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PALYNOLOGICAL ANALYSIS OF 48 OUTCROP SAMPLES FROM THE COLVILLE RIVER AND IVISHAK RIVER AREAS, NORTHERN ALASKA

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INTRODUCTION

This report describes the results of palynological analyses of nine samples from the Colville River area and 39 samples from the Ivishak River area, northern Alaska.

The samples were processed by Eric Young at the Bujak Davies Group and palynological analysis was performed by Dr. J.P. Bujak and Dr. E.H. Davies to determine the age and depositional environments of the samples.

Sample processing involved standard acid maceration in HCl and HF, followed by heavy liquid separation utilizing zinc bromide solution at 2.0 SG. Kerogen sub-samples were taken for the determination of Thermal Alteration Index (TAI), prior to concentration of the palynomorphs through oxidation and sieving. During the palynological analysis, an unoxidized kerogen slide, a coarse fraction palynolgical slide (>20 microns) and a fine fraction palynological slide (>10 and <20microns) were examined to determine the relative abundances of the in situ palynological assemblages in each sample.

The following categories were used to record the relative abundances of species:

present:	one specimen
rare:	2 to 4 specimens
common:	5 to 19 specimens
abundant:	more than 20 specimens

Palynological age assignments of the examined samples mainly utilize the occurrences of index species of marine dinoflagellates; brackish and freshwater algae including some dinoflagellates; the spores and pollen of terrestrial plants; and fungal spores.

The integrated Mesozoic-Cenozoic palynological zonation used for the biostratigraphic subdivision and age determinations in the examined samples has not been published but is shown in Figure 1. The zonation primarily utilizes unpublished data from previously examined surface and subsurface sections from North Alaska, plus data

from adjacent regions including the Bering Sea and the Beaufort-Mackenzie area. The age assignments of these zones are based on the established stratigraphic ranges of species from well-documented surface sections in regions extending from the Japanese area to northwest Europe.

The unpublished Cenzoic zonation for North Alaska is calibrated against zonations which have been published or are in press for the Bering Sea (Matsuoka & Bujak, 1988), the Japanese area (Matsuoka, 1983; Matsuoka et al., 1987), and the Beaufort Sea (Bujak & Matsuoka, in press). These in turn are calibrated against the published Bering Sea diatom-silicoflagellate and radiolarian zonations; the Japanese planktonic foraminiferal and nannofossil zonations; and dinoflagellate zonations previously established for the North Atlantic (Costa & Downie, 1979), Norwegian Sea (Manum, 1976), northwest Europe (listed in Williams & Bujak, 1985), offshore eastern Canada (Williams & Bujak, 1977), and the Bay of Biscay (Harland, 1979).

Previous unpublished palynological work utilized from North Alaska includes subsurface localities from the Flaxman Island Area and surface samples from the ANWR. In the nearby Beaufort-Mackenzie region, a synthesis of existing data by Bujak (1984a) utilized his observations on offshore and onshore sections plus the published work of Doerenkamp et al. (1976), Ioannides & McIntyre (1980), and Rouse (1977). Additional data on the age of certain zones were also provided by Piel (1971) based on surface sections from British Columbia.

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 Bujak (1984a) 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 unpublished Northern Hemisphere Oxfordian and younger Miospore Atlas of the Bujak Davies Group which also discusses the Berriasian to Turronian section.

Data are also given for each samples on the Thermal Alteration Index (TAI) based on the scale documented by Bujak *et al.* (1976a,1976b), as shown in figure 2 of this report.

AGE	C#		ZONATION	
PLEISTOCENE	9		Laevigatosporites ovatus	
PLIOCENE	8	B	Nalodinium cornutum	N.cornutum
		A		S.obscura
MIOCENE	7	D	Tsugaepollenites igniculus	F.lilifera
		C		S.ancyrea
		B		P.laticinctum
		A		P.paradoxum
OLIGOCENE	6	C	Ericipites compacti-pollenitus	———
		B		C.pseudopocusum
		A		———
	5		Boisduvalia clavatites	
EOCENE	4		Tiliaepollenites vescipites	
	3	C	Pesavis tagluensis	L.wetzelii
		B		P.echinatum
		A		G.ordinale cf.
	2		Apectodinium homomorphum	
PALEOCENE	1	B	Paraalnipollenites confusus	P.confusus
		A		P.pyrophorum

