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Dinocysts in Late Holocene sediments in the Skagerrak

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REPORT

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Dinocysts in Late Holocene sediments in the Skagerrak

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Summary:

The dinoflagellate cysts in eight samples from a 50 cm long core, four surface samples from the northwestern Skagerrak, and one surface sample located in the northwestern part of the Skagerrak, have been investigated. The dinoflagellate cyst assemblages in most of the samples are heavily dominated by the cosmopolitan species *Operculodinium centrocarpum*, and reflect a typical neritic (coastal), north temperate climate similar to that of the present time. The assemblage from one of the stations differs from the others in being dominated by *Peridinium faeroense*, which reflects the position of the sample location in a more sheltered part of the Skagerrak.

Possible changes in the water mass properties can be traced by the cyst record in the investigated deep basin core. The presence of the toxic *Gymnodinium catenatum* beeing restricted to the lower part of the core, indicates changing hydrographic conditions with an increased influence of colder surface water in the Skagerrak during the last few hundred years.

Keywords: Maringeologi	Miljøgeologi	Kjerne
Palynologi	Dinoflagellat	Hydrografi
Paleontologi	Fagrapport	

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1 INTRODUCTION

Dinoflagellates are single-celled, microscopic organisms which represent a major group of the marine phytoplankton. The autotrophic dinoflagellates which utilise photosynthesis, live in the photic zone (0-50 m). Heterotrophic dinoflagellates are not dependant on light and they prey on other phytoplankton such as diatoms and on organic particles. Some dinoflagellates produce cysts, which represent a resting stage in the life cycle. Most cysts are composed of very resistant organic material which is not subjected to dissolution.

The geographic distribution of dinoflagellates is controlled by the complex interaction of a variety of environmental parametres like temperature, salinity, stablity of the water column and the supply of nutrient (Dale 1983, Harland 1988). Most cysts are formed by neritic dinoflagellates, although cysts are also formed by some oceanic species. The composition and concentration of the cysts in the sediments are controlled by the cyst production, their transport in water, the sedimentation rate, and the amount of sedimentary mixing caused by bioturbation and resedimentation (Thorsen et al. 1995).

Recently, the distribution and abundance of dinoflagellate cysts in sediment cores from southern Norwegian fjords have demonstrated their potential as indicators of anthropogenically induced environmental change (Dale and Fjellså 1994). However, these investigations primarily focus on eutrophication signals.

The aim of this work was to investigate the possibility of detecting any change in the hydrography in the Skagerrak basin during the past few hundred years, on the basis of the content of dinoflagellate cysts in the sediments.

2 MATERIAL AND METHODS

The dinoflagellate cyst interpretations are based on analysis of 8 samples from a 50 cm long sediment core (P9307130) collected at station 74, located in the deep Skagerrak basin at 594 m water depth, and five surface samples at Stations 58, 56, 55, 54 (PP930723, P9205259, P9205252 and P9205249, respectively) and at Hvalerdypet (NC54), in the Skagerrak (Figs. 1 and 2; Tables 2 to 8). The analysed core represents sediments deposited since the late 16 hundreds.

The samples were processed following standard palynological procedures using cold 10% HCl and hot 40% HF to remove minerals. Ultrasounding was used to remove adhering

material. No oxidation was used. The analyses were performed on the >10 μm fraction. Slides were made by using Elvacite as a mounting medium, and slides were analysed by normal light microscopy. The calculation of cyst concentrations was based on the exotic marker grain method (Stockmarr 1971).

The percentage occurrences of the identified dinocyst taxa are shown in Tables 3, 6 and 8. Four samples of core P9307130 at Station 74 were analysed quantitatively (core depth 0,5-1 cm, 12-14 cm, 25-30 cm and 40-45 cm). The nomenclature of the species refers to Lentin & Williams (1989).The analysed slides are held in the collection at NGU.

Age and sedimentation rate

Twelve Pb-210 dates of the sediment in the uppermost 10 cm of the core at Station 74 suggest a continuous sedimentation rate of 1,6 mm/year (Kunzendorf et al. 1996). If this applies to the whole core, it may represent sediments deposited since the late 1600.

