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EASTERN ONTARIO MUSEUM
GEOLOGY SECTION
O. S. C.

BIOSTRATIGRAPHY AND MATURATION OF
17 LABRADOR AND BAFFIN SHELF
WELLS

Volume 5:
Leif M-48 & North Bjarni F-06

Report No. 86-0058
Bujak Davies Group

Calgary, Alberta

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EXPLANATION OF CONTENTS

This volume contains the following results of analyses on Leif M-48 and North Bjarni F-06.

1. General drilling information

2. Consensus Age

The consensus age based on micropaleontology (M) and palynology (P).

3. Palynological Results

The palynological zones and assigned ages in order of increasing depth within each well. The more important taxa are listed alphabetically, with miospores and fungal spores being denoted by an asterisk (*). Marker species are highlighted in bold type. The degree of confidence is given for each zonal assignment as follows:

"4" The highest degree of confidence regarding both the zonal assignment and the sample level to which the top of the zone is assigned.

"3" A high degree of confidence regarding the zonal assignment, but including the possibility that the zonal assignment may be slightly too low.

"2" Indicates that the zonal assignment is probably correct but that the sample level indicated for the top of the zone is probably too low due to a scarcity of marker species.

"1" A highly tentative zonal assignment due to extreme scarcity of marker species.

4. Micropaleontological Results

The micropaleontological zones and assigned ages in order of increasing depth. Within each zone the more important taxa are listed alphabetically with planktonic foraminiferal species being denoted by an asterisk (*) and diatom species by a cross (+). Marker species are highlighted in bold type. The degree of confidence is given for each zonal assignment as follows:

"4" The highest degree of confidence regarding both the zonal assignment and the sample level to which the top of the zone is assigned. This degree of confidence indicates the presence of planktonic foraminifera together with the main benthonic foraminiferal markers.

"3" A high degree of confidence regarding the zonal assignment. Indicates the presence of the main benthonic foraminiferal markers.

"2" Indicates that the zonal assignment is most probably correct. The assignment is based only on taxa occurring commonly within the zone, due to the scarcity of marker species.

"1" A tentative zonal assignment. Based solely on stratigraphic position due to extreme scarcity of marker species.

5. Paleobathymetric Interpretations

The interpreted paleobathymetries are in order of increasing depth, together with the criteria upon which they are based. The interpreted environments and corresponding paleobathymetries reported are: Non-marine (above sea level), Transitional (approx. 0m), Inner Neritic (approx. 0-20m), Middle Neritic (approx. 20-100m), Outer Neritic (approx. 100-200m), Upper Bathyal (approx. 200-1000m), and Lower Bathyal (>1000m).

6. Kerogen, TAI and Vitrinite Reflectance

Data on kerogen types and TAI are listed in a table, and are then discussed relative to petroleum source rock potential and the consensus ages assigned in this report. Data on vitrinite reflectance are listed and are discussed relative to their degree of reliability and indicated maturation level.

All references are given in Volume 1 of the report.

The following charts are included for each well:

1. A Palynological Summary Chart showing the assigned palynological zones, inferred ages, lithology, formational assignments provided by P.N. Moir, studies in progress, important palynological events (mostly species tops).
2. Sawtooth diagrams showing the relative abundances of the following palynological categories: Apectodinium homomorphum, Areoligera senonensis, marine dinoflagellates, Azolla, Pediastrum, gymnosperm pollen, angiosperm pollen, miospores, Late Cretaceous reworking, Early Cretaceous reworking.
3. A Micropaleontological Summary Chart showing the assigned micropaleontological zones, inferred ages, lithology, important micropaleontological events (mostly species tops), paleobathymetry.
4. A Kerogen Summary Chart showing the consensus ages, levels of Thermal Alteration (TAI), relative abundances of kerogen types.

5. A Vitrinite Summary Chart showing the consensus ages, histograms of the vitrinite reflectance measurements which are divided into three categories: caved (blue), in situ (green) and reworked (red). The in situ category is further subdivided into poor readings (horizontal lines) and good to excellent reading (solid colour). The means of the three main categories are indicated by correspondingly coloured triangles.

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BIOSTRATIGRAPHY AND MATURATION OF

LEIF M-48

EASTCAN et al. LEIF M-48

GSC locality: 54° 17' 45.92"N, 55° 07' 20.17"W

KB elevation: 12.2ft Water depth: 165ft

Casing set at: 202ft, 384ft, 1130ft

Total depth: 1879ft

Interval studied for palynology: 1300-6130ft

Interval studied for micropaleontology: 1300-6160ft

CONSENSUS AGE

1300-1450ft *442m* early Miocene (M)
1490-1520ft *463m* late Oligocene (M)
1520-2110ft *648m* early Oligocene (M)
2110-3920ft *1195m* late Eocene (M)
3940-5040ft *1586m* middle Eocene (P)
5100-5550ft *1692m* early Eocene (P)
5620-5876ft *1791m* early Paleocene (M)
5876-6034ft *1839m* Maastrichtian (P)
6034-6160ft *1876m* no age assignment

LEIF M-48PALYNOLOGICAL ZONATION

- 1300-1370ft Systematophora ancyrea Zone or older (middle Miocene
or older)
- 1420-1450ft Cordosphaeridium cantharellum Zone or older (early
Micoene or older)
- 1490-3790ft No zonal assignment (late Eocene to late Oligocene)
- 3850-4870ft Areosphaeridium fenestratum Zone (middle to late
Eocene)
- 4930-5040ft Eocladopyxis #LA Zone (middle Eocene)
- 5100-5130ft Trinovantedinium #LA Zone (early Eocene)
- 5280-5712ft Dracodinium condylos Zone (early Eocene)
- 5712-5800ft Ceratiopsis speciosa Zone (late Paleocene)
- 5800-5876ft Alisocysta circumtabulata Zone (late Paleocene)
- Not observed Palaeoperidinium pyrophorum Zone (early Paleocene)
- Not observed Spongodinium #LA Zone (early Paleocene)
- Not observed Spongodinium delitiense Zone (Maastrichtian)

5876-6034ft Impagidinium #LL Zone (Maastrichtian)

6034-6160ft No zonal assignment (No age assignment)

SELECTED SPECIES

1300-1370ft: Systematophora ancyrea Zone or older (middle Miocene or older)

1300ft: Systematophora ancyrea
Selenopemphix nephroides
Tsugaepollenites igniculus *

1340ft: Retulaceoipollenites betuloides *

Degree of Confidence: 2

Remarks: Palynomorphs are rare in this section of the well, but the presence of S. ancyrea at 1300-1320m indicates the penetration of middle Miocene or older strata. It is possible that the section is pre-middle Miocene and that the absence of older marker species results from the general scarcity of palynomorphs.

1420-1450ft: Cordosphaeridium cantharellum Zone or older (early Miocene or older)

1420ft: Cordosphaeridium cantharellum

Degree of Confidence: 2

Remarks: It is possible that this section is older than early Miocene because of the scarcity of palynomorphs including marker species.

1490-3790ft: No zonal assignment (late Eocene to late Oligocene)

- 1520ft: Phthanoperidinium #LA
- 1620ft: Paralecaniella indentata
- 1820ft: Cribroperidinium guiseppi
- 2040ft: Quercoidites #LA *
- 2210ft: Botrychium dissectum *
Pterocaryapollenites stellatus *
- 2310ft: Juglanspollenites nigripites *
Phthanoperidinium comatum
Selaginella perinata *
- 2470ft: Diporisporites *
Brachyporisporites *
- 3290ft: Liquidambar #LA *
- 3580ft: Caryapollenites simplex *
Faguspollenites #LA *
Retitricolpites #LF *

Degree of Confidence: 1

Remarks: Palynomorphs are rare in this section of the well, with few marker species being observed. No zonal assignment was therefore possible. The presence of Phthanoperidinium #LA at 1520-1540ft suggests the possible penetration of Oligocene strata, although the strati-

graphic range of this species is uncertain. The occurrence of P. comatum at 2310-2330ft definitely indicates the penetration of Oligocene or older strata, providing this specimen is in place. It is not possible to distinguish the late Eocene to late Oligocene palynological zones in this part of the well.

