Palynological analysis of core (342.9′ to 1037′) from the U. S. Navy Umiat Test Well No. 11.

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U.H.	709.6′
U.I.	716.4′
U.J.	723′
U.K.	762.5′
U.L.	778.5′
U.M.	1032′
U.N.	1037′

PALYNOLOGICAL ANALYSIS OF 14 OUTCROP SAMPLES FROM THE CRETACEOUS OF ALASKA

actually samples were from core of the U.S. Navy UMIAT TEST WELL No. 11 JR

Report No. 90-0012
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Bujak Davies Group
Calgary, Alberta

PALYNOLOGICAL ANALYSIS OF 14 OUTCROP SAMPLES FROM THE CRETACEOUS OF ALASKA

INTRODUCTION

This report discusses the results of palynological analyses of 14 outcrop samples from the Cretaceous of Alaska which were submitted to the Bujak Davies Group by James Talbot of ARCO Oil and Gas Co.

All of the samples were all processed at the Bujak Davies laboratories in Calgary. During palynological analysis, a kerogen slide, coarse fraction palynological slide (greater than 20 microns), and a fine fraction palynological slide (less than 20 microns) were examined to determine the relative abundances of the total reworked and in situ palynological assemblages in each sample.

Palynological zonal and age determinations of the samples mainly utilized index species of marine dinoflagellates plus the spores and pollen of terrestrial plants. Rare fungal palynomorphs observed in some samples represent taxa with long stratigraphic ranges, so that these specimens provided little information on the age of the samples.

The integrated Cenozoic-Mesozoic palynological zonation used for the biostratigraphic subdivision and age determinations of the 14 samples has not been published but is shown in Figure 1. This zonation has been developed in-house by the Bujak Davies Group and is generally consistent with that used by the Geological Survey of Canada and various petroleum exploration groups drilling in the Canadian Beaufort Sea and Alaskan North slope.

The zonation has been published in part by Norris (1986) for the Oligocene to Pleistocene based on his analysis of the Nuktak C-22 well, Canadian Beaufort Sea, but additionally utilizes the occurrences of marine Miocene dinoflagellates recognized through the use of fluorescence microscopy. The Cenozoic zonation is also partially based on earlier published work by Doerenkamp et al. (1976), Rouse (1977) and Staplin (1976) for the Paleogene section.

The Mesozoic palynological zonation used in the present study is primarily based on unpublished data from North Slope Alaskan surface and subsurface sections due to the scarcity of published Alaskan information, plus published and unpublished data from the adjacent MacKenzie Delta and other relevant Arctic regions.

Published data on the Cretaceous have been synthesized by the Bujak Davies Group (1984) and include the following papers: Brideaux (1976, 1977), Brideaux & Fisher (1976), Brideaux & McIntyre (1973, 1975), Brideaux & Myhr (1976), Brideaux *et al.* (1975, 1976), Davies (1979, 1983), Doerenkamp *et al.* (1976), Felix & Burbridge (1973, 1976), Manum & Cookson (1964), McIntyre (1974, 1975), McIntyre & Brideaux (1980), and Sweet (1978).

Published data on the Jurassic are rare and include Brideaux (1977), Brideaux & Fisher (1976), and Davies (1979, 1983), plus the Northern Hemisphere Oxfordian and younger Miospore Atlas of the Bujak Davies Group (1986) which also discusses the Berriasian to Turonian section.

FORMAT

In the following report, the examined samples are listed in alphabetic order, with a discussion of the zonal/age justification, and the interpreted paleoenvironment based on palynology. Within each sample, all of the oibserved taxa are listed and are grouped into the following categories reflecting their affinities and habitats:

marine dinoflagellates
other algae
terrestrial pollen and spores
fungi

The following categories of relative abundances are denoted, with undenoted abundances representing a single observed specimen:

Present:	one specimen
Rare:	two to four specimens
Few:	five to 19 specimens
Common:	20 to 49 specimens
Abundant:	more than 50 specimens

AGE	C#		ZONATION	
PLEISTOCENE	9		Leevigatosporites ovatus	
PLIOCENE	8	B	Naiadinium cornutum	N.cornutum
		A		S.obscura
MIOCENE	7	D	Taugaepollenites igniculus	F.illifera
		C		S.ancyrea
		B		P.leticinctum
		A		P.paradoxum
OLIGOCENE	6	C	Ericipites compacti-polleniatus	-------
		B		C.pseudopoculum
		A		-------
	5		Boisduvalia clavatilles	
EOCENE	4		Tiliaepollenites vescipites	
	3	C	Pesevis tegluensis	L.wetzelii
		B		P.echinatum
		A		G.erdinata cf.
	2		Apectodinium homomorphum	
PALEOCENE	1	B	Paraalnipollenites confusus	P.confusus
		A		P.pyrophorum