Groups of dinoflagellate cysts

Five cyst types have been grouped together.

cf. Bitectatodinium tepikiense
contains specimens identified as *B. tepikiense,* as well as specimens which lack critical identification criteria, either because of their orientation or because they are collapsed, but are supposed to represent *B. tepikiense.*

Spiniferites spp.
contains all recorded specimens with *Spiniferites* affinity.

Spiniferites spp. indet.
In the assemblage at Hvalerdypet specimens belonging to the genus *Spiniferites* were identified to species level when this was possible. *Spiniferites* spp. indet includes specimens of unequivocal *Spiniferites* affinity which could not be identified to species level.

Protoperidinium spp.
contains round, brown protoperidinoid cysts, where most of the specimens are supposed to represent *P. conicoides.*

Unidenified cysts
contains cysts which could not be identified because of their state of preservation.

3 RESULTS AND DISCUSSION

A total of 20 dinocyst taxa were identified and these are listed in Table 1.

3.1 Station 74

Most of assemblages in the sediment core at Station 74 are heavily dominated by *Operculodinium centrocarpum* (50 to 70%), except for the lowermost two samples which have distinctly different assemblages as compared to the rest of the core (Figs. 1, 2 and Tables 2, 3 and 4). The assemblages in the lowermost two samples in the core differ from the other assemblages in the core by containing the toxic species *Gymnodinium catenatum* (13.7 to 14.9 %), and by having a relatively high percentage of *Protoperidinium spp.* (24.5 to 40.5%).

The dominance of *O. centrocarpum* throughout the core is in accordance with other studies from the same area (Koniezcny 1983, Dale 1985, Thorsen et al. 1995). *O. centrocarpum* is a cosmopolitan species tolerating a wide range of temperatures and salinities, and is found in great abundances in oceanic as well as in estuarine environments. In the Atlantic Ocean it seems to be connected to the North Atlantic Current and it dominates the assemblages in sediments «underlying» the Norwegian Coastal Current and the Norwegian Current (Harland 1983, Dale 1985, Matthiessen 1991). It appears to be a good indicator for the modern, relatively warm North Atlantic current.

Previous investigations of *G. catenatum*

The toxic *G. catenatum* is today present in the surface water of the Gulf of California, Venezuela, Argentina, Tasmania, Japan, around the Iberian peninsula and in the Mediterranean, which is supposedly warmer than the Scandinavian waters today (Thorsen et al. 1995). *G. catenatum* first migrated into the Kattegat about 6200 years B.P., and had its first occurrence of high numbers at about 4300-4500 years B.P. (Dale et al. 1993, Dale & Nordberg 1993, Fjellså & Nordberg 1996). It decreased abruptly and subsequently disappeared at about 4000 years BP (Fjellså & Nordberg 1996). It got reestablished again at about 2000 year B.P., and occurred in massive «blooms» during the Medieval Warm Epoch, between 700 and 800 years B.P. (Dale et al. 1993, Dale & Nordberg 1993, Thorsen et al. 1995, Fjellså & Nordberg 1996).

G. catenatum probably got extinct in the area at about 300 years B.P., although extending in minor amounts to the top of the core in Kattegat (Thorsen et al., 1995). The concentration of *G. catenatum* immediately before its extinction at about 1 m depth in the core from Kattegat is around 5000 cysts/g. Above 1 m the concentration of *G. catenatum* decreases abruptly to

around 500 cysts/g and less. In the top of the core *G. catenatum* constitutes only 3% of the dinocyst assemblage. The presence of *G. catenatum* in sediments which accumulated after the extinction of *G. catenatum*, is suggested by Thorsen et al. (1995) to be due to the mixing of sediments.

Present investigation of G.catenatum

Gymnodinium catenatum accounts for 15% in the lowermost 10 cm in the analysed core, whereas it is absent in the uppermost 40 cm of the core (Fig. 2, Table 3). The occurrence of *G. catenatum* in such high amounts in an otherwise fairly uniform sequence of dinoflagellate cysts is most likely a result of changing environmental factors.

The age of the lowermost sediments in the investigated core which contain *G. catenatum* is roughly 300 years B.P. (Kunzendorf et al. 1996), which corresponds to the age of the postulated local extinction of *G. catenatum* in the Skagerrak/Kattegat region. Because *G. catenatum* appears to be an indicator of warmer surface water, its dissappearance at about 300 years B.P. is possibly due to an increased influence of colder surface water, as suggested by Thorsen et al. (1995). The absence of *G. catenatum* above 40 cm in the presently analysed core may therefore reflect its local extinction which was probably due to a change in hydrographic conditions at about 300 years B.P.