3850-4870ft: Areosphaeridium fenestratum Zone (middle to late Eocene)

- 3850ft: Araneosphaera araneosa
Cordosphaeridium fibrospinosum
Corylus #LA *
Glaphyrocysta sp. indet.
Lentinia serrata
- 3940ft: Glaphyrocysta vicina
Pesavis #LB *
Wetzeliella ovalis
- 4120ft: Areoligera senonensis
- 4210ft: Apectodinium homomorphum
Cicatricosisporites paradorogensis *
Impletosphaeridium scalenfurcatum (common)
Pentadinium laticinctum
- 4300ft: Momipites coryloides *
- 4390ft: Cicatricosisporites auritus *
Trudopollis plena *
Wetzeliella articulata
- 4480ft: Systemataphora placacantha

4660ft: Camarozonosporites #LA *

Degree of Confidence: 1

Remarks: The presence of the fungal spore Pesavis #LR at 3940-3960ft indicates the penetration of middle Eocene strata by comparisons with the stratigraphic range of this species in the Canadian Beaufort. Penetration of the A. fenestratum Zone is also tentatively indicated at 3850-3870ft by the occurrence of A. araneosa, and is more definitely indicated below 3940ft by the species highlighted above.

4930-5040ft: Eocladopyxis #LA Zone (middle Eocene)

4930ft: Eocladopyxis #LA

5010ft: Apectodinium homomorphum
Cicatricosisporites dorogensis *
Hystrichokolpoma salacium
Hystrichokolpoma #LP
Systematophora #LE
Tiliaepollenites vespicipites *

Degree of Confidence: 3

5100-5130ft: Trinovantedinium #LA Zone (early Eocene)

5100ft: Polysphaeridium subtile
Thalassiphora patula
Trinovantedinium #LA

Degree of Confidence: 4

5280-5712ft: Dracodinium condylos Zone (early Eocene)

- 5280ft: Azolla *
Dracodinium condylos
Homotryblium tenuispinosum
Lentinia wetzelii
- 5460ft: Dinopterygium cladoides
Glaphyrocysta divaricata
- 5550ft: Apectodinium augustum
Apectodinium homomorphum (abundant)
Areoligera senonensis (common)
Homotryblium pallidum
Wetzelifella meckelfeldensis

Degree of Confidence: 3

Remarks: Penetration of the D. condylos Zone is indicated by the presence of D. condylos in the cuttings sample at 5280-5300ft. The dinoflagellate Isabelidinium #LP which is also a marker for this zone was not recorded in southerly Labrador Shelf wells including Leif M-48.

5712-5800ft: Ceratiopsis speciosa Zone (late Paleocene)

- 5712ft: Ceratiopsis speciosa glabra

Degree of Confidence: Unknown

Remarks: Data in the present report for this and the underlying zones from Leif M-48 is taken from Barss, Bujak & Williams (1979), in which Williams reported results of analyses on sidewall core samples including that at 5712ft. It is therefore not possible to determine the degree of confidence and in this and the underlying zones at the present time.

5800-5876ft: Alisocysta circumtabulata Zone (late Paleocene)

5800ft: Alisocysta circumtabulata

Degree of Confidence: Unknown

Remarks: Data taken from Barss, Bujak & Williams (1979).

5876-6034ft: Impagidinium #LL Zone (Maastrichtian)

5876ft: Amphidiadema nucula
Ceratiopsis diebelii
Manumiella cretacea

Degree of Confidence: Unknown

Remarks: Data taken from Barss, Bujak & Williams (1979).

6034-6130ft: No zonal assignment (No age assignment)

MICROPALEONTOLOGICAL ZONATION

- Not observed Cassidulina teretis Zone (late Miocene or younger)
- 1300-1450ft Asterigerina guerichi Zone (early Miocene or older)
- 1490-1520ft Asterigerina bartoniana Zone (late Oligocene)
- 1520-2110ft Ceratobulimina contraria Zone (early Oligocene)
- 2110-3510ft Spiroplectamina adamsi Zone (late Eocene)
- 3580-4750ft Cyclamina amplexans Zone (late Eocene)
- 4810-5190ft Haplophragmoides acutidorsatum Zone (middle Eocene)
- Not observed Bulimina ovata Zone (early Eocene)
- 5250-5550ft Karrerella apicularis Zone (early Eocene)
- Not observed Spiroplectamina grzybowski Zone (early Eocene)
- Not observed Glomospira charoides Zone (late Paleocene)
- 5620-6034ft Glomospira corona Zone (early Paleocene)
- 6034-6160ft No zonal assignment (no age assignment)
- Not observed Praecystamina globigerinaeformis Zone (early Paleocene)
- Not observed Rzehakina epigona Zone (Maastrichtian)
- Not observed Arenobulimina dorbigny Zone (?Campanian)

SELECTED FORAMINIFERA

1300-1450ft: Asterigerina guerichi Zone (early Miocene or older)

1300ft Asterigerina guerichi
 Cassidulina teretis (caved)
 Melonis affinis

Degree of Confidence: 3

1490-1520ft: Asterigerina bartoniana Zone (late Oligocene)

1490ft Coscinodiscus #H 1 *

Degree of Confidence: 2

1520-2110ft: Ceratobulimina contraria Zone (early Oligocene)

1520ft Ceratobulimina contraria
 Fursenkoina schreibersiana

1590ft Cyclogyra involvens

1720ft Globigerina cf. yequaensis *

1890ft Cyclammina placenta

Degree of Confidence: 3

2110-3300ft: Spiroplectammina adamsi Zone (late Eocene)

- 2110ft Coscinodiscus #H 2 *
 Cyclammina sp.
- 2180ft Spiroplectammina adamsi
 Baggina subconica
- 2310ft Gyroidinoides girardana
 Turrilina alsatica
- 2470ft Pullenia quinqueloba
- 2670ft Abundant scaphopods
- 3290ft Globigerina linaperta *
 Nodosaria soluta
- 3380ft Globigerina officinalis *
- 3480ft Nodosaria latejugata
 Ammodiscus cretaceus
 Bathysiphon discreta
 Alabamina wilcoxensis

Degree of Confidence: 3

3580-4750ft: Cyclammina amplexans Zone (late Eocene)

3580ft	<u>Bulimina kugleri</u> <u>Heterolepa grimsdalei</u>
3680ft	<u>Catapsydrax cf. howei</u> * <u>Cribrostomoides subglobosus</u> <u>Pleurostomella paleocenica</u>
3790ft	<u>Stilostomella midwayensis</u> <u>Osangularia mexicana</u>
3880ft	<u>Trochammina deformis</u> <u>Glandulina laevigata</u> <u>Pullenia coryelli</u>
3970ft	<u>Nodosaria minor</u>
4150ft	<u>Vaginulinopsis decorata</u>
4630ft	<u>Haplophragmoides walteri</u> <u>Haplophragmoides eggeri</u>
4720ft	<u>Cyclammina amplexans</u>

Degree of Confidence: 3

4810-5190ft: Haplophragmoides acutidorsatum Zone (middle Eocene)

4810ft	<u>Haplophragmoides acutidorsatum</u> <u>Karrerella danica</u>
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5060ft Budashevaella multicamerata
Recurvoides walteri

5160ft Plectofrondicularia lirata
Reophax pilulifer
Lenticulina cassis

Degree of Confidence: 3

5250-555ft: Karreriella apicularis Zone (early Eocene)

5250ft Karreriella apicularis
Spiroplectamina navarroana
Cibicides westi

5520ft Trochammina aff. albertense

Degree of Confidence: 3

5620-6034ft: Glomospira corona Zone (early Paleocene)

5620ft Glomospira corona
Glomospira charoides
Amodiscus peruvianus

5720ft Spiroplectamina grzybowski
Globigerina triloculinoides *

6020ft Clavulina cf. parisiensis

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Degree of Confidence: 3

6034-6160ft: No zonal assignment (No age assignment)

6130ft Rhizammina indivisa (caved)