AGE	K#	ZONATION
MAASTRICTIAN	24	Cyclonephelium distinctum
	23	Isabelidinium amphiatum
CAMPANIAN	22	Hystrichosphaeridium difficile
	21	Chatangiella coronata
SANTONIAN	20	Chatangiella ditissima
CONIACIAN	19	Chatangiella verrucosa
TURONIAN	18	Eurydinium glomeratum
	17	Isabelidinium magnum
CENOMANIAN	16	Kiokansium polypes
	15	Luxadinium propatulum
ALBIAN	14	Chichaouadinium davidii
	13	Chichaouadinium vestitum
	12	Vesperopsis mayi
APTIAN	11	Oligosphaeridium asterigerum
	10	Pilosisporites crassiangularis
	9	Pseudoceratium regium
BARREMIAN	8	Dingodinium cerviculum
	7	Canningia reticulata
HAUTERIVIAN	6	Oligosphaeridium abaculum
	5	Parvocavatus sp.S
VALANGINIAN	4	Gochteodinium dasyformis
	3	Gochteodinium judilentinae
BERRIASIAN	2	Paragonyaulacysta borealis
	1	Horologinella spinosigibberosa

AGE	J#	ZONATION
TITHONIAN	19	Paragonyaulacysta capillosa
	18	Cribroperidinium jubaris
	17	Chytroeisphaeridium chytroeides
KIMMERIDGIAN	16	Oligosphaeridium sp.A
	15	Gonyaulacysta dualis
OXFORDIAN	14	Stephanelytron redcliffense
	13	Acanthaulax senta
	12	Occisucysta thulia
CALLOVIAN	11	Gonyaulacysta adecta
	10	Paragonyaulacysta calloviense
BATHONIAN	9	Cleridodinium combazii
	8	Energlynia sp.A
	7	Kylindrocysta sp.C
BAJOCIAN	6	Gonglyodinium hocneratum
	5	Comparodinium aquilonium
AALENIAN	4	Wallodinium elongatum
TOARCIAN	3	Dapcodinium coalitum
PLIENSBACHIAN	2	Lithodinia serrulata
SINEMURIAN		
HETTANGIAN	1	Dapcodinium priscum

AGE	Tr#	ZONATION
RHAETIAN	16	Rhaetogonyaulax rhaetica
NORIAN	15	Suessia swabiana
	14	Sverdrupiella sabinensis
	13	Heibergella salebrosacea
CARNIAN	12	Shublikodinium verrucosum
	11	Taeniaesporites kraeuselii

Figure 1. Bujak Davies Group Late Triassic to Pleistocene palynological zonation, Canadian Beaufort and Alaskan North Slope.

BIOSTRATIGRAPHIC SUMMARY

Sample (code)	(depth)	Age and Zone
1 U.A.	342.9'	Late Coniacian to early Santonian *Chatangiella verrucosa* Zone
2 U.B.	345.5'	late Turonian to early Coniacian *Eurydinium glomeratum* Zone
3 U.C.	392.3'	probable early to ?middle Albian *Vesperopsis mayi* Zone
4 U.D.	462.5'	Aptian to early - ?middle Albian *Pseudoceratium regium* to *Vesperopsis mayi* Zone
5 U.E.	546.2'	middle Albian *Chichaouadinium vestitum* Zone
6 U.F.	547.'	probable early to ?middle Albian *Vesperopsis mayi* Zone
7 U.G.	561.2'	late Santonian *Chatangiella ditissima* Zone
8 U.H.	709.6'	late Turonian to early Coniacian *Eurydinium glomeratum* Zone
9 U.I.	716.4'	early Turonian *Isabelidinium magnum* Zone
10 U.J.	723'	early Turonian *Isabelidinium magnum* Zone with Cenomanian to Albian reworking
11 U.K.	762.5'	late Aptian or older *Oligosphaeridium asterigerum* Zone, or possibly as old as early Aptian
12 U.L.	778.5'	early to ?middle Albian *Vesperopsis mayi* Zone
13 U.M.	1032'	probable middle to late Albian *Chichaouadinium vestitum* to *Chichaouadinium davidii* Zones RA's correction
14 U.N.	1037'	either (1) early to ?middle Albian *Vesperopsis mayi* Zone or (2) Turonian *Eurydinium glomeratum* Zone with Albian reworking.

PALYNOLOGICAL ASSEMBLAGE DESCRIPTIONS

Unless otherwise noted, single specimens were observed.