The assemblage composition in the analysed core is basically the same as that of late Holocene assemblages in the NE Atlantic, off west Scotland (Harland & Howe, 1995).

3.2 Stations 58, 56, 55 and 54

In the assemblages recorded in the surface samples from station 58, 56, 55 and 54, *O. centrocarpum* (22-39%) is the most abundant species (Fig. 1,Table 5, 6). However, its percentage abundance does not reach as high values as in the assemblages at Station 74 (Table 3, 4). At two of these stations, *Protoperidinium* spp. (6-21%) was the second most abundant taxon. Spiniferites spp. (6%-23%) is the second most abundant species in one of the surface samples.

3.3 Hvalerdypet

In the dinocyst assemblage of the uppermost 2 cm at Hvalerdypet (Figure 1), *P. faeroense* (37%) is the most abundant species (Table 7, 8). It dominates the assemblage together with, *O. centrocarpum* (21%) and *Protoperidinium* spp. (21%).

P. faeroense is an estuarine species which is characteristic for temperate to north temperate regions and is often dominating assemblages in fjords (Dale 1976, 1977, 1985, Baumann & Matthiessen 1992). The ecological requirements of *P. faeroense* is yet not fully understood.

The dinocyst assemblage at Hvalerdypet differs from all the other presently investigated assemblages by having very high contents of *P. faeroense*. This is most likely due to its position in the inner part of Skagerrak, in the outer Oslofjord area. Although *P. faeronse* is thought to tolerate low salinities, it prefers sheltered regions influenced by marine water masses (Gundersen 1988).

4. CONCLUSION

1. The dinoflagellate cyst assemblages in most of the samples are heavily dominated by the cosmopolitan species *O. centrocarpum*, and reflect a typical neritic, north temperate climate similar to that of the present time.

2. The assemblage from one of the stations differs from the others in being dominated by *Peridinium faeroense*, which reflects the position of the sample location in a more sheltered part of the Skagerrak.

3. The dinocyst assemblages in the lowermost part of core P9307130 indicate a distinctly different environmental setting as compared to that in the rest of the core.The presence of the toxic *G. catenatum,* which is restricted to the lowemost part of the core, indicate changing climatic conditions with an increased influence of colder surface water in the Skagerrak during the last few hundred years.