PALEOBATHYMETRY

- 1300-1490m ^{ft} ← Inner Neritic
Criteria: Asterigerina guerichi, Melonis Affinis
- 1490-1750m Inner Neritic to Middle Neritic
Criteria: Coscinodiscus #H1, Globigerina cf. yeguaensis
- 1790-3210m Middle Neritic to Outer Neritic
Criteria: Coscinodiscus #H2, Cyclammina sp., Gyroidinoides girardana, abundant pyrite
- 3290-3410m Outer Neritic
Criteria: Planktonic foraminifera
- 3480-4570m Outer Neritic to Upper Bathyal
Criteria: Bathysiphon discreta, Cribrostomoides subglobosus, Osangularia mexicana, glauconite, pyrite
- 4630-5010m Upper Bathyal
Criteria: Cyclammina cf. amplexans, Haplophragmoides acutodorsatum, Karrerella danica, Haplophragmoides walteri
- 5070-5550m Upper Bathyal to Lower Bathyal
Criteria: Recurvoides walteri, Budashevaella multicamerata, Plectofrondicularia lirata, Reophax pilulifer, Karrerella apicularis
- 5620-6050m Lower Bathyal
Criteria: Glomospira charoides, Ammodiscus glabratus, Clavulina cf. parisiensis

KEROGEN & TAI

Depth	AM	AT	AG	SA	M	BT	ST	I	R	TAI
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1330.0	35	20	0	0	10	15	15	5	0	2-
1650.0	30	20	0	0	10	15	15	10	0	2-
1850.0	30	20	0	5	5	10	20	10	0	2-
2110.0	40	25	0	0	5	10	10	10	0	2-
2240.0	40	25	0	0	0	10	15	10	0	
2500.0	35	20	0	0	10	10	20	5	0	2-
2910.0	35	35	0	0	5	15	15	5	0	2-
3610.0	40	30	0	0	0	10	10	10	0	2-2
3970.0	40	35	0	0	0	10	10	5	0	2-2
4240.0	40	35	0	0	0	10	10	5	0	2-2
4470.0	40	35	0	0	0	10	10	5	0	2-2
4600.0	35	30	0	0	5	15	10	5	0	2-2
4870.0	40	30	0	0	0	15	10	5	0	2-2
5040.0	40	30	0	0	5	10	10	5	0	2-2
5220.0	40	30	0	0	5	10	10	5	0	2-2
5400.0	40	30	0	0	0	15	10	5	0	2
5490.0	40	35	0	0	0	10	10	5	0	2
5580.0	40	30	0	0	0	10	10	10	0	2

KEROGEN, TAI AND VITRINITE REFLECTANCE

Kerogen slides were available for analysis only between 1330-5600ft within the section assigned an early Eocene to early Miocene age. No samples were available for analysis below 5620ft where a hiatus is indicated above a Maastrichtian to lower Paleocene section. The relative abundance of kerogen types is fairly constant throughout the examined section with amorphous kerogen predominating and comprising from 50% to 75% of the total kerogen. The amorphous kerogen consists entirely of marine amorphous and degraded terrestrial amorphous material, with the marine amorphous kerogen being slightly more common. Herbaceous kerogen decreases slightly downhole in relative abundance from 35% to 10%. Most of this material represents the degraded remains of terrestrial plant material. Woody kerogen is slightly more common in the upper part of the section but generally averages from 10% to 15% of the total kerogen. Coaly inertinitic material comprises 5% to 10% of the total kerogen.

The level of Thermal Alteration indicates that the marine amorphous kerogen is mature below 5610ft and has some source rock potential for thermogenic liquid hydrocarbons. The TAI indicates that all of the kerogen types are immature within the examined section from 1330-5600ft.

The following levels of thermal maturity are indicated by vitrinite reflectance analysis.

- 1380ft: Immature (Ro% = 0.421%)
- 1980-4420ft: Onset of maturity (Ro% = 0.481% to 0.522%)
- 4960-6130ft: Mature (Ro% = 0.612% to 0.704%)

Throughout this well, cavings are prevalent especially within the interval between 4420ft and 5400ft as well as at 6130ft. Reworking in the upper portion of the well is also prevalent between 1380ft and 3580ft. The best sample for indicating the maturity of the basal portions of the well is at 5760ft which indicates a thermal maturity of .704.

VITRINITE REFLECTANCEKey to Measurement Qualifying Labels

E = Excellent

= Good

P = Poor

C = Caved

R = Reworked

Sample Depth : 1380.0

0.184	C	0.245	C	0.282	C	0.285	C	0.294	C	0.299	C	0.311	C
0.343		0.356		0.358		0.363		0.382		0.438		0.450	
0.463		0.481		0.483		0.519		0.540	R	0.542	R	0.646	R
0.646	R	0.653	R	0.723	R	0.738	R	0.794	R	0.852	R	0.863	R
0.877	R	0.898	R	0.963	R	1.036	R	1.050	R	1.063	R	1.075	R
1.087	R	1.220	R	1.240	R	1.458	R	1.504	R	1.559	R	1.690	R
1.716	R	1.773	R	1.781	R	1.782	R						

Actual Mean = 0.811 Actual Standard Deviation = 0.485

Edited Mean = 0.421 Edited Standard Deviation = 0.063

Sample Depth : 1980.0

0.164	C	0.202	C	0.221	C	0.292	C	0.317	C	0.319	C	0.345	C
0.371	C	0.420		0.424		0.442		0.479		0.487		0.500	
0.503		0.597		0.638	R	0.641	R	0.712	R	0.778	R	0.827	R
0.966	R	0.977	R	0.987	R	1.040	R	1.138	R	1.171	R	1.260	R
1.462	R	1.573	R	1.706	R								

Actual Mean = 0.708 Actual Standard Deviation = 0.421

Edited Mean = 0.481 Edited Standard Deviation = 0.057

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Sample Depth : 2580.0

0.160	C	0.183	C	0.188	C	0.223	C	0.227	C	0.231	C	0.242	C
0.271	C	0.280	C	0.304	C	0.306	C	0.371	C	0.382	C	0.388	C
0.415	C	0.475		0.496		0.498		0.507		0.509		0.542	P
0.594		0.681		0.658		0.699		0.733	R	0.810	R	0.873	R
0.904	R	0.919	R	0.937	R	1.152	R	1.531	R	1.725	R		

Actual Mean = 0.572 Actual Standard Deviation = 0.373

Edited Mean = 0.570 Edited Standard Deviation = 0.091

Sample Depth : 3080.0

0.161	C	0.163	C	0.213	C	0.225	C	0.272	C	0.294	C	0.308	C
0.323	C	0.353	C	0.363	C	0.447	C	0.482	P	0.492		0.492	
0.502		0.504	P	0.528	P	0.548		0.556	P	0.565	E	0.620	P
0.630	R	0.646	R	0.660	R	0.712	R	0.739	R	0.815	R	0.860	R
0.908	R	0.931	R	0.943	R	0.974	R	0.998	R	1.059	R	1.085	R
1.127	R	1.137	R	1.156	R	1.198	R	1.268	R	1.315	R	1.320	R
1.427	R	1.570	R	1.592	R	1.625	R	1.698	R	1.887	R		

Actual Mean = 0.806 Actual Standard Deviation = 0.453

Edited Mean = 0.529 Edited Standard Deviation = 0.043

Sample Depth : 3580.0

0.276	C	0.286	C	0.303	C	0.322	C	0.337	C	0.376	C	0.379	C
0.388	C	0.410	C	0.415	C	0.425	C	0.459	C	0.495	P	0.506	P
0.518	P	0.526	P	0.530	P	0.574	P	0.589	P	0.608	P	0.842	R
0.883	R	1.038	R	1.092	R	1.130	R	1.159	R	1.295	R	1.308	R
1.312	R	1.693	R	1.704	R	1.895	R						

Actual Mean = 0.752 Actual Standard Deviation = 0.467

Edited Mean = 0.543 Edited Standard Deviation = 0.042

Sample Depth : 3970.0

0.303	C	0.328	C	0.331	C	0.335	C	0.345	C	0.360	C	0.367	C
0.374	C	0.375	C	0.380	C	0.385	C	0.390	C	0.421	C	0.426	C
0.434	C	0.435	C	0.437	C	0.445	C	0.461	P	0.479		0.481	
0.489		0.555	P	0.565	P	0.731	R						