(+) indicates a marker species.

1: Sample designation: [illegible] outcrop

Age & Zone

late Coniacian to early Santonian *Chatangiella verrucosa* Zone

Dinoflagellates

Astrocystra cretacea (Abundant)
Canningia colliveri (Common)
Chatangiella scheii (+) (Rare)
Chatangiella sp. 1, Bujak 1985 (+) (Common)
Chatangiella sp. 2, Bujak 1985 (+) (Common)
Chatangiella verrucosa (+) (Rare)
Ginginodinium ornatum (+) (Common)
Isabelidinium magnum (Common)
Laciniadinium biconiculatum (+) (Rare)
Pseudoceratium sp. 1, Bujak 1985 (+)
Spinidinium sverdruplanum (+) (Common)
Trithyrodinium suspectum (+) (Common)

Other Algae

No taxa observed.

Pollen

Alisporites spp. (Abundant)
Taxodiaceaepollenites hiatus (Abundant)

Fern and Moss Spores

Camarozonosporites insignis
Cicatricosisporites mohrioides
Cyathidites australis (Abundant)
Cyathidites minor (Common)
Gleichenidites minor
Gleichenidites senonicus (Rare)
Laevigatosporites ovatus (Common)
Lycopodiumsporites austroclavitidites
Lycopodiumsporites marginatus
Osmundacidites wellmannii (Common)
Stereisporites antiquasporites (Abundant)
Stereisporites minor (Common)
Stereisporites regium (Common)

Fungal Spores

No taxa observed.

Reworked Palynomorphs

Densosporites spp.

Paleoenvironment

Neritic marine

Comments

Dinoflagellates are abundant in this samples, including several species whose association indicated assignment to the *Chatangiella verrucosa* Zone.

Miospores are also abundant, with all of the observed taxa being fairly long-ranging stratigraphically. Their association with abundant marine dinoflagellates reflects a neritic marine environment with the common input of terrestrial material to the depositional site.

2: Sample designation: U.B. outcrop

Age & Zone

late Turonian to early Coniacian *Eurydinium glomeratum* Zone

Dinoflagellates

Astrocystra cretacea
Gen. et sp. indet. 1, Bujak 1985 (+) (Common)
Nelsoniella aceras sensu McIntyre 1974 (+)

Other Algae

No taxa observed.

Pollen

Alisporites spp. (Common)
Taxodiaceaepollenites hiatus (Rare)

Fern and Moss Spores

Cyathidites australis (Abundant)
Cyathidites minor (Abundant)
Gleichenidites minor
Laevigatosporites ovatus (Rare)
Osmundacidites wellmannii (Rare)
Stereisporites antiquasporites (Rare)
Stereisporites minor

Fungal Spores

Pluricellaesporites spp. (Rare)

Reworked Palynomorphs

No taxa observed.

Paleoenviromnet

Stressed marine

Comments

Dinoflagellates are rare in this sample and have low diversity, but the taxa that occur indicate assignment to the *E. glomeratum* Zone and a stressed marine depositional environment. Miospores are more common, with rare fungal spores also being observed.

<u>3: Sample designation: U.C. outcrop</u>

Age & Zone

probable early to ? middle Albian, *Vesperopsis mayi* Zone

Dinoflagellates

Ctenidodinium #ES, Banerjee & Davies '88 (+)

Other Algae

Schizocysta parvus (Common)

Pollen

Alisporites spp. (Rare)
Araucariacites australis
Cycadopites spp.
Ephedripites costaliferus (+)
Parvisaccites amplus (+)
Phyllocladites inchoatus (+) (Rare)
Taxodiaceaepollenites hiatus (Abundant)
Vitreisporites pallidus

Fern and Moss Spores

Cicatricosisporites #EF (+)
Cicatricosisporites cocononiensis (+) (Rare)
Cyathidites minor (Rare)
Gleichenidites senonicus
Laevigatosporites ovatus
Lycopodiumsporites austroclavitidites
Osmundacidites wellmannii (Dominant)
Stereisporites antiquasporites (Rare)

Fungal Spores

Pluricellaesporites spp.

Paleoenvironment:

Paralic to marginally marine with euryhaline conditions.

Comments

Dinoflagellates are rare consisting of opportunistic species. Euryhaline algal cysts are common. The miospores are abundant with high-dominance in gymnospermous pollen and generalized fern spores.