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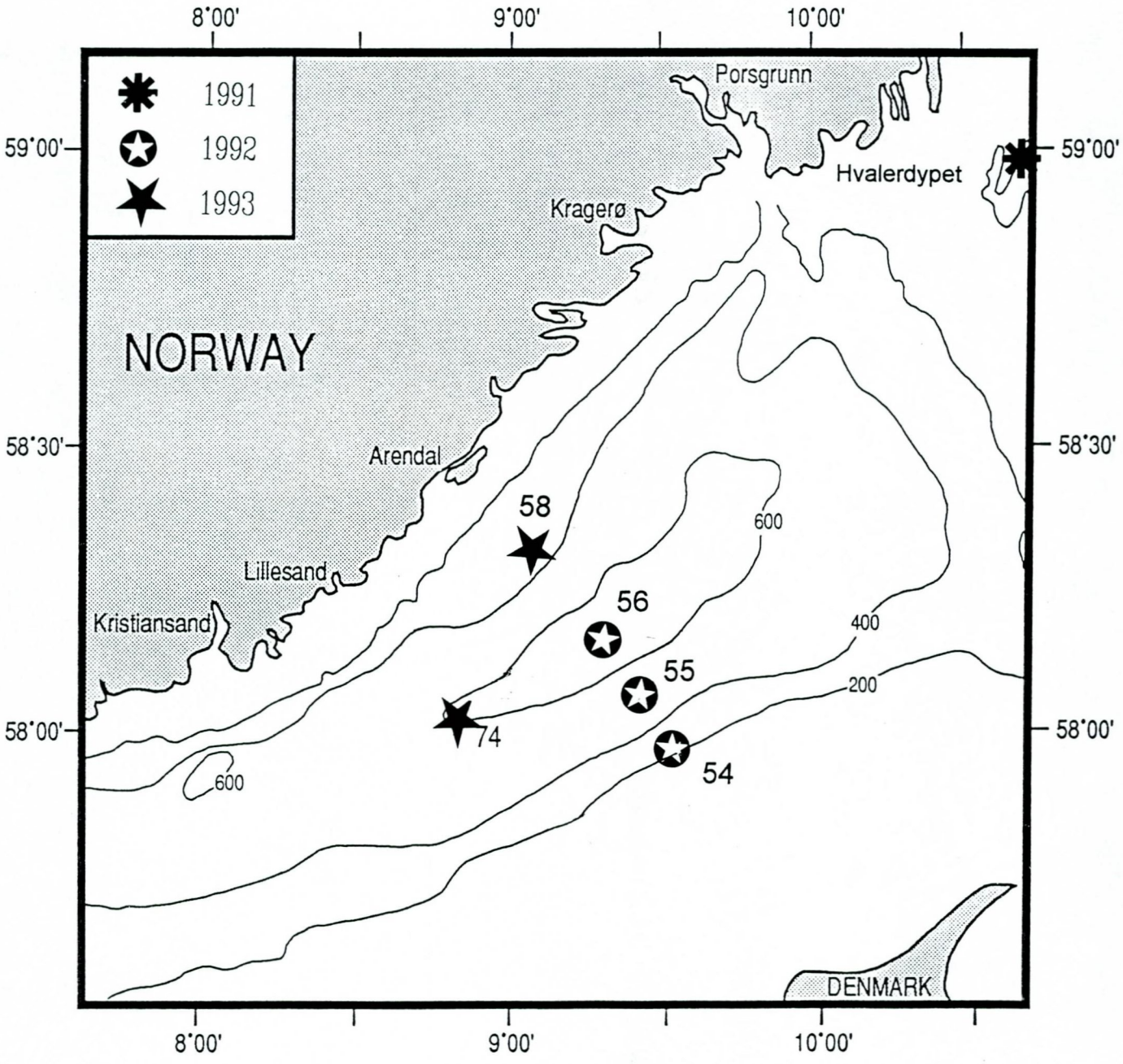

Fig. 1. Investigation area showing sample locations and station numbers (modified after Alve 1995).