AGE	K#	ZONATION
MAASTRICHTIAN	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.B
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	Chytroeisphaeridia 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	Ctenidodinium combazii
	8	Energlynia sp.A
	7	Kylindrocysta sp.C
BAJOCIAN	6	Gongylodinium hocneratum
	5	Comparodinium aquilonium
AALENIAN	4	Wallodinium elongatum
TOARCIAN	3	Dapcodinium cosillarum
PLIENSBACHIAN	2	Lithodinia serrulata
SINEMURIAN	1	Dapcodinium priscum
HETTANGIAN		

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

Figure 1. Mesozoic-Cenozoic palynological zonation used in the present study, based on published work and unpublished data of the Bujak Davies Group.

TAI	SPORE COLOUR	Ro% EQUIVALENT	AMORPHOUS KEROGEN	HERBACEOUS/ WOODY KEROGEN
1	Green-yellow	<0.3%	Immature	Immature
1+	Yellow	0.35%	Immature	Immature
2-	Yellow-orange	0.45%	Immature	Immature
2- to 2	Orange	0.50%	Onset of maturity	Immature
2	Orange-brown	0.6%	Mature	Immature
2 to 2+	Brown-orange	0.7%	Peak maturity	Onset of maturity
2+	Light brown	0.9%	Peak matority	Onset of maturity
2+ to 3-	Light brown-brown	1.0%	Highly mature	Peak maturity
3-	Brown	1.1%	Highly mature	Peak maturity
3- to 3	Medium brown	1.2%	Highly mature	Peak maturity
3	Brown/dark brown	1.5%	Overmature	Peak maturity
3+	Dark brown	2.0%	Overmature	Highly mature
4-	Black	2.5%	Overmature	Highly mature
4	Black/corroded	4.0%	Overmature	Overmature

Figure 2. Thermal Alteration Index (TAI) scale used in the present study.

BIOSTRATIGRAPHIC SUMMARY LISTING ONLY THOSE SAMPLES WITH RELIABLE AGE DETERMINATIONS BASED ON PALYNOLOGY

SAMPLE: 88MR6A
Isabelidinium amphiatum Zone
(early Maastrichtian)
marginally marine

SAMPLE 88MR7A
Indeterminate zone
(possibly Albian)
non-marine to paralic

SAMPLE 88MR8B
Isabelidinium amphiatum Zone
(early Maastrichtian)
non-marine to paralic

SAMPLE 88POS40L
Chatangiella ditissima Zone
(late Santonian)
inner to middle neritic

SAMPLE NS402
Indeterminate zone
(Cretaceous)
marginally marine

SAMPLES NS508
Isabelidinium amphiatum Zone
(early Maastrichtian)
non-marine to paralic

SAMPLE 89MR8C
Indeterminate zone
(probable Early Cretaceous)
non-marine to paralic

SAMPLE 89MR13C
Indeterminate zone
(Barremian to Albian)
marginally marine

SAMPLE 89MR16C
Indeterminate zone
(Jurassic)
non-marine to paralic

SAMPLE 89MR16E
Wallodinium elongatum Zone
(Bajocian)
paralic to marginally marine

SAMPLE 89MR39C
Indeterminate zone
(Early Cretaceous)
paralic - marginal marine

SAMPLE 89MR44C
Vesperopsis mayi Zone
(early Albian)
paralic

SAMPLE 89RR19A
Indeterminate zone
(probably Jurassic)
paralic to marginally marine

SAMPLE 89RR39B
Indeterminate
(Barremian to Aptian)
marginal marine

SAMPLE 89RR45C
Oligosphaeridium abaculum Zone or older
(Berriasian to Hauterivian)
marginal marine

SAMPLE 89RR46A
tentatively *Paragonyaulacysta borealis* Zone
(Berriasian)
marginally marine - inner neritic

SAMPLE 89PE22B
Chatangiella ditissima to C. *coronata* Zones
(Santonian to Campanian)
marginally marine - inner neritic

SAMPLE 89PE34
possibly *Kylindrocysta* sp.C Zone
(possible Bathonian)
paralic - inner neritic

SAMPLE 89PE49
Indeterminate zone
(probable Jurassic)
paralic - inner neritic

SAMPLE NS90A
Indeterminate zone
(Aptian to early Albian)
paralic to marginally marine

BIOSTRATIGRAPHIC RESULTS

Ages are assigned according to the concurrent ranges of the marker species, indicated by (+).

