protooperidinium conicum</i> (Gran) Balech
<i>Selenopemphix nephroides</i> Benedek	<i>Protooperidinium subinermis</i> (Paulsen) Loeblich III
<i>Stelladinium stellatum</i> (Wall) Reid	<i>Protooperidinium compressum</i> (Abé) Balech
<i>Trinovantedinium sabrinum</i> Reid	<i>Protooperidinium leonis</i> (Pavillard) Balech
<i>Quinquecuspis concretum</i> (Reid) Harland	<i>Protooperidinium leonis</i> (Pavillard) Balech
Order <i>GYMNODINALES</i> Lemmermann 1910	
Family <i>POLYKRIKACEAE</i> Kofoid & Swezy 1921	
Cyst	<i>Polykrikos schwartzii</i> Bütschli

TABLE 17:1. Dinoflagellate cyst counts for the Brastad core.

MPA No	Depth	Species	01	02	03	04	05	06	07	08	09	10	11	12	13
8333	100-105	cms	5												
8334	150-155		87	1			1	1							
8335	200-205														
8336	210-215													4	
8337	215-220														
8338	220-225		2										1	5	
8339	225-231														
8340	231-235		9			1	1		1	1			1	3	
8341	235-240		5						1	1			1	6	
8342	240-245		13			1				1				9	
8343	250-255		5							1			3	6	
8344	260-265					1						1		6	
8345	270-275		1											10	
8346	275-280		6											18	
8347	290-295													3	
8348	300-305		1											2	1
8349	350-355		4									2		16	
8350	400-405		9	1					1		1	2	2	13	
8351	450-455		6	2						1		3	3	21	
8352	500-505		9	6						3				10	
8353	550-555		6											2	12
8354	600-605		20	16		1				5			5	7	
8355	650-655		125	38				1	5	14		4	9	46	
8356	700-705		31	3					4	3			2	8	
8357	750-755		18	11		3				4			7	8	
8358	800-805		15	7		2				3			1	6	
8359	850-855		11	9		1	1		11			2	2	9	
8360	900-905		7	2						2		1		7	
8361	950-955		32	2					4	7				8	
8362	1000-1005		10	2						10		1	4	37	
8363	1050-1055		1									1		11	
8364	1100-1105		72	2										2	
8365	1150-1155		180	6											
8366	1200-1205													3	
8367	1250-1255		12	3										1	
8368	1300-1305		53							1					
8369	1310-1315		9												
8370	1332-1335		14	1											
8371	1350-1355		111	6	1							2			
8372	1400-1405		3												
8373	1450-1455		74	4						1				3	
8374	1503-1509													16	
8375	1509-1515														

The code numbers refer to the following species: 01. *Operculodinium centrocarpum*. 02. *Bitectatodinium tepikiense*. 03. *Spiniferites belerius*. 04. *Spiniferites elongatus*. 05. *Spiniferites lazus*. 06. *Spiniferites membranaceus*. 07. *Spiniferites ramosus*. 08. *Spiniferites* spp. indet. 09. *Brigantedinium simplex*. 10. *Multispinula minuta*. 11. *Multispinula quanta*. 12. *Protoperidinium* spp. indet. 13. Cyst B of Harland 1977.

TABLE 17:2, continued.

MPA No	Depth	Special	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
13051	470-480		28	1			7		2												
13052	480-490		27			3	9		2									1	1		
13053	490-500		22	2			49		4											1	
13054	500-503		11		1		14		4												
13055	510-520		17	1	2	2	7		1											1	
13056	520-530		13	1	7	3	2		1											2	
13057	530-540		52	4	6	9	14		5				1	1						1	
13058	540-550		30	3	15	2	14		7				1								
13059	550-560		14	2	8		9		4					1							
13060	560-570		140	13	23	4	9		11					5						8	
13061	570-580		136	17	12	36	11		1			1	1	4						5	
13062	580-590		47	12	5	22	5					1	1	1						1	
13063	590-600		51	1	17		10		1					3						1	
13064	600-610		29	2	5		27		3					4							
13065	610-620		10		2		18							2							
13066	620-630		3				31							7							
13067	630-640		4				24														
13068	640-650		13		4		21		1												1

The code numbers refer to the following species: 01. *Operculodinium centrocarpum*. 02. *Bitectatodinium tepikiense*. 03. *Spiniferites* spp. indet. 04. *Spiniferites ramosus*. 05. *Protoperidinium* spp. indet. 06. *Spiniferites lazus*. 07. *Stelladinium stellatum*. 08. *Multispinula quanta*. 09. *Brigantedinium cariacensis*. 10. *Polykrikos schwartzii* cyst. 11. *Brigantedinium simplex*. 12. *Multispinula minuta*. 13. *Lejeunia paratenella*. 14. *Spiniferites belerius*. 15. *Protoperidinium punctulatum* cyst. 16. *Selenopemphix nephroides*. 17. *Planinosphaeridium choanum*. 18. *Spiniferites elongatus*. 19. *Quinquacuspis concretionum*.

TABLE 17.3. Dinoflagellate cyst counts for the Solberga core.