Figure 2. Percentage abundance and concentrations of dinocyst taxa at Station 74

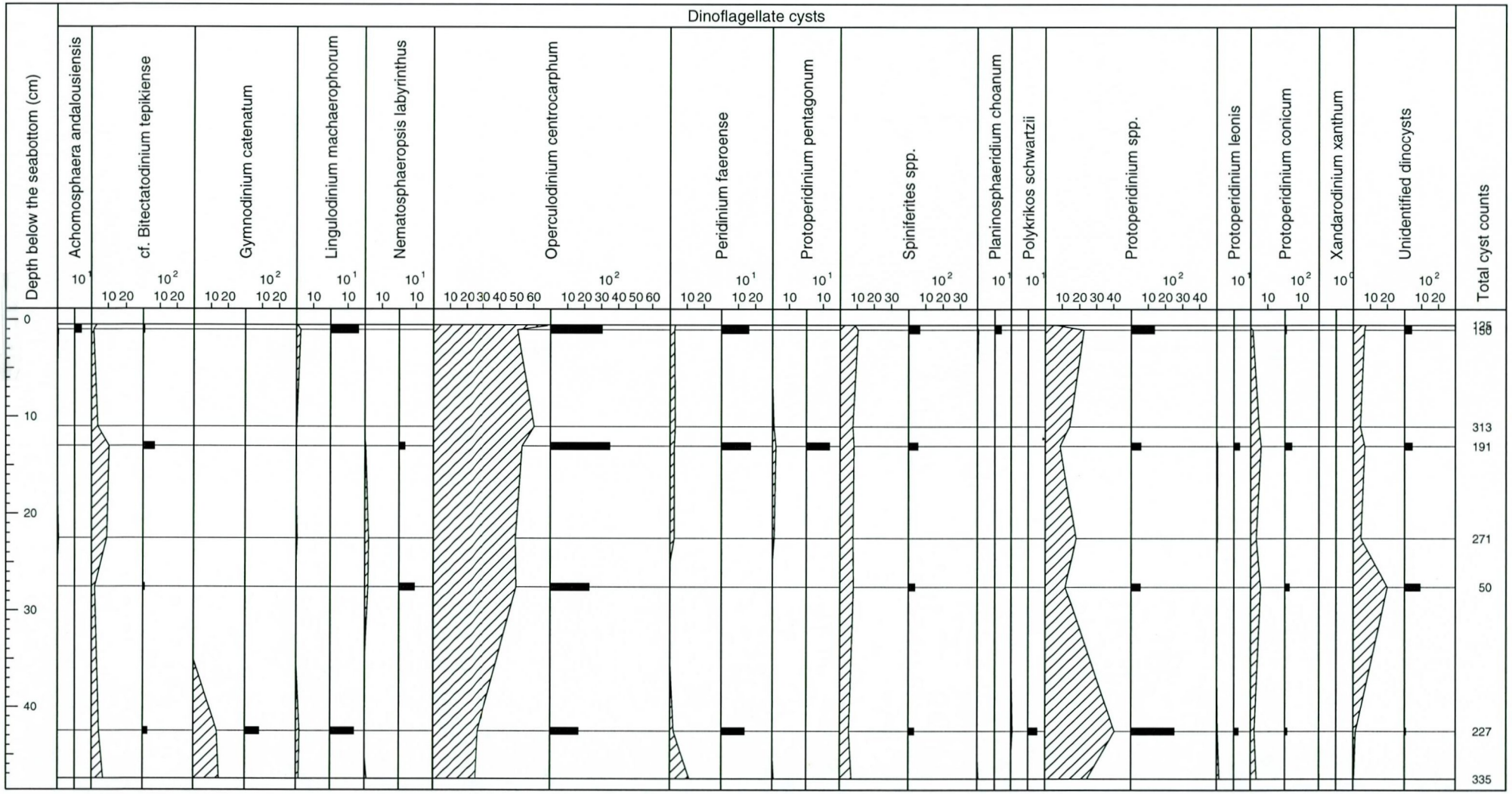

Table 1. List of dinoflaggellate cyst species/taxa

Alexandrium excavatum
Achomosphaera andalousiensis
Bitectatodinium tepikiense
cf. Bitectatodinium tepikiense
Bitectatodinium spp.
Gymnodinium catenatum
Lingulodinium machaerophorum
Nematosphaeropsis labyrinthus
Operculodinium centrocarpum
Protoperidinium leonis
Protoperidinium conicum
Protoperidinium pentagonum
Peridinium faeroense
Planinosphaeridium choanum
Polykrikos schwartzii
Protoperidinium spp.
Spiniferites elongatus
Spiniferites hyperacanthus
Spiniferites mirabilis
Spiniferites ramosus
Spiniferites spp. indet.
Spiniferites spp.
Xandarodinium xanthum

Table 2. Number of counted dinocyst specimens in the core at Station 74.

Coordinates: 58,022N; 8,835E; water depth: 594m

Sed. dyp	*A. andalousiensis*	*cf. B. tepikiense*	*G. catenatum*	*L. machaerophorum*	*N. labyrinthus*	*O. centrocarpum*	*P. choanum*	*P. conicum*	*P. faeroense*	*P. leonis*	*P. pentagonum*	*P. schwartzii*	*Protoperidinium spp.*	*Spiniferites spp.*	*X. xanthum*	Unidentified cysts	Counted cysts	Counted markers	Prequaternary cysts	Weight (g)	Added markers
0-0,5		4		1		88			4				8	11		9	125	388	2		13911
0,5-1,0	1	2		4		76	1	2	4				34	16		10	150	356		1	13911
10,0-12,0		12		1		189		16	10		3		45	24		13	313	290			13911
12,0-14,0		20			1	102		12	5	1	4		17	16		13	191	439		0,9	13911
20,0-25,0	2	25		2	6	134		9	7	1	3		49	21		12	271	320			13911
25,0-30,0		1			1	25		3					6	4		10	50	179		0,9	13911
40,0-45,0		10	31	5		61		5	5	1		2	92	12		3	227	599		0,9	13911
45,0-50,0		23	50	6	4	85	2	12	38	5	3		82	23	1	1	335	384	1		13911

Table 3. Percentage abundances of dinocyst taxa in the core at Station 74.