SAMPLE 88MR5B

Zone Indeterminate (Indeterminate age)

Miospores

Allsporites bilateralis (Common)
Corollina torosa (?reworked)
Cyathidites australis (Rare)
Laevigatosporites ovatus (Common)
Lycopodiumsporites austroclavitidites
Lycopodiumsporites circolumenus
Lycopodiumsporites marginatus
Osmundacidites wellmannii (Rare)
Sterelsporites antiquasporites
Taxodiaceaepollenites hiatus

Assemblage Characteristics

miospores uncommon
mostly woody kerogen
no dinoflagellates observed

Paleoenvironment: A non-marine to paralic depositional environment is indicated by the presence of common terrigenous miospores and the lack of marine dinoflagellates.

Comments: All of the palynomorphs presnt in this sample are long-ranging taxa, so that it is not possible to determine the age or zonal assignment based on the present study. If the single observed specimen of *C. torosa* were in place it would indicate an age no younger than Turonian based on its stratigraphic range in the Alaskan North Slope region.

TAI: 2-

SAMPLE: 88MR6A

***Isabelidinium amphiatum* Zone (early Maastrichtian)**

Microplankton

Isabelidinium amphiatum (+)

Miospores

Acanthotriletes varispinosus
Allsporites bilateralis (Rare)
Araucariacites australis (Rare)
Araucariacites punctatus
Cyathidites australis (Rare)
Cyathidites minor
Deltoidospora hallii
Mancicorpus senonicum (+) (Rare)
Laevigatosporites ovatus (Common)
Lycopodiacidites irregularis
Lycopodiumsporites austroclavitidites (Rare)
Lycopodiumsporites circolumenus
Osmundacidites wellmannii (Abundant)
Stereisporites antiquasporites (Abundant)

Assemblage Characteristics

dinoflagellates rare
miospores uncommon
mostly woody kerogen

Paleoenvironment: A marginally marine depositional environment is indicated by the presence of rare dinoflagellates.

Comments: Most species are long-ranging and poorly preserved, with only rare marker species being present.

TAI: 2

SAMPLE 88MR7A

Zone indeterminate (possibly Albian)

Miospores

Allsporites bilateralis (Rare)
Araucariacites australis
Araucariacites punctatus
Baculatisporites comaumensis
Cyathidites australis (Abundant)
Cyathidites minor (Common)
Deltoidospora diaphana (Common)
Deltoidospora hallii (Common)
Granulatisporites #EA (+) (Abundant)
Laevigatosporites ovatus (Abundant)
Leptolepidites bossus (+)
Lycopodiacidites irregularis (+) (Common)
Lycopodiumsporites austroclavitidites (Common)
Lycopodiumsporites circolumenus (Common)
Osmundacidites wellmannii (Abundant)
Perinopollenites elatoides (Rare)
Polypodiidites favus (Rare)
Psilatricolpites parvus (+)
Stereisporites antiquasporites (Common)
Taxodiaceaepollenites hiatus (Rare)

Assemblage Characteristics

abundant fern spores
abundant woody kerogen

Paleoenvironment: A non-marine to paralic depositional environment is indicated by abundant terrigenous miospores and rare dinoflagellates.

Comments: Similar assemblages dominated by the species *Granulatisporites #EA* occur rarely in the Albian of Alberta and northeastern British Columbia.

TAI: 2- to 2

SAMPLE 88MR8B

***Isabelidinium amphiatum* Zone (early Maastrichtian)**

Miospores

Alisporites bilateralis (Common)
Aquilapollenites quadrilobatus (+) (Dominant)
Cyathidites australis (Rare)
Laevigatosporites ovatus (Rare)
Lycopodiumsporites circolumenus
Osmundacidites wellmannii (Common)
Perinopollenites elatoides
Stereisporites antiquasporites (Abundant)
Stereisporites clavus (Common)
Taxodiaceaepollenites hiatus (Abundant)
Verrucosisporites subrotundus (Abundant)

Assemblage Characteristics

common woody kerogen

Paleoenvironment: A non-marine to paralic depositional environment is indicated by a terrigenous high-dominance pollen assemblage and the lack of dinoflagellates.

Comments: The high dominance of the angiosperm pollen *Aquilapollenites* suggests deposition close to the plant source.