Actual Mean = 0.425 Actual Standard Deviation = 0.093

Edited Mean = 0.505 Edited Standard Deviation = 0.044

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Sample Depth : 4420.0

0.242 C	0.274 C	0.291 C	0.314 C	0.317 C	0.318 C	0.351 C
0.385 C	0.448 P	0.512	0.520 P	0.608		

Actual Mean = 0.382 Actual Standard Deviation = 0.115

Edited Mean = 0.522 Edited Standard Deviation = 0.066

Sample Depth : 4960.0

0.262 C	0.291 C	0.294 C	0.342 C	0.668	0.696
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Actual Mean = 0.426 Actual Standard Deviation = 0.201

Edited Mean = 0.682 Edited Standard Deviation = 0.020

Sample Depth : 5220.0

0.217 C	0.249 C	0.274 C	0.279 C	0.304 C	0.340 C	0.359 C
0.360 C	0.431 C					

Actual Mean = 0.313 Actual Standard Deviation = 0.066

Sample Depth : 5310.0

0.245 C	0.257 C	0.258 C	0.260 C	0.278 C	0.283 C	0.295 C
0.315 C	0.327 C	0.368 C	0.468	0.493 C	0.512 P	0.868 R

Actual Mean = 0.373 Actual Standard Deviation = 0.169

Edited Mean = 0.490 Edited Standard Deviation = 0.031

Sample Depth : 5400.0

0.209 C	0.250 C	0.300 C	0.309 C	0.358 C	0.363 C	0.396 C
0.439 C	0.447 C	0.511 P	0.673 R	1.020 R		

Actual Mean = 0.440 Actual Standard Deviation = 0.221

Edited Mean = 0.511 Edited Standard Deviation = 0.000

Sample Depth : 5760.0

0.259	C	0.309	C	0.390	C	0.391	C	0.478	C	0.480	C	0.512	C
0.550	P	0.569		0.627	P	0.650		0.660	P	0.685		0.693	P
0.772		0.784		0.786		0.801	P	0.867	P	0.920	R	0.957	R
1.072	R	1.147	R	1.149	R	1.236	R	1.250	R	1.280	R	1.485	R
1.509	R	1.620	R	1.738	R	1.745	R	1.780	R	1.890	R		

Actual Mean = 0.942 Actual Standard Deviation = 0.468

Edited Mean = 0.704 Edited Standard Deviation = 0.099

Sample Depth : 6130.0

0.144	C	0.222	C	0.243	C	0.255	C	0.371	C	0.601	P	0.615	P
0.615	P												

Actual Mean = 0.383 Actual Standard Deviation = 0.198

Edited Mean = 0.610 Edited Standard Deviation = 0.008

North Bjamti F-06:

BIOSTRATIGRAPHY AND MATURATION OF

NORTH BJARNI F-06

PETRO-CANADA NORTH BJARNI F-06GSC locality: 55° 35' 30" N, 57° 45' 49" WKB elevation: 12m Water depth: 162mCasing set at: 412m, 1153mTotal depth: 2812mInterval studied for palynology: 420-2812mInterval studied for micropaleontology: 420-2812mCONSENSUS AGE

420- 690m	late Miocene (M,P)
710- 720m	early to middle Miocene (P)
740-1290m	early Oligocene (P)
1310-1650m	late Eocene (P)
1670-1800m	middle Eocene (M)
1820-2190m	early Eocene (M,P)
2210-2340m	late Paleocene (M,P)
2360-2380m	Maastrichtian (M,P)
2390-2400m	Maastrichtian to Campanian (P)
2420-2490m	Coniacian to Turonian (P)
2510-2812m	early to middle Albian (P)

NORTH BJARNI F-06PALYNOLOGICAL ZONATION

- 420- 690m Operculodinium centrocarpum Zone or older (late Miocene or older)
- 710- 720m Systematophora ancyrea Zone to Cordosphaeridium cantharellum Zone (early to middle Miocene)
- 740-1290m Areosphaeridium arcuatum Zone (early Oligocene)
- 1310-1470m Deflandrea #LR Zone (late Eocene to early Oligocene)
- 1490-1710m Areosphaeridium fenestratum Zone (middle to late Eocene)
- 1730-1800m Eocladopyxis #LA Zone (middle Eocene)
- 1820-2010m Trinovantedinium #LA Zone (early Eocene)
- 2030-2190m Dracodinium condylos Zone (early Eocene)
- 2210-2250m Ceratiopsis speciosa Zone (late Paleocene)
- 2270-2280m Alisocysta circumtabulata Zone to Palaeoperidinium pyrophorum Zone (early to late Paleocene)
- 2300-2340m Spongodinium #LA Zone (early Paleocene)
- 2360-2370m Spongodinium delitiense Zone to Impagidinium #LL (Maastrichtian)

- 2390-2400m Isabelidium cooksoniae Zone to Chatangiella tripartita Zone (Maastrichtian to Campanian)
- Not observed Hystrichosphaeridium difficile Zone (Campanian)
- Not observed Palaeohystrichophora infusorioides Zone (early Campanian)
- Not observed Senoniasphaera rotundata Zone (Santonian)
- 2420-2490m Cometodinium obscurum Zone (Coniacian to Turonian)
- Not observed Kiokansium polypes Zone (Cenomanian)
- Not observed Epelidosphaeridia spinosa/Trilobosporites crassus Zone (late Albian to early Cenomanian)
- Not observed Trilobosporites humilis Zone (middle Albian)
- 2510-2610m Parvisaccites amplus Zone (early to middle Albian)
- 2630-2812m Muderongia asymmetrica Zone (early to middle Albian)

SELECTED SPECIES420-690m: Operculodinium centrocarpum Zone or older (late Miocene or older)

- 420m: Caryapollenites simplex *
 Corylus #LA *
 Quercoidites #LA * (?reworked)
- 440m: Tsugaepollenites igniculus *
- 530m: Lingulodinium machaerophorum
 Tsugaepollenites viridifluminipites *
 Veryhachium trispinosum
- 560m: Osmundacidites claytonites *
- 650m: Operculodinium centrocarpum

Degree of Confidence: 1

Remarks: The occurrence of Caryapollenites simplex at 420-440m tentatively suggests the penetration of late Miocene or older strata, although the stratigraphic range of C. simplex in the Labrador Shelf region is uncertain. The occurrence of L. machaerophorum at 530-550m supports the age assignment. It is possible that the section is older and that pre-late Miocene marker species were not observed due to their scarcity.

710-720m: Systematophora ancyrea Zone to Cordosphaeridium cantharellum Zone (early to middle Miocene)

710m: Systematophora ancyrea
 Spiniferites pseudofurcatus

Degree of Confidence: 2

Remarks: The single sample available from this interval at 710-720m contains the middle Miocene and older marker species S. ancyrea but the presence of lower Miocene strata within this interval cannot be discounted. It is possible that this interval is older than Miocene and that Oligocene marker species were not observed due to their scarcity.

740-1290m: Areosphaeridium arcuatum Zone (early Oligocene)

740m: Cyclonephelium sp. E, Williams & Brideaux 1975

770m: Hystrichokolpoma rigaudiae
 Deflandrea heterophlycta

800m: Chiropteridium #LS (reworked)
 Cicatricosisporites dorogensis *
 Deflandrea phosphoritica

830m: Cordosphaeridium cantharellum
 Dicellaesporites *

950m: Lentinia serrata

- 1100m: Fagus #LA *
Quercoidites #LA * (common)
Ulmipollenites undulosus *
- 1130m: Chiropteridium mespilanum
- 1160m: Ericipites compactipolleniatus *
- 1220m: Alnipollenites verus *
- 1280m: Momipites coryloides * (?reworked)

Degree of Confidence: 2

Remarks: The occurrence of early Oligocene marker species in several samples from this interval indicates penetration of the A. arcuatum Zone. The top of this zonal boundary is indicated as being tentative because the marker species occur as single specimens in samples from this interval, and it is possible that the top of the lower Oligocene section occurs slightly above 740m.

1310-1470m: Deflandrea #LR Zone (late Eocene to early Oligocene)

- 1310m: Cicatricosisporites paradoxogensis *
- 1340m: Juglanspollenites nigripites *
Paralecaneia indentata
- 1370m: Pterocaryapollenites stellatus *
- 1400m: Deflandrea #LR
Tricolpites #LR *

Degree of Confidence: 2

Remarks: The top of the Deflandrea #LF Zone is tentatively indicated at 1310-1330m by the occurrence of the fern spore C. paradorogensis, although the stratigraphic range of this species in the Labrador Shelf region is uncertain. A more definite top for the zone is indicated by the occurrence of the dinoflagellate Deflandrea #LR at 1400-1420m.