Coordinates: 58,022N; 8,835E; water depth: 594m

Sed. dyp	*A. andalousiensis*	*cf. B. tepikiense*	*G. catenatum*	*L. machaerophorum*	*N. labyrinthus*	*O. centrocarpum*	*P. choanum*	*P. conicum*	*P. faeroense*	*P. leonis*	*P. pentagonum*	*P. schwartzii*	*Protoperidinium spp.*	*Spiniferites spp.*	*X. xanthum*	Unidentified cysts
0-0,5	0,0 %	3,2 %	0,0 %	0,8 %	0,0 %	70,4 %	0,0 %	0,0 %	3,2 %	0,0 %	0,0 %	0,0 %	6,4 %	8,8 %	0,0 %	7,2 %
0,5-1,0	0,7 %	1,3 %	0,0 %	2,7 %	0,0 %	50,7 %	0,7 %	1,3 %	2,7 %	0,0 %	0,0 %	0,0 %	22,7 %	10,7 %	0,0 %	6,7 %
10,0-12,0	0,0 %	3,8 %	0,0 %	0,3 %	0,0 %	60,4 %	0,0 %	5,1 %	3,2 %	0,0 %	1,0 %	0,0 %	14,4 %	7,7 %	0,0 %	4,2 %
12,0-14,0	0,0 %	10,5 %	0,0 %	0,0 %	0,5 %	53,4 %	0,0 %	6,3 %	2,6 %	0,5 %	2,1 %	0,0 %	8,9 %	8,4 %	0,0 %	6,8 %
20,0-25,0	0,7 %	9,2 %	0,0 %	0,7 %	2,2 %	49,4 %	0,0 %	3,3 %	2,6 %	0,4 %	1,1 %	0,0 %	18,1 %	7,7 %	0,0 %	4,4 %
25,0-30,0	0,0 %	2,0 %	0,0 %	0,0 %	2,0 %	50,0 %	0,0 %	6,0 %	0,0 %	0,0 %	0,0 %	0,0 %	12,0 %	8,0 %	0,0 %	20,0 %
40,0-45,0	0,0 %	4,4 %	13,7 %	2,2 %	0,0 %	26,9 %	0,0 %	2,2 %	2,2 %	0,4 %	0,0 %	0,9 %	40,5 %	5,3 %	0,0 %	1,3 %
45,0-50,0	0,0 %	6,9 %	14,9 %	1,8 %	1,2 %	25,4 %	0,6 %	3,6 %	11,3 %	1,5 %	0,9 %	0,0 %	24,5 %	6,9 %	0,3 %	0,3 %

Table 4. Concentrations (cysts per gram of dry sediment) at Station 74																				
Coordinates: 58,022N; 8,835E; water depth: 594m																				
Sed. dyp	*A. andalousiensis*	*cf. B. tepikiense*	*G. catenatum*	*L. machaerophorum*	*N. labyrinthus*	*O. centrocarpum*	*P. choanum*	*P. conicum*	*P. faeroense*	*P. leonis*	*P. pentagonum*	*P. schwartzii*	*Protoperidinium spp.*	*Spiniferites spp.*	*X. xanthum*	Uident. cyster	Total concentration				
0,5-1,0	40	80	0	159	0	3030	40	80	159	0	0	0	1356	638	0	399	5981				
12,0-14,0	0	681	0	0	34	3475	0	409	170	34	136	0	579	545	0	443	6508				
25,0-30,0	0	91	0	0	91	2286	0	274	0	0	0	0	549	366	0	914	4571				
40,0-45,0	0	273	847	137	0	1667	0	137	137	27	0	55	2514	328	0	82	6202				

Table 5. Number of counted dinocyst specimens at Stations 58, 56, 55 and 54.