TAI: 2-

SAMPLE 88POS68B

Zone Indeterminate (Indeterminate age)

Miospores

Allsporites bilateralis (Common)
Betulaceoipollenites betuloides (+) (Questionably present)
Cerebropollenites #ECoptosporoid (+)
Deltoidospora diaphana
Laevigatosporites ovatus
Taxodiaceaepollenites hiatus

Assemblage Characteristics

poor preservation
two kerogen populations

Paleoenvironment: A non-marine to paralic depositional environment is indicated by the presence of a terrigenous miospore assemblage with predominately gymnospermous pollen, and by the lack of dinoflagellates.

Comments: A highly tentative mid Cretaceous age is indicated by the presence of *Cerebropollenites #*ECoptosporoid, but this specimen may be reworked into a Cenozoic section containing the pollen *Betulaceoipollenites betuloides.*

TAI: 2

SAMPLE 88POS69B

Zone Indeterminate (indeterminate age)

Assemblage Characteristics

mostly woody kerogen

Paleoenvironment: Indeterminate

Comments: No palynomorphs were observed in this sample.

TAI: 1+ to 2-

SAMPLE 88POS40L

***Chatangiella ditissima* Zone (late Santonian)**

Microplankton

Alterbidinium minor (+)
Chatangiella ditissima (+)

Miospores

Acanthotrilletes varispinosus
Alisporites bilateralis (Common)
Araucariacites australis (Rare)
Cyathidites australis (Common)
Cyathidites minor (Common)
Deltoidospora diaphana (Common)
Laevigatosporites ovatus (Abundant)
Lycopodiacidites irregularis (Rare)
Lycopodiumsporites austroclavitidites (Common)
Lycopodiumsporites circolumenus (Common)
Osmundacidites wellmannii (Abundant)
Stereisporites antiquasporites (Common)
Taxodiaceaepollenites hiatus (Common)
Verrucosisporites subrotundus (Rare)

Paleoenvironment: A nearshore inner to middle neritic marine depositional environment is indicated by the presence of rare dinoflagellates and abundant terrestrial miospores.

TAI: 1+

SAMPLE NS402

Zone Indeterminate (Cretaceous)

Microplankton

Odontochitina operculata (+)

Miospores

Alisporites bilateralis (Rare)
Cyathidites australis (Rare)
Cyathidites minor
Laevigatosporites ovatus
Osmundacidites wellmannii (Rare)
Stereisporites antiquasporites
Verrucosisporites subrotundus

Paleoenvironment: A marginally marine depositional environment is indicated by the presence of a single dinoflagellate specimen.

Comment: All palynomorphs belong to long-ranging species, although the dinoflagellate *Odontochitina operculata* has a stratigraphic range from the Berriasian to Campanian.

TAI: 1+

SAMPLE NS508

***Isabelidinium amphiatum* Zone (early Maastrichtian)**

Microplankton

Palaeoperidinium pyrophorum (+)

Miospores

Allsporites bilateralis
Triptojectus magnus (+)
Cyathidites minor
Stereisporites antiquasporites
Taxodiaceaepollenites hiatus

Assemblage Characteristics

mostly woody kerogen

Paleoenvironment: A non-marine to paralic depositional environment is indicated by the assemblage of rare terrigenous miospores and dinoflagellates.

TAI: 1+

SAMPLE 89MR2C

Zone Indeterminate (Indeterminate age)

Miospores

Deltoidospora hallii

Assemblage Characteristics

Black woody and coaly material dominant

Paleoenvironment: Indeterminate

Comments: The single palynomorph found in the sample is a long-ranging Mesozoic to Cenozoic spore.

TAI: 2+

SAMPLE 89MR3A

Zone Indeterminate (Jurassic to Cretaceous)

Miospores

Allsporites bilateralis

Assemblage Characteristics

abundant black coaly material
poor preservation

Paleoenvironment: indeterminate

Comments: The rare in situ palynomorph is highly corroded. The assemblage is contaminated with rare modern pollen.

TAI: 2+

SAMPLE 89MR7C

Zone Indeterminate (Indeterminate age)

Miospores

Lycopodiumsporites annotinioides

Assemblage Characteristics

abundant black coaly material

Paleoenvironment: Indeterminate

Comments: The highly corroded and thermally altered kerogen is contaminated with rare modern spores.