The sample lacks the primary zonal marker species of the *Vesperopsis mayii* Zone but it contains several species that can be related to the terrigenous miospore zonation (Subzones 11A-B) of equivalent age proposed by the Bujak Davies Group (1986) for the North America and Europe. *Ctenidodinium* sp. S of Banerjee and Davies (1988) is known from the Barremian to Albian Mannville Formation of Western Canada.

4: Sample designation: U.D. outcrop

Age & Zone

Aptian to early - ? middle Albian *Pseudoceratium regium* to *Vesperopsis mayi* Zone

Dinoflagellates

Ctenidodinium #ES, Banerjee & Davies '88 (+) (Rare)
Luxadinium sp. indet.

Other Algae

Concentricystes minor
Schizocysta parvus (Rare)

Pollen

Alisporites spp. (Rare)
Cedripites canadensis
Laricoidites magnus (Rare)
Parvisaccites amplus (+) (Fragments)
Perinopollenites elatoides
Taxodiaceaepollenites hiatus (Common)

Fern and Moss Spores

Cyathidites australis (Common)
Cyathidites minor (Common)
Densoisporites microreticulatus
Gleichenidites senonicus
Laevigatosporites ovatus (Rare)
Lycopodiumsporites austroclavitidites
Osmundacidites wellmannii (Abundant)
Stereisporites antiquasporites (Rare)

Fungal Spores

Multicellaesporites spp.

Paleoenvironment:

Paralic to marginally marine with euryhaline conditions.

Comments

Dinoflagellates are rare consisting of opportunistic species. Euryhaline algal cysts are common. The miospores are abundant with high-dominance in gymnospermous pollen and generalized fern spores. The sample lacks the primary zonal marker species Alaskan North Slope -Beaufort palynological zonation but it contains a few species that can be related to the terrigenous miospore zonation (Zones 10-11) of Aptian to Albian age proposed by the Bujak Davies Group (1986) for the North America and Europe. *Ctenidodinium* sp. S of Banerjee and Davies (1988) is known from the Barremian to Albian Mannville Formation of Western Canada.

5: Sample designation: U.E. outcrop

Age & Zone

middle Albian *Chichaouadinium vestitum* Zone

Dinoflagellates

Astrocystra cretacea (Common)
Chichaouadinium #EA (+)
Chichaouadinium vestitum (+)
Cleistosphaeridium huguoniotii (+)
Ctenidodinium #ES, Banerjee & Davies '88
Cyclonephelium distinctum
Luxadinium propatulum (+) (Rare)
Maghrebina cingulata (+) (Rare)
Odontochitina operculata (Rare)
Spiniferites ramosus
Stiphrosphaeridium anthophorum (+)

Other Algae

Concentricystis sp. A
Schizocysta parvus

Pollen

Alisporites spp. (Rare)
Cedripites canadensis (Rare)
Parvisaccites amplus (+) (Rare)
Perinopollenites elatoides
Podocarpidites potomacensis (Rare)
Taxodiaceaepollenites hiatus (Abundant)
Vitreisporites pallidus (Rare)

Fern and Moss Spores

Chytroeisphaeridia ringnesorium
Cicatricosisporites delicatus (Common)
Cicatricosisporites mohrioides
Cicatricosisporites problematicus
Cicatricosisporites subrotundus (Rare)
Densoisporites microrugulatus

Gleichenidites senonicus
Laevigatosporites ovatus
Leiotriletes mecklenburgensis
Leptolepidites verrucosus
Osmundacidites wellmannii (Common)
Rouseisporites simplex (Rare)
Stereisporites antiquasporites (Abundant)

Paleoenvironment:

Marginally marine

Comments

Dinoflagellates are common consisting of high tolerance marine species. Euryhaline algal cysts are rare. The miospores are abundant with high-dominance in gymnospermous pollen and generalized fern spores.

The presence of *C.vestitum, L.propatulum, C.huguoniotii, M.cingulata, C.delicatus* and *C.subrotundus* is indicative of the middle Albian *C.vestitum* Zone.

6: Sample designation: U.F. outcrop

Age & Zone

probable early to ? middle Albian *Vesperopsis mayi* Zone

Dinoflagellates

Astrocystra cretacea

Other Algae

No taxa present

Pollen

Alisporites spp. (Common)
Araucariacites australis
Cedripites canadensis
Cerebropollenites mesozoicus (Rare)
Parvisaccates rugiatus (+)
Parvisaccites amplus (+) (Common)
Phyllocladites inchoatus (+)
Taxodiaceaepollenites hiatus (Abundant)
Vitreisporites pallidus (Rare)

Fern and Moss Spores

Acanthotriletes varispinosum (+)
Cicatricosisporites #EF (+) (Rare)
Cicatricosisporites annulatus (+) (Rare)
Cyathidites australis
Gleichenidites senonicus (Rare)
Interiobites triangularis (+) (Rare)
Laevigatosporites ovatus (Common)
Lycopodiumsporites austroclavitidites (Rare)
Lycopodiumsporites marginatus
Osmundacidites wellmannii (Common)
Rouseisporites simplex (+)
Stereisporites antiquasporites (Common)

Fungal Spores

Pluricellaesporites spp.