1490-1710m: Areosphaeridium fenestratum Zone (middle to late Eocene)

- 1490m: Chiropteridium #LS
 Dinopterygium cladoides
 Micrhystridium fragile (abundant)
 Phthanoperidium #LG
- 1550m: Araneosphaera araneosa
 Hystrichokolpoma salacium
 Rouseisporites #LA *
 Systematophora placacantha
- 1640m: Kisselovia crassiramosa
 Palaeocystodinium golzowense
- 1670m: Thalassiphora patula
- 1700m: Wetzeliella articulata

Degree of Confidence: 3

Remarks: Penetration of this zone is strongly indicated by the occurrence of both the dinoflagellate species Chiropteridium #LS and

abundant specimens of the acritarch M. fragile in the sample at 1490-1510m, with other markers being common in several underlying samples as indicated above.

1730-1800m: Eocladopyxis #LA Zone (middle Eocene)

1730m: Eocladopyxis #LA
 Glaphyrocysta vicina
 Phthanoperidinium multispinosum
 Systematophora #LE

1790m: Horologinella #LA

Degree of Confidence: 3

Remarks: Unlike many wells studied during the present project, the Eocladopyxis #LA Zone is well-represented in North Bjarni F-06 at 1730-1750m by the occurrence of both Eocladopyxis #LA and Systematophora #LE.

1820-2010m: Trinovantedinium #LA Zone (early Eocene)

1820m: Azolla *
 Homotryblium oceanicum
 Lentinia wetzelii
 Trinovantedinium #LA
 Wetzeleilla meckelfeldensis

1850m: Apectodinium homomorphum
 Hafniasphaera cryptovesiculata
 Polysphaeridium subtile
 Quercoidites #LG *

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- 1880m: Achilleodinium biformoides sensu Heilman-Clausen 1985
Homotryblum pallidum
Thalassiphora pelagica
- 1910m: Areoligera senonensis
Cribroperidinium giusepei
Cordosphaeridium fibrospinosum
Diphyes colligerum
Homotryblum tenuispinosum
Kisselovia edwardsii
Trinovantedinium #LS
- 1940m: Cicatricosporites auritus *
Heteraulacacysta leptalea
Kisselovia crassiramosa
Systematophora #LC

Degree of Confidence: 4

Remarks: Penetration of the Trinovantedinium #LA Zone is strongly indicated by the marker species listed above in the sample 1820-1840m, plus most underlying samples from the interval.

2030-2190m: Dracodinium condylos Zone (early Eocene)

- 2030m: Dracodinium condylos
Glaphyrocysta exuberans
- 2060m: Platycaryapollenites platycaryoides *
- 2090m: Hystrichkolpoma cinctum
Isabelidinium #LP

2120m: Homotryblum abbreviatum

2150m: Areosphaeridium sp.A, Williams & Bujak 1977

Degree of Confidence: 3

2210-2250m: Ceratiopsis speciosa Zone (late Paleocene)

2210m: Adnatosphaeridium robustum
Alisocysta #LA
Ceratiopsis speciosa glabra
Dracodinium simile

2240m: Hystrichokolpoma #LP
Paraalnipollenites confusus *

Degree of Confidence: 3

Remarks: Penetration of the C. speciosa Zone is indicated by the occurrence of the dinoflagellate C. speciosa glabra at 2210-2230m. The species Alisocysta #LA may range into the C. speciosa Zone in wells from the Labrador Shelf.

2270-2280m: Alisocysta circumtabulata Zone to Palaeoperidinium pyrophorum Zone (early to late Paleocene)

2270m: Alisocysta crassitabulata
Areoligera senonensis (abundant)
Ceratiopsis speciosa speciosa

Degree of Confidence: 3

2300-2340m: Spongodinium #LA Zone (early Paleocene)

- 2300m: Alisocysta margarita
Alisocysta circumtabulata
Gonyaulacysta wetzelii
Fromea fragilis
Palaeocystodinium lidiae
Phelodinium tricuspe
Trithyrodinium evittii
Palaeoperidinium pyrophorum
Spongodinium #LA
Pervosphaeridium pseudhystrichodinium
- 2330m: Cordosphaeridium inodes longipes
Hystrichosphaeridium tubiferum
Isabelidium cretaceum (?reworked)
Trithyrodinium #LA

Degree of Confidence: 3

2360-2370m: Spongodinium delitiense Zone to Impagidinium #LL Zone (Maastrichtian)

- 2360m: Ceratiopsis diebelii sensu McIntyre 1975
Manumiella cretacea
Oligosphaeridium complex

Degree of Confidence: 2

Remarks: The presence of Manumiella cretacea at 2360-2380m indicates penetration of the Impagidinium #LL Zone. It is possible that a condensed sequence occurs immediately above this sample or within this sample interval which includes strata of the Maastrichtian S. delitiense Zone.

2390-2400m: Isabelidinium cooksoniae Zone to Chatangiella tripartita Zone (Maastrichtian to Campanian)

2390m: Ceratiopsis diebelii
 Chatangiella ditissima
 Impagidinium #LL *
 Spongodinium delitiense

Degree of Confidence: 2

Remarks: The occurrence of C. ditissima in the cuttings sample at 2390-2410m indicates penetration of the C. tripartita Zone. It is possible that this sample or the interval between 2370m and 2390m includes a condensed sequence including the Isabelidinium cooksoniae Zone.

2420-2490m: Cometodinium obscurum Zone (Coniacian to Turonian)

2420m: Triporoletes radiatus *
 Cleistosphaeridium huguoniotii

2450m: Parvisaccites radiatus *
 Florentinia buspina
 Manumiella lata

2480m: Rugubivesiculites reductus *

Degree of Confidence: 3

Remarks: The presence of C. huguoniotii and F. buspina suggests that it is the lower portions of the Cometodinium obscurum Zone of Turonian age. C. obscurum is found caved into the next lower zone at 2540m, confirming the presence of C. obscurum Zone within this well.

2510-2610m: Parvisaccites amplus Zone (early to middle Albian)

- 2510m: Cerebropollenites mesozoicus *
Ellipsoidictyum imperfectum
Parvisaccites amplus *
- 2540m: Cometodinium obscurum (depressed top)
Kiokansium polytypes (depressed top)
- 2600m: Aptea polymorpha *
Canningia attadalicum cf.

Degree of Confidence: 4

Remarks: A marked hiatus is indicated between 2490m and 2510m. The presence of Kiokansium polytypes within this zone may indicate cavings of Cenomanian age.

2630-2792m: Muderongia asymmetrica Zone (early to middle Albian)

- 2630m: Muderongia asymmetrica
- 2660m: Cedripites canadensis *
- 2690m: Muderongia #LS

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2720m: Podocarpidites granulosus *

2780m: Podocarpidites epistriatus *

Degree of Confidence: 4

Remarks: The lack of terrestrial fern spores, which are generally present within this zone, may indicate a more distal sedimentary environment than for similar intervals in other wells.

MICROPALEONTOLOGICAL ZONATION

- 420- 930m Cassidulina teretis Zone (late Miocene or younger)
- 950- 990m Asterigerina guerichi Zone (early Miocene or older)
- 1010-1050m Asterigerina bartoniana Zone (late Oligocene)
- 1070-1320m Ceratobulimina contraria Zone (early Oligocene)
- 1340-1620m Spiroplectamina adamsi Zone (late Eocene)
- 1640-1650m Cyclammina amplexans Zone (late Eocene)
- 1670-1800m Haplophragmoides acutidorsatum Zone (middle Eocene)
- 1820-1950m Bulimina ovata Zone (early Eocene)
- 1970-1980m Karrerella apicularis Zone (early Eocene)
- 2000-2250m Spiroplectamina grzybowski Zone (early Eocene)
- 2270-2280m Glomospira charoides Zone (late Paleocene)
- 2300-2340m Glomospira corona Zone (early Paleocene)
- Not observed Praecystamina globigerinaeformis Zone (early Paleocene)
- 2360-2400m Rzehakina epigona zone (early Paleocene)

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2420-2490m Arenobulimina dorbigny Zone (?Campanian)

2510-2812m No zonal assignment (No age assignment)

SELECTED FORAMINIFERA

420-930m: Cassidulina teretis Zone (late Miocene or younger)

440m Globigerina bulloides *

Degree of Confidence: 1

Remarks: The age and zonal assignments for this interval are only tentative, due to poor fossil recovery. The reported stratigraphic range of G. bulloides is early Oligocene to Holocene (Jenkins, in Bolli et al., 1985).