TAI: 2+ to 3-

SAMPLE 89MR8C

Zone Indeterminate (probable Early Cretaceous)

Miospores

Cedripites canadensis (Questionably present)
Perinopollenites elatoides

Assemblage Characteristics

abundant black coaly material
thermally corroded

Paleoenvironment: A non-marine to paralic depositional environment is indicated by the presence of rare terrigenous gymnospermous pollen and the absence of dinoflagellates.

Comments: The palynomorphs are highly thermally altered making, identifications difficult.

TAI: 3

SAMPLE 89MR9C

Zone indeterminate (indeterminate age)

Miospores

Laevigatosporites ovatus
Lycopodiumsporites annotinloides (Common)

Assemblage Characteristics

abundant black coaly material

Paleoenvironment: indeterminate

Comments: The dark thermally altered in situ assemblage is contaminated by common modern spores

TAI: 3

SAMPLE 89MR13C

Zone Indeterminate (Barremian to Albian)

Microplankton

Achomosphaera sp. Indet. (Rare)
Astrocysta cretacea (+) (Rare)
Cleistosphaeridium sp. Indet. (Common)
Cribroperidinium sp. Indet.
Kleithriasphaeridium loffrense (+)
Muderongia simplex simplex (+) (Questionably present)
Pterodinium aliferum (+) (Questionably present)
Spiniferites ramosus ramosus

Miospores

Allsporites grandis
Araucariacites australis
Cedripites canadensis (+) (Rare)
Laevigatosporites ovatus
Podocarpidites granulosus

Assemblage Characteristics

black coaly material (Abundant)

Paleoenvironment: A marginally marine depositional environment is indicated by an assemblage of dinoflagellates with low diversity and low abundances.

Comments: The assemblage mostly contains long-ranging Early Cretaceous species.

TAI: 2

SAMPLE 89MR16C

Zone Indeterminate (Jurassic)

Miospores

Acanthotriletes varispinosus
Corollina sp. indet. (+) (Abundant)

Assemblage Characteristics

black coaly material (Dominant)
thermally corroded

Paleoenvironment: A non-marine to paralic depositional environment is indicated by the high-dominance gymnospermous assemblage and the absence of dinoflagellates.

Comments: Palynomorphs in this sample have high thermal alteration and are very difficult to identify. Assemblages dominated by *Corollina* are generally Jurassic but they may rarely found in Early Cretaceous in the Alaskan North Slope region.

TAI: 3+

SAMPLE 89MR16D

Zone Indeterminate (Jurassic to Early Cretaceous)

Miospores

Cerebropollenites mesozoicus (Questionably present)
Corollina sp. indet.

Assemblage Characteristics

black coaly material (Dominant)
poor preservation
thermally corroded

Paleoenvironment: A non-marine to paralic depositional environment is indicated by the terrigenous assemblage of rare gymnospermous pollen and the absence of dinoflagellates.

Comments: Only rare thermally altered miospores which are highly corroded are present.

TAI: 4-

SAMPLE 89MR16E

***Wallodinium elongatum* Zone (Bajocian)**

Microplankton

Escharisphaeridia sp. indet. (+) (Rare)
Nannoceratopsis senex (+) (Questionably present)
Parvocysta cracens (+) (Common)

Miospores

Allsporites thomasii (+)
Corollina sp. indet. (Rare)
Deltoidospora hallii
Podocarpidites epistriatus

Assemblage Characteristics

black coaly material (Dominant)

Paleoenvironment: A paralic to marginally marine depositional environment is indicated by the presence of a high-dominance dinoflagellate assemblage.

Comments: The few palynomorphs are thermally corroded but still easily identifiable such as the zonal marker species *Parvocysta cracens.*

TAI: 3

SAMPLE 89MR18C

Zone indeterminate (indeterminate age)

Miospores

Spore indet.

Assemblage Characteristics

black coaly material (Dominant)

Paleoenvironment: indeterminate

Comments: The rare palynomorphs are too thermally altered to be identified.

TAI: 4-

SAMPLE 89MR19C

Zone indeterminate (indeterminate age)

Assemblage Characteristics

black coaly material (Dominant)
fungal hyphae and spores (Common)

Paleoenvironment: indeterminate

Comments: Only thermally altered black coaly material is considered to be in place. The common fungal hyphae and spores in the sample probably represent a weathered soil zone.