Paleoenvironment:

paralic

Comments

Dinoflagellates are very rare consisting of a single opportunistic species. The miospores are abundant with high-dominance in gymnospermous pollen and generalized fern spores.

The sample lacks the primary zonal marker species of the *Vesperopsis mayii* Zone but it contains a several species that can be related to the terrigenous miospore zonation (Subzones 11A-B and possibly older) of equivalent age proposed by the Bujak Davies Group (1986) for the North America and Europe. *Ctenidodinium* sp. S of Banerjee and Davies (1988) is knwon from the Barremian to Albian Mannville Formation of Western Canada.

7: Sample designation: U.G. outcrop

Age & Zone

late Santonian *Chatangiella ditissima* Zone

Dinoflagellates

Astrocystra cretacea
Callalosphaeridium asymmetricum (+)
Chatangiella sp. 1, Bujak 1985 (+) (Common)

Chlamydophorella grossa (+) (Common)
Chlamydophorella nyei (Rare)
Cleistosphaeridium aciculare (Rare)
Cribroperidinium sp., McIntyre 1974 (Common)
Cyclonephelium distinctum (Common)
Dorocysta litotes (+)
Exochosphaeridium bifidum (Common)
Florentinia cooksoniae
Florentinia mantellii
Ginginodinium ornatum (+) (Rare)
Hystrichodinium pulchrum (Rare)
Hystrichosphaeridium difficile (+) (Abundant)
Hystrichosphaeropsis sp., McIntyre '74 (Common)
Isabelidinium amphiatum (Questionably present)
Isabelidinium magnum (Common)
Laciniadinium biconiculatum (+)
Laciniadinium orbiculatum (+) (Rare)
Odontochitina costata (Rare)
Odontochitina operculata (Common)
Oligosphaeridium complex (Common)
Oligosphaeridium pulcherrimum (+)
Pseudoceratium sp., McIntyre 1974 (Rare)
Pterodinium sp. 1 McIntyre 1974
Spiniferites cingulatus (Rare)
Spiniferites ramosus sensu lato
Trithyrodinium suspectum (+) (Common)
Xenascus ceratioides

Other Algae

Micrhystridium fragile (Common)

Pollen

Alisporites spp. (Abundant)
Taxodiaceaepollenites hiatus (Abundant)

Fern and Moss Spores

Cicatricosisporites delicatus
Converrucosisporites exquisitus
Cyathidites australis (Common)
Cyathidites minor (Common)
Laevigatosporites ovatus (Common)
Lycopodiumsporites austroclavitidites
Osmundacidites wellmannii (Common)
Stereisporites antiquasporites (Rare)
Stereisporites minor (Rare)

Fungal Spores

Pluricellaesporites spp.

Reworked Palynomorphs

Densosporites spp.

Paleoenvironment

neritic marine

Comments

Dinoflagellates are abundant and diverse in this sample, with most taxa indicating assignment to the *C. ditissima* Zone. One exception is a tentatively identified specimen of *Isabelidinium amphiatum* which, if correctly identified, would indicate and age no older than the early Campanian *Chatangiella coronata* Zone. However, the poorly preserved specimen may represent *Isabelidinium magnum* which occurs in the *C. ditissima* Zone.

Miospores are also common to abundant in this sample and include common water-transported fern spores.

8: Sample designation: U.H. outcrop

Age & Zone

late Turonian to early Coniacian *Eurydinium glomeratum* Zone

Dinoflagellates

Chlamydophorella nyei
Cleistosphaeridium aciculare (Rare)
Cribroperidinium sp., McIntyre 1974
Gen. et sp. indet. 1, Bujak 1985 (+) (Common)
Isabelidinium magnum (+) (Rare)
Nelsoniella aceras sensu McIntyre '74 (+) (Common)
Oligosphaeridium complex
Spiniferites cingulatus
Spiniferites ramosus sensu lato
Tanyosphaeridium xanthiopyxides

Other Algae

Micrhystridium fragile (Rare)

Pollen

Alisporites spp. (Abundant)
Taxodiaceaepollenites hiatus (Abundant)

Fern and Moss Spores

Acanthotriletes varispinosus
Camarozonosporites insignis
Cyathidites australis (Common)
Cyathidites minor (Rare)
Gleichenidites minor
Laevigatosporites ovatus (Rare)
Lycopodiumsporites austroclavitidites
Osmundacidites wellmannii (Rare)
Stereisporites antiquasporites (Common)
Stereisporites minor

Fungal Spores

Dicellaesporites sp. indet.