950-990m: Asterigerina guerichi Zone (early Miocene or older)

950m Heterolepa sp. 1
Guttulina problema

Degree of Confidence: 1

1010-1050m: Asterigerina bartoniana Zone (late Oligocene)

- 1010m Coscinodiscus #H 1
 Gyroidinoides cf. angustiumbilicata

Degree of Confidence: 2

1070-1320m: Ceratobulimina contraria Zone (early Oligocene)

- 1070m Textularia smithvillensis
 Gyroidinoides girardana
- 1100m Cibicidoides proprius
 Hoeglundina elegans
 Lenticulina #H 1
- 1154m CASING
- 1160m Textularia sp.
- 1220m Cyclammina sp.
 Coscinodiscus sp. +
- 1280m Alveolophragmium #H 1
- 1310m Glandulina laevigata
 Ammodiscus cretaceus
 Eponides plummerae
 Globorotaloides suteri *

Degree of Confidence: 3

1340-1620m: Spiroplectamina adamsi Zone (late Eocene)

- 1340m Haplophragmoides eggeri
 Bathysiphon discreta
- 1370m Nodosaria elegantissima
- 1400m Cyclammina placenta
- 1430m Spiroplectamina adamsi
 Haplophragmoides walteri
 Trochammina collyra
- 1460m Cribrostomoides subglobosus
 Cyclammina cancellata
 Recurvoides walteri
 Lenticulina midwayensis
 Ceratobulimina contraria
 Pullenia quinqueloba
 Trochammina inflata
 Coscinodiscus #H 2 *
- 1490m Cribrostomoides scitulus
 Globigerina linaperta *

Degree of Confidence: 3

1640-1650m: Cyclammina amplexans Zone (late Eocene)

1640m Vaginulinopsis decorata
Trifarina cf. gracilis
Cibicidoides blanpiedi

Degree of Confidence: 3

Remarks: The top of this zone could be located at 1490m due to the highest occurrence of C. scitulus

1670-1800m: Haplophragmoides acutidorsatum Zone (middle Eocene)

1670m Haplophragmoides acutidorsatum
Trochammina globigeriniformis
Nodosaria cf. minor

1730m Ammodiscus peruvianus
Stilostomella midwayensis

1760m Cyclammina amplexans

1790m Catapsydrax cf. dissimilis *

Degree of Confidence: 3

Remarks: The presence of C. cf. dissimilis indicates a maximum age of middle Eocene at the bottom (1790-1800m) of this zone.

1820-1950m: Bulimina ovata Zone (early Eocene)

1820m	<u>Bulimina ovata</u> <u>Anomalinoides acuta</u> <u>Reophax pilulifer</u>
1850m	<u>Cibicidoides mirificus</u> <u>Trochammina deformis</u>
1880m	<u>Budashevaella multicamerata</u> <u>Siphogenerinoides eleganta</u>
1910m	<u>Hoeglundina eocenica</u> <u>Bulimina alazanensis</u> <u>Plectofrondicularia lirata</u>

Degree of Confidence: 3

1970-2100m: Karreriella apicularis Zone (early Eocene)

1970m	<u>Karreriella apicularis</u>
2030m	<u>Spiroplectammina mexiaensis</u> <u>Anmodiscus glabratus</u> <u>Trochamminoides subtrullisatus</u> <u>Bathysiphon discreta</u>

2090m Acarinina soldadoensis *
 Planularia toddae
 Saccamina sphaerica

Degree of Confidence: 3

Remarks: The top of this zone could be located at 1880m due to the highest occurrence of Siphogenerinoides eleganta.

2210-2250m: Spiroplectammina grzybowski Zone (early Eocene)

2210m Bulimina cf. quadrata
 Cibicidoides alleni
 Heterolepa grimsdalei
 Ammobaculites expansus
 Chilostomella cylindroides

2240m Haplophragmoides linki
 Haplophragmoides impensus
 Spiroplectammina navarroana
 Bulimina quadrata
 Clavulina parisiensis

Degree of Confidence: 3

2270-2280m: Glomospira charoides Zone (late Paleocene)

2270m Glomospira charoides
 Gavelinella micra
 Ammobaculites polythalamus

Bulimina midwayensis

Gavelinella danica

Degree of Confidence: 3

2300-2340m: Glomospira corona Zone (early Paleocene)

2300m

Glomospira corona

Gavelinella becariformis

Dorothia trochoidea

Saccamina placenta

Pelosina sp.

Degree of Confidence: 3

2360-2400m: Rzehakina epigona Zone (Maastrichtian)

2420m

Rzehakina epigona

Dorothia oxycona

Haplophragmoides cf. suborbicularis

2390m

Saccamina complanata

Ammolagena clavata

2403m

CASING

Degree of Confidence: 3

2420-2490m: Arenobulimina dorbigny Zone (Campanian?)

2420m Arenobulimina dorbigny
 Uvigerinamina jankoi

Degree of Confidence: 3

2510-2792m: No zonal assignment (No age assignment)

PALEOBATHYMETRY

410- 420m	Non-marine to Transitional
<u>Criteria:</u>	No foraminifera
440- 540m	Inner Neritic
<u>Criteria:</u>	<u>Globigerina bulloides</u> , marine dinoflagellates
560- 630m	Transitional to Inner Neritic
<u>Criteria:</u>	No foraminifera to 950m, angiosperm pollen
650- 780m	Inner Neritic
<u>Criteria:</u>	Marine dinoflagellates to 950m
800- 900m	Transitional to Inner Neritic
<u>Criteria:</u>	Fungal spores
920- 990m	Inner Neritic
<u>Criteria:</u>	Marine dinoflagellates, <u>Guttulina problema</u>
1010-1260m	Inner Neritic to Middle Neritic
<u>Criteria:</u>	<u>Coscinodiscus #H 1</u> , <u>Textularia smithvillensis</u> , <u>Gyroidinoides girardana</u>
1280-1320m	Middle Neritic
<u>Criteria:</u>	<u>Globorotaloides suteri</u> , <u>Ammodiscus cretaceus</u>
1340-1410m	Middle Neritic to Outer Neritic
<u>Criteria:</u>	<u>Bathysiphon discreta</u> , <u>Cyclammina placenta</u> , <u>Haplophragmoides eggeri</u>

- 1430-1440m Outer Neritic
Criteria: Haplophragmoides walteri, Trochammina collyra
- 1460-1620m Outer Neritic to Upper Bathyal
Criteria: Cribrostomoides subglobosus, Cyclammina cancellata,
Recurvoides walteri, Cribrostomoides scitulus
- 1640-1800m Upper Bathyal
Criteria: Haplophragmoides acutidorsatum, Trochammina globigeriniformis, Cyclammina amplexans
- 1820-2280m Upper Bathyal to Lower Bathyal
Criteria: Reophax pilulifer, Budashevaella multicamerata,
Karrieriella apicularis, Ammodiscus glabratus,
finer-grained Bathysiphon discreta, Chilostomella cylindroides
- 2300-2400m Lower Bathyal
Criteria: Glomospira corona, Saccamina complanata, Pelosina
sp., Ammolagena clavata
- 2420-2490m Upper Bathyal to Lower Bathyal
Criteria: Decrease in diversity and abundance
- Remarks: Paleoenvironments interpreted from 2400m to 2640m are only tentative due to poor fossil recovery.
- 2510-2640m Middle Neritic to Outer Neritic
Criteria: Poor fossil recovery, quartz grains