TAI: 3

SAMPLE 89MR24C

Zone Indeterminate (indeterminate age)

Assemblage Characteristics

black coaly material (Dominant)

Paleoenvironment: indeterminate

TAI: 4-

SAMPLE 89MR30C

Zone Indeterminate (indeterminate age)

Microplankton

Melourogonyaulax sp. indet. (+) (Questionably present)

Assemblage Characteristics

abundant black coaly material

Paleoenvironment: indeterminate

Comments: If the highly corroded specimen of *Melourogonyaulax* is identified correctly then a Middle to Late Jurassic age and a marine depositional environment is indicated.

TAI: 2+

SAMPLE 89MR32C

Zone Indeterminate (indeterminate age)

Assemblage Characteristics

black coaly material (Dominant)

Paleoenvironment: Indeterminate

TAI: 4-

SAMPLE 89MR33D

Zone Indeterminate (indeterminate age)

Miospores

Coronatispora valdensis (Questionably present)

Assemblage Characteristics

black coaly material (Abundant)
woody kerogen (common)

Paleoenvironment: A probable high-energy, non-marine to paralic depositional environment is indicated by the presence of common woody kerogen and the absence of other palynomorphs.

Comments: If *Coronatispora valdensis* is correctly identified then a Middle Jurassic to Early Cretaceous age is indicated.

TAI: 3-

SAMPLE 89MR39C

Zone Indeterminate (Early Cretaceous)

Microplankton

Cleistosphaeridium sp. Indet.

Miospores

Alisporites bilateralis
Araucariacites australis
Deltoidospora hallii
Vitreisporites pallidus

Assemblage Characteristics

black coaly material (Dominant)

Paleoenvironment: A paralic - marginal marine depositional environment is indicated by the dinoflagellate assemblage which has low diversity and low abundances.

Comments: The few fossils present are mostly long-ranging Jurassic to Cretaceous species.

TAI: 2+

SAMPLE 89MR44C

Vesperopsis mayi Zone (early Albian)

Microplankton

Astrocysta cretacea (+) (Rare)
Cyclonephelium distinctum (Rare)
Kleithriasphaeridium loffrense (+)
Subtilisphaera pirnaensis (kalyptra) (+) (Rare)
Vesperopsis mayii (+) (Abundant)

Miospores

Alisporites grandis (Rare)
Cedripites canadensis (+) (Common)
Deltoidospora hallii
Stereisporites antiquasporites
Taxodiaceaepollenites hiatus (Rare)
Vitreisporites pallidus (Rare)

Assemblage Characteristics

black coaly material (Abundant)

Paleoenvironment: A paralic depositional environment with brackish water is indicated by the presence of the opportunistic species *Vesperopsis mayi.*

TAI: 3-

SAMPLE 89MR49C

Zone Indeterminate (indeterminate age)

Assemblage Characteristics

black coaly material (Dominant)

Paleoenvironment: indeterminate

Comments: No palynomorphs were observed in the thermally corroded kerogen.

TAI: 3+

SAMPLE 89MR50C

Zone Indeterminate (indeterminate age)

Assemblage Characteristics

black coaly material (abundant)

Paleoenvironment: indeterminate

Comments: The oxidized and poorly preserved kerogen suggests that the sample is weathered rock.

TAI: 3

SAMPLE 89RR19A

Zone Indeterminate (probably Jurassic)

Microplankton

Pareodinia ceratophora (+)

Miospores

Allsporites bilateralis (Rare)
Corollina sp. indet. (+) (Common)

Assemblage Characteristics

black coaly material (Abundant)
poor preservation
thermally corroded

Paleoenvironment: A paralic to marginally marine depositional environment is suggested by the single, poorly preserved specimen of *Pareodinia ceratophora*.

TAI: 3+

SAMPLE 89RR20-500

Zone Indeterminate (indeterminate age)

Miospores

Osmundacidites wellmannii
Selaginellaites perinatus

Assemblage Characteristics

black coaly material (Abundant)
woody and root fragments (Abundant)
oxidized kerogen

Paleoenvironment: Indeterminate

Comments: The highly oxidized kerogen is contaminated with woody and root fragments as well as modern algae and miospores, suggests that most palynomorphs in this sample represent a weathering or soil zone. The in situ assemblage has very poor preservation so that the palynomorphs are difficult to identify.

TAI: 3-

SAMPLE 89RR20-1856

Zone Indeterminate (indeterminate age)

Assemblage Characteristics

black coaly material (Dominant)

Paleoenvironment: Indeterminate

Comments: The kerogen is oxidized and possibly represents a weathered rock.