Reworked Palynomorphs

Muderongia asymmetrica

Paleoenvironment

stressed marine

Comments

Dinoflagellates are rare in this sample, but the population that ocurs is a high-dominance assemblage indicating a stressed marine environment. Miospores inlcuding water-transported fern spores are more common, reflecting some input of terrigenous material to the depositional site, and this is supported by the presence of rare fungal spores.

The rare marine dinoflagellates that occur indicate assignment to the late Turonian to early Coniacian *Eurydinium glomeratum* Zone.

9: Sample designation: U.I. outcrop

Age & Zone

early Turonian *Isabelidinium magnum* Zone

Dinoflagellates

Astrocystra cretacea (Rare)
Cleistosphaeridium aciculare (Common)
Cyclonephelium distinctum (Rare)
Dorocysta litotes (+)
Exochosphaeridium bifidum
Gen. et sp. indet. 1, Bujak 1985 (+) (Rare)
(in atlas)
Hystrichodinium lanceatum (Questionably present)
Hystrichosphaeropsis sp., McIntyre '74
Isabelidinium amphiatum (Questionably present)
Isabelidinium magnum (Rare)
Nelsoniella aceras sensu McIntyre 1974 (+) (Rare)
Odontochitina costata
Odontochitina operculata (Rare)
Oligosphaeridium complex (Common)
Oligosphaeridium pulcherrimum cf. (+)
Palaeohystrichophora infusorioides (Rare)
Spinidinium sverdrupianum (+)
Spiniferites cingulatus
Spiniferites ramosus sensu lato (Rare)
Xiphophoridium alatum
Xiphophoridium sp. 1 (+)

Other Algae

Micrhystridium fragile
Palambages spp. (Rare)

Pollen

Alisporites spp. (Abundant)
Taxodiaceaepollenites hiatus (Abundant)

Fern and Moss Spores

Acanthotriletes varispinosus
Cicatricosisporites mohrioides
Contignisporites cooksoniae
Costatoperforosporites foveolatus
Cyathidites australis (Abundant)
Cyathidites minor (Rare)
Foveotriletes triangularis
Laevigatosporites ovatus (Rare)
Lycopodiumsporites austroclavitidites
Lycopodiumsporites marginatus
Osmundacidites wellmannii (Rare)
Stereisporites antiquasporites (Common)
Stereisporites minor (Common)

Fungal Spores

Pluricellaesporites spp.

Reworked Palynomorphs

No taxa observed.

Paleoenviroment

nearshore marine

Comments

Dinoflagellates and water-transported fern spores are abundant in this sample, indicating a nearshore marine environment with the common input of terrigenous material to the depositional site. Fungal spores and euryhaline algae are also rare.

10: Sample designation: U.J. outcrop

Age & Zone

early Turonian *Isabelidinium magnum* Zone with Cenomanian to Albian reworking

Dinoflagellates

Astrocystra cretacea (Rare)
Chatangiella sp. 1, Bujak 1985 (+) (Rare)
Chlamydophorella nyei
Cleistosphaeridium aciculare
Cyclonephelium distinctum (Rare)
Gen. et sp. indet. 1, Bujak 1985 (+) (Rare)
Hystrichosphaeridium difficile
Isabelidinium magnum (+) (Rare)
Laciniadinium biconiculatum
Odontochitina operculata (Rare)
Oligosphaeridium macrotubulum
Spiniferites ramosus sensu lato
Trithyrodinium suspectum (+)

Other Algae

No taxa observed.

Pollen

Alisporites spp. (Abundant)
Paraalnipollenites confusus (Questionably present)
Taxodiaceaepollenites hiatus (Abundant)

Fern and Moss Spores

Acanthotriletes varispinosus
Aequitriradites sp. (Questionably present)
Cicatricosisporites hallei
Cicatricosisporites mohrioides
Cyathidites australis (Common)
Cyathidites minor (Rare)
Gleicheniidites minor
Gleicheniidites senonicus (Rare)
Laevigatosporites ovatus (Common)
Lycopodiumsporites austroclavitidites
Lycopodiumsporites marginatus
Osmundacidites wellmannii (Abundant)
Stereisporites antiquasporites (Common)
Stereisporites minor (Abundant)
Stereisporites regium (Rare)

Fungal Spores

No taxa observed.