Station	Core	Latitude	Longitude	Waterdepth (m)	Core depth (cm)	*A. andalousiensis*	*B. tepikiense*	*Bitectatotidium spp*	*L. machaerophorum*	*N. labyrinthus*	*O. centrocarpum*	*P. choanum*	*P. conicum*	*P. faeroense*	*P. leonis*	*P. pentagonum*	*P. schwartzii*	*Protoperidinium spp.*	*Spiniferites spp.*	*X. xanthum*	Unidentified cysts	Counted cysts	Counted markers
58	P9307023	58,273	9,047	404	0.0-1.0	1	4	1	4		16	1	2	4			2	11	8	1	4	59	150
56	P9205259	60,323	5,240	>600	0.0-1.0	1			2		30		6	5		7		5	5		16	77	62
55	P9205252	58,097	9,414	571	0.0-1.0	2	3	1		1	43		4	7		2		16	28		16	123	304
54	P9205249	58,044	9,518	419	0.0-1.0	2	1				84	3	36	6	7	1	3	57	53		22	275	184

Table 6. Percentage abundances of dinocyst taxa at Stations 58, 56, 55 and 54.

Station	Core	Latitude	Longitude	Waterdepth (m)	Core depth (cm)	*A. andalousiensis*	*B. tepikiense*	*Bitectatotidium spp*	*L. machaerophorum*	*N. labyrinthus*	*O. centrocarpum*	*P. choanum*	*P. conicum*	*P. faeroense*	*P. leonis*	*P. pentagonum*	*P. schwartzii*	*Protoperidinium spp.*	*Spiniferites spp.*	*X. xanthum*	Unidentified cysts
58	P9307023	58,273	9,047	404	0.0-1.0	1,7 %	6,8 %	1,7 %	6,8 %	0,0 %	27,1 %	1,7 %	3,4 %	6,8 %	0,0 %	0,0 %	3,4 %	18,6 %	13,6 %	1,7 %	6,8 %
56	P9205259	60,323	5,240	73	0.0-1.0	1,3 %	0,0 %	0,0 %	2,6 %	0,0 %	39,0 %	0,0 %	7,8 %	6,5 %	0,0 %	9,1 %	0,0 %	6,5 %	6,5 %	0,0 %	20,8 %
55	P9205252	58,097	9,414	571	0.0-1.0	1,6 %	2,4 %	0,8 %	0,0 %	0,8 %	35,0 %	0,0 %	3,3 %	5,7 %	0,0 %	1,6 %	0,0 %	13,0 %	22,8 %	0,0 %	13,0 %
54	P9205249	58,044	9,518	419	0.0-1.0	0,7 %	0,4 %	0,0 %	0,0 %	0,0 %	30,5 %	1,1 %	13,1 %	2,2 %	2,5 %	0,4 %	1,1 %	20,7 %	19,3 %	0,0 %	8,0 %

Hvaler depth

Table 7. Number of counted dinocyst specimens in the sample at Hvalerdypet.

Core	Latitude	Longitude	Water depth (m)	Core depth (cm)	*A.excavatum*	*A. andalousiensis*	*B. tepikiense*	*L. machaerophorum*	*N. labyrinthus*	*O. centrocarpum*	*P. conicum*	*P. faeroense*	*P. schwartzii*	*Protoperidinium spp.*	*S. elongatus*	*S. hyperacanthus*	*S.mirabilis*	*S. ramosus*	*Spiniferites spp. indet.*	*X. xanthum*	Unidentified cysts	Counted cysts
NC54	58 59' 60" N	10 40' 37" E	451	0.0-2.0	2	1	15	9	1	70	6	125	11	70	8	1	1	1	7	1	10	339

Table 8. Percentage abundances of dinocyst taxa at Hvalerdypet.

Core	Latitude	Longitude	Water depth (m)	Core depth (cm)	*A.excavatum*	*A. andalousiensis*	*B. tepikiense*	*L. machaerophorum*	*N. labyrinthus*	*O. centrocarpum*	*P. conicum*	*P. faeroense*	*P. schwartzii*	*Protoperidinium spp.*	*S. elongatus*	*S. hyperacanthus*	*S.mirabilis*	*S. ramosus*	*Spiniferites spp. indet.*	*X. xanthum*	Unidentified cysts
NC54	58 59' 60" N	10 40' 37" E	451	0.0-2.0	0,6 %	0,3 %	4,4 %	2,7 %	0,3 %	20,6 %	1,8 %	36,9 %	3,2 %	20,6 %	2,4 %	0,3 %	0,3 %	0,3 %	2,1 %	0,3 %	2,9 %