KEROGEN & TAI

Depth	AM	AT	AG	SA	M	BT	ST	I	R	TAI
*****	---	---	---	---	---	---	---	---	---	---
650.0	0	0	0	0	5	35	55	5	0	2-
770.0	0	0	0	0	5	30	55	10	0	2-
860.0	0	0	0	0	5	35	50	10	0	2-
950.0	0	0	0	0	5	35	50	10	0	2-
1100.0	10	25	0	0	0	35	25	5	0	2-2
1310.0	10	25	0	0	0	35	25	5	0	22
1430.0	10	30	0	0	5	30	25	5	0	2-2
1520.0	10	25	0	0	5	35	25	5	0	2-2
1610.0	5	20	0	0	5	35	30	5	0	2-2
1730.0	10	25	0	0	5	30	25	5	0	2-2
1820.0	10	20	0	0	5	35	25	5	0	2-2
1940.0	10	25	0	0	0	30	30	5	0	2-2
2030.0	10	25	0	0	5	25	20	15	0	2
2150.0	10	25	0	0	5	25	20	15	0	2
2240.0	10	25	0	0	5	30	15	10	0	2
2330.0	5	10	0	5	5	15	35	25	0	2
2450.0	5	5	0	5	5	20	40	20	0	2
2540.0	5	5	0	5	5	15	45	20	0	2
2660.0	0	0	0	0	5	20	50	25	0	2+
2750.0	0	0	0	0	5	20	50	25	0	2+
2805.0	0	5	0	0	5	30	40	20	0	2+
2812.0	0	5	0	0	5	30	40	20	0	

KEROGEN, TAI AND VITRINITE REFLECTANCE

The interval from 650-950m of early Oligocene age is devoid of amorphous kerogen. Woody kerogen comprises 50% to 55%, coaly inertinitic kerogen comprises 5% to 10%, and herbaceous kerogen 35% to 40% of the total kerogen. The interval from 1100-2240m contains relatively high relative abundances of amorphous kerogen, reaching a peak of 40% in the sample at 1430m. Marine amorphous kerogen occurs in relatively low quantities (5% to 10%) throughout this interval. Coaly inertinitic kerogen comprises 5% in the upper part of this interval above 1940m, but increases to 15% in the lower part of the section in strata of late Paleocene age. Woody kerogen is relatively uncommon compared to the overlying and underlying intervals and averages 25%. Herbaceous kerogen comprises between 30% and 40% of the total kerogen content. The interval from 2330-2450m of Coniacian-Turonian and Maastrichtian age contains 10% to 15% amorphous kerogen, 20% to 25% coaly inertinitic kerogen, 35% to 40% woody kerogen and 25% to 30% herbaceous kerogen. The Lower Cretaceous interval is devoid of amorphous kerogen or contains only rare quantities (mostly 5%). Coaly inertinitic kerogen, woody kerogen and herbaceous kerogen are generally present in approximately equal proportions to those in the overlying Upper Cretaceous interval.

The level of Thermal Alteration increase from a value of 2⁻ at 650m, to a value of 2⁻ to 2 below 1100m in strata of early Oligocene age, to a value of 2 at 2030m in strata of early Eocene age, to a value of 2⁺ below 2660m in strata of early Albian to late Aptian age. The level of Thermal Alteration and the kerogen types indicate source rock potential for liquid hydrocarbons from the marine amorphous kerogen in the interval from 1100-2240m of upper Paleocene to lower Oligocene age. Source rock potential for predominantly gaseous hydrocarbons is indicated from the herbaceous and woody kerogen below 2660m in the Lower Cretaceous section.

The following levels of thermal maturity are indicated by vitrinite reflectance analysis

- 435- 940m: Immature (Ro% = 0.204% to 0.326%)
- 1100-1460m: Indeterminate (Barren or Ro% is widely divergent)
- 1490-2300m: Onset of maturation (Ro% = 0.415% to 0.555%)
- 2470-2645m: Mature (Ro% = 0.729% to 0.854%)
- 2805m: Highly mature (Ro% = 1.004%)

The interval between 1100m and 2120m contained numerous barren samples or unreliable population distributions.

VITRINITE REFLECTANCEKey to Measurement Qualifying Labels

E = Excellent
 = Good
 P = Poor
 C = Caved
 R = Reworked

Sample Depth : 435.0

0.140	P	0.164	P	0.206		0.215	E	0.293	P	0.373	P	0.404	E
0.430	E	0.435	P	0.537	R	0.593	R	0.596	R	0.609	R	0.789	R
0.825	R	0.897	R	1.005	R	1.156	R	1.169	R	1.252	R	1.565	R
1.973	R												

Actual Mean = 0.710 Actual Standard Deviation = 0.483

Edited Mean = 0.296 Edited Standard Deviation = 0.118

Sample Depth : 610.0

0.122	P	0.122	P	0.122	P	0.125	P	0.164	P	0.167	P	0.249	E
0.252		0.278		0.324	P	0.324	P	0.555	R				

Actual Mean = 0.234 Actual Standard Deviation = 0.128

Edited Mean = 0.204 Edited Standard Deviation = 0.082

Sample Depth : 775.0

0.120	E	0.134	E	0.140	E	0.907	R
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Actual Mean = 0.325 Actual Standard Deviation = 0.388

Edited Mean = 0.131 Edited Standard Deviation = 0.010

Bujak Davies Group

North Bjarni F-06.....31

Sample Depth : 940.0

0.210		0.212		0.221	P	0.252		0.316	P	0.360	P	0.381	P
0.414	P	0.445	P	0.449	P	0.500	R	0.516	R	0.524	R	0.563	R
0.684	R	0.707	R	0.755	R	0.916	R	0.932	R	1.201	R		

Actual Mean = 0.528 Actual Standard Deviation = 0.268

Edited Mean = 0.326 Edited Standard Deviation = 0.097

Sample Depth : 1100.0

0.000

Actual Mean = 0.000 Actual Standard Deviation = 0.000

Edited Mean = 0.000 Edited Standard Deviation = 0.000

Sample Depth : 1275.0

0.140	C	0.230	C	0.290	C	0.399	P	0.411	P	0.472	P	0.512	
0.522	P	0.610	P	0.638	P	0.649	P	0.707	P	0.780	P	0.810	R
0.847	R	0.849	R	0.852	R	0.933	R	0.938	R	1.048	R	1.059	R
1.115	R	1.180	R	1.472	R	1.542	R	1.627	R				

Actual Mean = 0.794 Actual Standard Deviation = 0.390

Edited Mean = 0.570 Edited Standard Deviation = 0.127

Sample Depth : 1430.0

0.290 C

Actual Mean = 0.290 Actual Standard Deviation = 0.000

Sample Depth : 1460.0

0.000

Actual Mean = 0.000 Actual Standard Deviation = 0.000

Edited Mean = 0.000 Edited Standard Deviation = 0.000

Bujak Davies Group

North Bjarni F-06.....32

Sample Depth : 1490.0

0.190	C	0.282	C	0.285	C	0.295	C	0.348	P	0.377	P	0.441
0.524	P	0.541	P	0.670	R	0.687	R	0.806	R	0.825	R	

Actual Mean = 0.482 Actual Standard Deviation = 0.211

Edited Mean = 0.446 Edited Standard Deviation = 0.086

Sample Depth : 1700.0

0.309 P

Actual Mean = 0.309 Actual Standard Deviation = 0.000

Edited Mean = 0.309 Edited Standard Deviation = 0.000

Sample Depth : 1730.0

0.217	C	0.219	C	0.291	P	0.317	P	0.318	P	0.335	P	0.346	P
0.349	P	0.373	P	0.433	P	0.443	P	0.450	P	0.460	P	0.543	P
0.576	P	0.578	P	0.602	R	0.833	R	0.934	R	0.955	R		

Actual Mean = 0.479 Actual Standard Deviation = 0.217

Edited Mean = 0.415 Edited Standard Deviation = 0.098

Sample Depth : 1820.0

0.228	C	0.244	C	0.275	C	0.297	P	0.309	P	0.322	P	0.338	P
0.358	P	0.360	P	0.382	P	0.390	P	0.390	P	0.558	P	0.608	P
0.684	R	0.700	R	0.711	R	0.753	R	0.756	R	0.868	R	1.099	R
1.333	R	1.400	R										