Reworked Palynomorphs

Aequitriradites spinulosus
Luxadinium propatulum
Oligosphaeridium asterigerum
Parvisaccites amplus

Palaeoenviroment

nearshore marine

Comments

Dinoflagellate: rare to common
Miospores: common to abundant
Paleoenvironment: nearshore marine
Sample designation: U.J.
Zone: *Isabelidinium magnum*

Paleoenvironment:

nearshore marine

Comments

Dinoflagellates are rare to common and comprise marginal to open marine species, with water-transported fern spores being abundant. Euryhaline algal cysts are absent..

Most of the taxa that occur in this sample indicate assignment to the *Isabelidinium magnum* Zone, but Albian to Cenomanian dinoflagellates and gymnosperm pollen were also observed and are interpreted to be reworked, particularly due to the occurrence of the genus *Chatangiella*. A questionably identified poorly preserved specimen of the pollen *Paraalnipollenites confusus* would indicate assignment to strata no older than Maastrichtian, providing the specimen were correctly identified. However, this interpretation would indicate that almost all of

the other palynomorphs in the sample are reworked, and the preferred interpretation is that the sample should be assigned to the *Isabelidinium magnum* Zone.

11: Sample designation: U.K. outcrop

Age & Zone

late Aptian or older, *Oligosphaeridium asterigerum* Zone or possibly as old as Early Aptian.

Dinoflagellates

Eyrea nebulosa (Rare)
Florentina cooksoniae (+)
Luxadinium primulum (+) (Questionably present)
Oligosphaeridium asterigerum (+) (Rare)
Odontochitina operculata (corroded)
Subtilisphera sp. indet. (Rare)
Vesperopsis mayii (+)

Other Algae

No taxa observed.

Pollen

Alisporites spp. (Rare)
Araucariacites australis (Common)
Cedripites canadensis (Abundant)
Parvisaccites amplus (+) (Common)
Phyllocladites inchoatus (+)
Plicatella tricornitata (+)
Podocarpidites potomacensis
Podocarpidites epistriatus
Taxodiaceaepollenites hiatus (Abundant)
Vitreisporites pallidus

Fern and Moss Spores

Acanthotriletes varispinosum (+)
Cicatricosisporites delicatus (+)
Cicatricosisporites potomacensis (+)
Cyathidites australis
Gleichenidites senonicus
Interlobites triangularis (+)
Klukisporites foveolatus
Lycopodiumsporites austroclavitidites
Osmundacidites wellmannii (Rare)

Fungal Spores

No taxa observed.

Paleoenvironment:

paralic to marginally marine

Comments

Dinoflagellates are rare consisting of primarily opportunistic species and the occasional marine species. Euryhaline algal cysts are absent. The miospores are abundant with high-dominance in gymnospermous pollen and generalized fern spores. Black coaly material is abundant.

The association of *O. asterigerum*, *V.mayii*, and *L. primulum* suggest assignment to the late Aptian *Oligosphaeridium asterigerum* Zone although most species range down further into the Aptian. The miospores are long-ranging indicating a Barremian to early Albian Age.

12: Sample designation: U.L. outcrop

Age & Zone

early - ? middle Albian, *Vesperopsis mayi* Zone

Dinoflagellates

Astrocystra cretacea (+) (Common)
Cribroperidinium edwardsii (+)
Ctenidodinium #ES, Banerjee & Davies '88 (+) (Rare)
Stiphrosphaeridium anthophorum (+) (Questionably present)
Subtilisphaera sp. indet.
Vesperospis mayii (+) (questionably present)

Other Algae

Schizocysta parva

Pollen

Alisporites spp. (Common)
Araucariacites australis (Common)
Cedripites canadensis (Common)
Parvisaccites amplus (+)
Phyllocladites inchoatus (+)
Podocarpidites epistriatus
Retitricolpites vulgaris (+)
Taxodiaceaepollenites hiatus (Abundant)

Fern and Moss Spores

Acritosporites excavatus (+)
Aequitriradites spinulosus
Cicatricosisporites #EF (+)
Cyathidites australis (Common)
Gleichenidites minor
Gleichenidites senonicus (Rare)
Granulatisporites sp. A
Klukisporites foveolatus
Lycopodiumsporites austroclavitidites
Osmundacidites wellmannii
Plicatella problematicus (+)
Podocarpidites epistriatus

Fungal Spores

No taxa observed.

Paleoenvironment:

Paralic to marginally marine

Comments

Dinoflagellates are rare consisting of primarily opportunistic species. Euryhaline algal cysts are rare. The miospores are abundant with high-dominance in gymnospermous pollen and generalized fern spores.