TAI: 3-

SAMPLE 89RR20-2722

Zone Indeterminate (Late Jurassic to Early Cretaceous)

Miospores

Cedripites canadensis

Assemblage Characteristics

black coaly material (Dominant)
woody kerogen (Abundant)

Paleoenvironment: Non-marine to Paralic

Comments: The assemblage contains only rare long-ranging Late Jurassic to Early Cretaceous gymnospermous pollen.

TAI: 2

SAMPLE 89RR26B

Zone indeterminate (indeterminate age)

Assemblage Characteristics

black coaly material (Dominant)

Paleoenvironment: Indeterminate

Comment: No palynomorphs were observed in this sample.

TAI: 3+

SAMPLE 89RR39B

Zone indeterminate (Barremian to Aptian)

Microplankton

Sverdrupiella sp. indet. (reworked Triassic)
Apteodinium sp. indet.
Cleistosphaeridium huguoniotii (+)
Cyclonephelium brevispinum (+)
Gardodinium eisenackii (+)
Odontochitina operculata (+)
Oligosphaeridium complex (+)
Spiniferites ramosus ramosus

Miospores

Hymenoxonosporites lepidophytus (Common)
Kraeuselisporites sp. indet. (Reworked Triassic)
Taenaesporites sp. indet.
Alisporites thomasii
Cedripites canadensis (Common)
Deltoidospora diaphana (Common)
Granulatisporites #EA (+)

Paleoenvironment: A marginal marine depositional environment is indicated by the dinoflagellate assemblage which has low diversity and low abundances.

Comments: High amounts of reworked Triassic and Paleozoic palynomorphs occur in this sample.

TAI: 2

SAMPLE 89RR45C

***Oligosphaeridium abaculum* Zone or older (Berriasian to Hauterivian)**

Microplankton

Apteodinium sp. indet. (+)
Gonglyodinium sp. indet. (Questionably present)
Oligosphaeridium asterigerum (+)
Simlodinium grossii (+)

Miospores

Taenaesporites sp. indet. (Reworked Triassic)
Alnipollenites verus (Cavings)
Cedripites #EH (+) (Rare)
Cedripites canadensis
Deltoidospora hallii (Rare)
Stereisporites antiquasporites

Paleoenvironment: A marginal marine depositional environment is indicated by the dinoflagellate assemblage which has low diversity and low abundances.

TAI: 2

SAMPLE 89RR46A

tentatively *Paragonyaulacysta borealis* Zone (Berriasian)

Microplankton

Oligosphaeridium asterigerum (+)
Paragonyaulacysta borealis (+)

Miospores

Hymenozonosporites lepidophytus (Common- reworked Devonian)
Ablespollenites sp. indet.
Allsporites grandis (Rare)
Callialasporites dampieri (+)
Cedripites canadensis (Rare)
Cycadopites nitidus (Rare)
Distaltriangulisporites sp. indet.
Osmundacidites wellmannii
Sterelsporites antiquasporites
Taurocusporites reduncus (Rare)

Miscellaneous Palynomorphs

Tasmanites sp. indet. (Rare)

Paleoenvironment: A marginally marine - inner neritic depositional environment is indicated by the rare dinoflagellates.

Comments: Devonian reworking is common.

TAI: 2

SAMPLE 89RR65B

Zone Indeterminate (Indeterminate age)

Miospores

Hymenozonosporites lepidophytus (reworked Devonian)

Assemblage Characteristics

black coaly material (Dominant)

Paleoenvironment: Indeterminate

Comments: No in situ palynomorphs are presnet. Only oxidized kerogen with re-worked Devonian spores were observed.

TAI: possibly 4-

SAMPLE 89RR70A

Zone Indeterminate (Indeterminate age)

Miospores

Lycopodiumsporites annotinioides (Rare)

Assemblage Characteristics

black coaly material (Abundant)
wood and root fragments (Dominant)
fungal hyphae and spores (Rare)

Paleoenvironment: Indeterminate

Comments: The presence of wood and root fragments with fungal hyphae and spores suggests that this sample represents a weathered or soil zone.