MPA No	Depth	Species	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	18	19
8376	250-255		10		1										6				17	
8377	300-305		13	1			1								2	1	2		31	
8378	350-355		9	2	1										6				11	
8379	400-405		3												1				2	
8380	450-455		2	2															3	
8381	470-475		3																5	
8382	480-485		5																1	
8383	490-495		3	3															2	
8384	500-505		7	1															2	
8385	510-515		11	2											1				6	
8386	520-525		4							1									8	
8387	530-535														1				4	
8388	550-555		2																2	
8389	590-595		6	9						1									2	
8390	595-600		3	3									1						3	
8391	600-605		1			1													8	
8392	650-655		1																6	
8393	700-705		6	2															4	
8394	750-755		2																1	
8395	780-785		4																3	
8396	785-790		4	3											2				9	
8397	800-805		7					1											4	
8398	850-855		4																7	1
8399	900-905		2	2													1		13	
8400	945-950		2	2										1					1	
8401	950-955		1																13	
8402	1000-1005		2																8	2
8403	1050-1055		7																1	
8404	1100-1105		2																1	
8405	1050-1155																			
8406	1200-1205																		3	
8407	1250-1255		2	1										2	1		1		1	6

TABLE 17:3, continued.

MPA No	Depth	Special	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
8408	1300-1305																		3		
8409	1350-1355		1							1									6		
8410	1380-1385																		1		
8411	1400-1405													2	1				1		
8412	1450-1455		2	1						1				1					4		
8413	1500-1505									2									5		
8414	1550-1555													1					5		
8415	1600-1605		2											1					7		
8416	1620-1625		2	1											1				1		
8417	1635-1640		1	2										1					2		
8418	1650-1655		2																6		
8419	1665-1670		1												1				7		
8420	1675-1680		67							1					1				15		
8421	1690-1695		3							3					1				19		
8422	1700-1705																		11		
8423	1710-1715		3											1					1		
8424	1720-1725		2						1										9		
8425	1725-1730		1	4										1					6		
8426	1730-1735		3	5															8		
8427	1740-1745		2	2															15		
8428	1750-1755		2	2															16		1
8429	1760-1765		3											2					11		1
8430	1770-1775		8	7															20		
8431	1775-1780		6	34										1	4				18		
8432	1780-1785		7		1					3									34		
8433	1790-1795		16	4															65		
8434	1800-1805		4														2		30		
8435	1810-1815		5	46															17		1
8436	1820-1825		2							3	1			3					33		1
8437	1825-1830		6																25		
8438	1830-1835		9									1							3		20
8439	1840-1845		10														1		2		26
8440	1850-1855		9																1		30
8441	1860-1865		7							1									1		46

TABLE 17:3, continued.

MPA No	Depth	Special	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
8442	1870-1875		5												1		1		14		
8443	1875-1880		6							1								1		8	
8444	1880-1885		14	2					1	1						2				16	
8445	1890-1895		8	1				1					1			1				26	
8446	1900-1905		35		1				1				1			7				37	
8447	1910-1915		48						1						5	4				22	
8448	1920-1925		20						1				1							39	
8449	1925-1930		53						4				1							39	
8450	1930-1935		43	2				3					1	2						12	
8451	1945-1950		69	2			1	1	9				1	1	3					33	1
8452	1955-1960		78					2	7				1	1	1					35	
8453	1975-1980		20						1				2	3	1					20	
8454	2000-2005		151	1			2			2				2	2		1			47	
8455	2050-2055		27					2		2				1	1					35	
8456	2100-2105		4										1	1						7	
8457	2150-2155																			4	
8458	2200-2205		4																	1	
8459	2250-2255		2						1											3	
8460	2300-2305																			2	
8461	2350-2355																			3	1
8462	2400-2405		2																	3	
8463	2455-2460		4																	4	
8464	2500-2505		1																	8	2
8465	2550-2555		5																	12	3
8466	2600-2605		3	2										1						2	
8467	2650-2655		15	11				1	3					3	2					4	
8468	2700-2705		11	6					1					1						2	
8469	2725-2730																			13	

The code numbers refer to the following species: 01. *Operculodinium centrocarpum*. 02. *Bitectatodinium tepikiense*. 03. *Spiniferites belerius*. 04. *Spiniferites elongatus*. 05. *Spiniferites lazus*. 06. *Spiniferites membranaceus*. 07. *Spiniferites ramosus*. 08. *Spiniferites* spp. indet. 09. *Lingulodinium machaerophorum*. 10. *Brigantidinium simplex*. 11. *Lejeunia paratenella*. 12. *Multispinula minuta*. 13. *Multispinula quanta*. 14. *Selenopemphix nephroides*. 15. *Stelladinium stellatum*. 16. *Trinovantedinium sabrinum*. 17. *Protoperidinium* spp. indet. 18. Cyst B of Harland 1977. 19. *Polykrikos schwartzii* cyst.

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REFERENCES

- DALE, B., 1976: Cyst formation, sedimentation, and preservation: factors affecting dinoflagellate assemblages in Recent sediments from Trondheimsfjord, Norway. – *Rev. Palaeobot. Palynol.* 22, 39–60.
- HARLAND, R., 1977: Recent and late Quaternary (Flandrian and Devensian) dinoflagellate cysts from marine continental shelf sediments around the British Isles. – *Palaeontographica, Abt. B*, 164, 87–126.
- REID, P.C., and HARLAND, R., 1977: Studies of Quaternary dinoflagellate cysts from the North Atlantic. – *In* W.C. Elsie, (ed.): *Contributions of Stratigraphic Palynology, Vol. 1, Cenozoic Palynology.* – Amer. Assoc. Strat. Palynol., Contr. Ser. 5A, 147–169.
- WALL, D., DALE, B., LOHMANN, G.P., and SMITH, W.K., 1977: The environmental and climatic distribution of dinoflagellate cysts in Modern marine sediments from regions in the North and South Atlantic Oceans and adjacent seas. – *Mar. Micropaleontol.* 2, 121–200.