The association of *?V. mayii, Ctenidodinium sp. S, C.edwardsii, Cicatricosisporites* #EF, *P. amplus, P.problematicus* and *R.vulgaris* suggests an assignment to the early to ?middle Albian *Vesperopsis mayii* Zone.

<u>13: Sample designation: U.M. outcrop</u>

Age & Zone

probable middle to late Albian. *Chichaouadinium vestitum* to *Chichaouadinium davidii* Zones

Dinoflagellates

Achomosphaera sp. indet.
Astrocystra cretacea
Callalosphaeridium asymmetricum (+)
Canningia colliveri
Chichaouadinium sp. indet. (+)
? *Eyrea nebulosa*
Eurydinium glomeratum (+) (Rare)
Fromea complicata (+)
Hystrichodinium pulchrum (+) (Rare)
Hystrichosphaeridium difficile(Questionably present)
Imbatodinium jaegeri (+)
Luxadinium primulum (+) (Questionably present)
Luxadinium propatulum (+) (Questionably present)
Maghribina cingulata (+)
Odontochitina operculata
Oligosphaeridium complex
Paleohystrichophora infusorioides
Spiniferites sp. indet.

Other Algae

Schizocysta parvus

Pollen

Alisporites spp. (Common) alb: an + of dn in Cat
Parvisaccites amplus (+) =
Taxodiaceaepollenites hiatus (Abundant)
Vitreisporites pallidus

Fern and Moss Spores

Acanthotriletes varispinosum
Camarozonosporites insignis
Cicatricosisporites annulatus (+)
Crybelisporites pannaceus (+)
Cyathidites australis (Common)
Distaltriangulisporites costatus (+) (Rare)
Leiotriletes mecklenburgensis
Lycopodiumsporites austroclavitidites
Lycopodiumsporites marginatus
Osmundacidites wellmannii (Rare)
Pilosisporites crassiangularis
Rouseisporites reticulatus
Stereisporites antiquasporites
Striamonoletes auritus (+)

Fungal Spores

No taxa observed.

Reworked Palynomorphs

Hymenozonosporites/leptolepidiphytes(Devonian)

Paleoenvironment:

Restricted marine with high freshwater influx.

Comments

Dinoflagellates are common consisting of primarily opportunistic euryhaline species along with a few rare open marine species. Euryhaline algal cysts are rare. The miospores are abundant with high-dominance in gymnospermous pollen and generalized fern spores.

The association of the dinoflagellates *Chichaouadinium sp., E.glomeratum, F.complicata, I.jaegeri, L.primulum, L.propatulum, and M.cingulata* along with the miospores *C.annulatus, C.pannaceus, D.costatus* and *S.auritus* indicates assignment to the middle to late Albian *C.vestitium* to *C.davidii* Zones

<u>14: Sample designation: U.N. outcrop</u>

Age & Zone

either
(1) early to ?middle Albian *Vesperopsis mayi* Zone, or
(2) Turonian *Eurydinium glomeratum* Zone with Cenomanian reworking

Dinoflagellates

Astrocystra cretacea
Cyclonephelium distinctum (Rare)
Gen. et sp. indet. 1, Bujak 1985 (+) (Common)
Luxadinium primulum (?reworked)
Nelsoniella aceras sensu McIntyre 1974 (+) (Questionably present)
Spiniferites cingulatus
Spiniferites ramosus sensu lato (Rare)

Other Algae

No taxa observed.

Pollen

Alisporites spp. (Common)
Parvisaccites amplus (Common)
Taxodiaceaepollenites hiatus (Abundant)
Ulmipollenites undulosus (?contaminant)

Fern and Moss Spores

Acanthotriletes varispinosus
Cicatricosisporites hallei
Cicatricosisporites mohrioides
Cyathidites australis (Common)
Cyathidites minor (Common)
Laevigatosporites ovatus (Rare)
Lycopodiumsporites austroclavitidites
Osmundacidites wellmannii (Common)
Stereisporites antiquasporites (Rare)
Stereisporites minor (Rare)

Fungal Spores

No taxa observed.

Reworked Palynomorphs

Densosporites spp.

Paleoenvironment

stressed marine

Comments

Dinoflagellates are extremely rare in this sample and include species indicating assignment to the *Eurydinium glomeratum* Zone. A single specimen of the dinoflagellate *Luxadinium primulum* would indicate the penetration of Cenomanian strata, providing the observed specimen were in place.

A specimen of the angiosperm pollen *Ulmipollenites undulosus* is interpreted to be a modern contaminant.

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