TAI: possibly 3-

SAMPLE 89PE22B

Chatangiella ditissima to _Chatangiella coronata_ Zones (Santonian to Campanian)

Microplankton

Achomosphaera sp. indet.
Chatangiella coronata (+) (Common)
Chatangiella sverdrupiana (+)
Cribroperidinium sp. indet. (Reworking)
Cyclonephelium distinctum
Geiselodinium sp. (Rare)
Isabelidinium belfastense (+) (Rare)
Oligosphaeridium complex
Tubotuberella rhombiformis (Reworking)

Miospores

Allsporites bilateralis
Aquilapollenites quadrilobatus (+)
Osmundacidites wellmannii

Assemblage Characteristics

black coaly material (Abundant)

Paleoenvironment: A marginally marine - inner neritic depostional environment with high energy.

Comments: Dinoflagellate specimens are highly weathered.

TAI: 2

SAMPLE 89PE34

possible *Kylindrocysta* sp.C Zone (possible Bathonian)

Microplankton

Kylindracysta sp. Indet. (Questionably present)

Miospores

Allsporites bilateralis
Corollina sp. Indet. (Rare)
Deltoidospora hallii

Assemblage Characteristics

black coaly material (Common)

Paleoenvironment: A paralic to inner neritic depositional environment is suggested if the identification of the dinoflagellate *Kylindracysta sp.* is correct.

Comments: Positive identifications are inhibited by the high thermal alteration, oxidized kerogen, and poor preservation.

TAI: 3+

SAMPLE 89PE49

Zone Indeterminate (probable Jurassic)

Microplankton

Sentusidinium sp. indet. (+) (Questionably present)

Miospores

Allsporites thomasii
Corollina sp. indet. (Rare)
Distaltriangulisporites *sp. indet.* (Questionably present)

Assemblage Characteristics

black coaly material (Dominant)

Paleoenvironment: A paralic to inner neritic depositional environment is indicated by the presence of rare dinoflagellates.

Comments: Positive identifications are inhibited by the high thermal alteration and poor preservation.

TAI: 3+

SAMPLE 89IM05

Zone indeterminate (indeterminate age)

Assemblage Characteristics

black coaly material (Abundant)
woody kerogen (Common)

Paleoenvironment: indeterminate

Comment: No palynomorphs were observed in this sample.

TAI: 3-

SAMPLE 89IM06

Zone indeterminate (indeterminate age)

Miospores

Lycopodiumsporites annotiniolides (Rare, probable modern contaminants)

Assemblage Characteristics

black coaly material (Dominant)

Paleoenvironment: indeterminate

Comments: No in situ palynomorphs were observed in this sample. The modern spores have a TAI of 1 and are considered to be contaminants, and the in situ kerogen is thermally corroded.

TAI: 3-

SAMPLE 89IM08

Zone indeterminate (indeterminate age)

Assemblage Characteristics

black coaly material (Dominant)

Paleoenvironment: indeterminate

Comments: No palynomorphs were observed in this sample.

TAI: 4-

SAMPLE 89IM50A

Zone indeterminate (indeterminate age)

Miospores

Piceae/Pinuspollenites sp. indet. (Common, probable modern contaminants)

Assemblage Characteristics

black coaly material (Abundant, probable in situ kerogen)
fungal hyphae and spores (Dominant, probable modern soil contaminants)

Paleoenvironment: indeterminate

Comments: The fungal hyphae and modern spores suggest that the sample is part of the soil or weathering zone.

TAI: 4

SAMPLE NS79C

Zone Indeterminate (Jurassic - Early Cretaceous)

Miospores

Alisporites bilateralis

Assemblage Characteristics

black coaly material (Dominant)

Paleoenvironment: A non-marine to paralic depositional environment is indicated by the presence of rare terrigenous gymnospermous pollen and the absence of dinoflagellates.

Comments: The few palynomorphs observed are highly thermally corroded.

TAI: 3

SAMPLE NS90A

Zone Indeterminate (Aptian to early Albian)

Microplankton

Chlchaouadinium sp. indet. (+)
Odontochitina operculata (+)

Miospores

Ablespollenites sp. indet.
Allsporites bilateralis (Abundant)
Cedripites canadensis (Common)
Laevigatosporites ovatus (Rare)
Lycopodiumsporites circolumenus
Osmundacidites wellmannii (Rare)
Perinopollenites elatoides (Rare)
Platysaccus megasaccus (Rare)
Podocarpidites epistriatus (Rare)

Paleoenvironment: A paralic to marginally marine depositional environment is indicated by the presence of rare dinoflagellates and abundant bisaccate gymnospermous pollen.

Comments: This assemblage is characterised by good palynomorph recovery, but with very few marker species.

TAI: 2-

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