Actual Mean = 0.581 Actual Standard Deviation = 0.338

Edited Mean = 0.392 Edited Standard Deviation = 0.100

Sample Depth : 1910.0

0.000

Actual Mean = 0.000 Actual Standard Deviation = 0.000

Edited Mean = 0.000 Edited Standard Deviation = 0.000

Bujak Davies Group

North Bjarni F-06.....33

Sample Depth : 1940.0

0.198 C 0.225 C 0.256 C 0.278 C 0.298 C 0.510 P 0.982 R

Actual Mean = 0.392 Actual Standard Deviation = 0.279

Edited Mean = 0.510 Edited Standard Deviation = 0.000

Sample Depth : 2120.0

0.282 C 0.299 C 0.322 C 0.376 P 0.384 P 0.403 P 0.471 P
0.766 R

Actual Mean = 0.413 Actual Standard Deviation = 0.155

Edited Mean = 0.408 Edited Standard Deviation = 0.043

Sample Depth : 2300.0

0.190 C 0.347 C 0.492 P 0.505 0.515 P 0.516 0.517
0.543 0.556 0.668 P 0.682 0.800 R 0.874 R 0.969 R
1.012 R 1.038 R 1.130 R 1.149 R 1.176 R 1.356 R

Actual Mean = 0.752 Actual Standard Deviation = 0.319

Edited Mean = 0.555 Edited Standard Deviation = 0.071

Sample Depth : 2470.0

0.610 P 0.616 0.707 P 0.715 0.730 P 0.763 E 0.768
0.780 0.802 0.802 0.885 R 0.901 R 0.956 R 0.959 R
0.991 R 1.001 R 1.008 R 1.072 R 1.078 R 1.096 R 1.148 R
1.183 R 1.195 R

Actual Mean = 0.903 Actual Standard Deviation = 0.178

Edited Mean = 0.729 Edited Standard Deviation = 0.070

Bujak Davies Group

North Bjarni F-06.....34

Sample Depth : 2645.0

0.436	C	0.664	P	0.752		0.786	P	0.825	P	0.872		0.875	P
0.895	P	0.901	P	0.924	P	0.936	P	0.960	P	1.123	R	1.125	R
1.141	R	1.145	R	1.149	R	1.281	R	1.333	R				

Actual Mean = 0.954 Actual Standard Deviation = 0.221

Edited Mean = 0.854 Edited Standard Deviation = 0.009

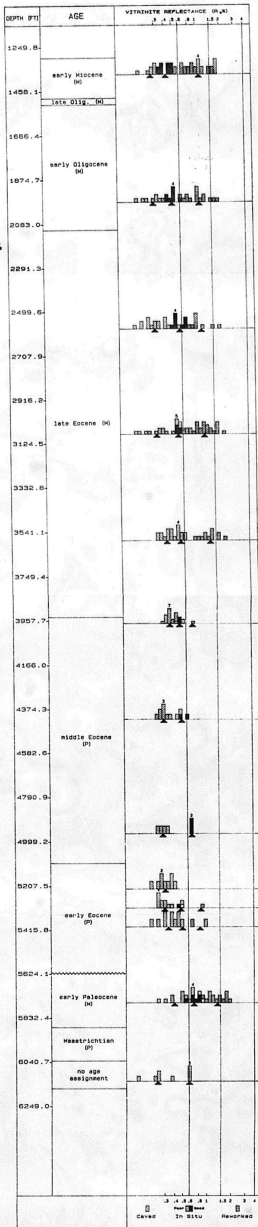
Sample Depth : 2805.0

0.429	C	0.493	C	0.501	C	0.536	C	0.546	C	0.559	C	0.589	C
0.614	C	0.928	E	0.945	E	0.980	E	0.996	E	1.033	E	1.053	
1.095	E	1.130	R	1.157	R	1.195	R	1.212	R	1.217	R	1.270	R
1.655	R												

Actual Mean = 0.915 Actual Standard Deviation = 0.331

Edited Mean = 1.004 Edited Standard Deviation = 0.060

BUJAK DAVIES GROUP VITRINITE: Leif M-4B



BUJAK DAVIES GROUP

KEROGEN: Leif M-48

DEPTH (FT)	AGE	THERMAL ALTERATION INDEX *					K1/K2	K3/K4
		1+	2-	2	2-3	3+4		
1250	early Miocene (M)			•				
	late Olig. - O ₀							
1666	early Oligocene (O)			•				
2083				•				
2500				•				
2916	late Eocene (O)			•				
3333								
3749				•				
4166				•				
4583	middle Eocene (P)			•				
4999				•				
5416	early Eocene (P)			•				
	early Paleocene (O)			•				
5832	Maastrichtian (P)			•				
	no age assignment			•				
6249				•				

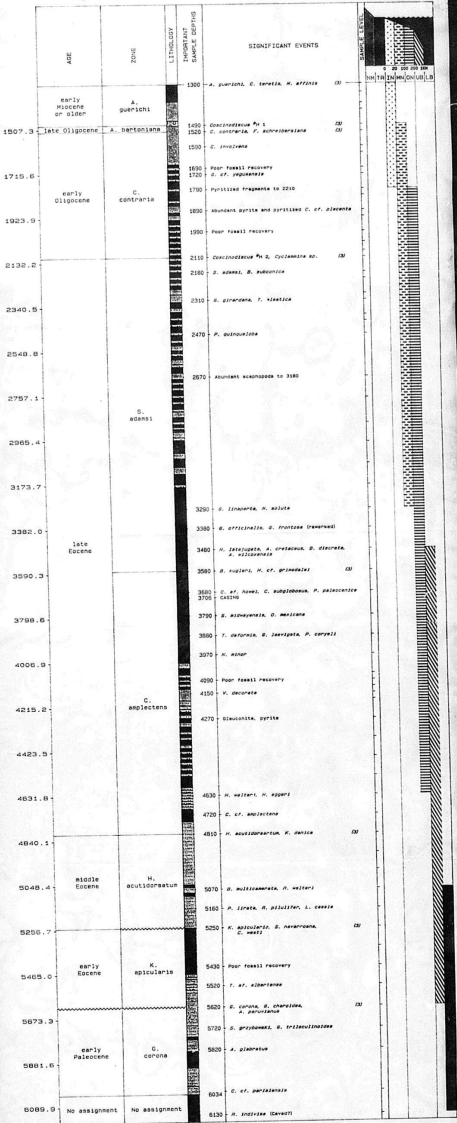
.5 .6 .8 .9 1.0 1.5 2.5 4

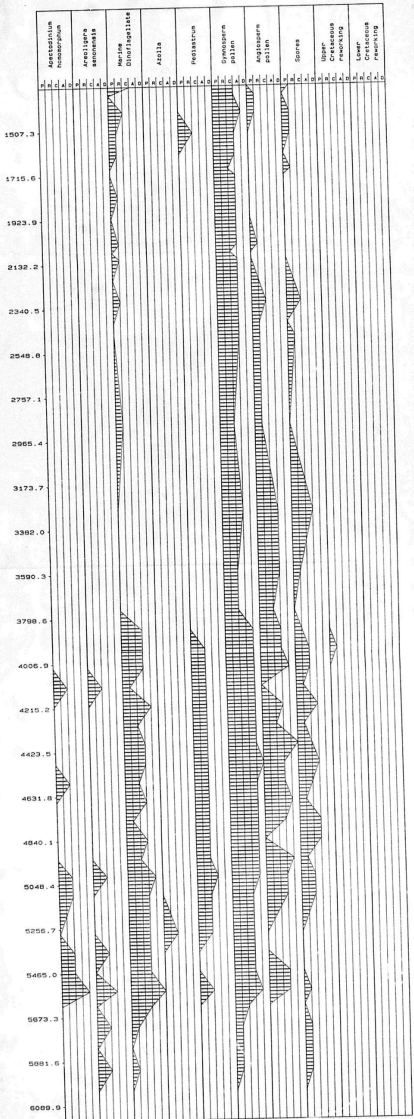
VITRINITE REFLECTANCE (R_v%) *KEROGEN
TYPE

MICROPALEONTOLOGICAL ANALYSIS CHART
BUJAK DAVIES GROUP

CLIENT: G.S.C.
WELL: Leif M-48
AREA: Labrador Shelf

SCIENTIST: Bujak Davies Group
DATE: April 1987
SCALE: 1 inch = 208.3 feet





PALYNOLOGICAL ANALYSIS CHART
BUJAK DAVIES GROUP

CLIENT: G.S.C.
WELL: Leif M-4B
AREA: Labrador Shelf

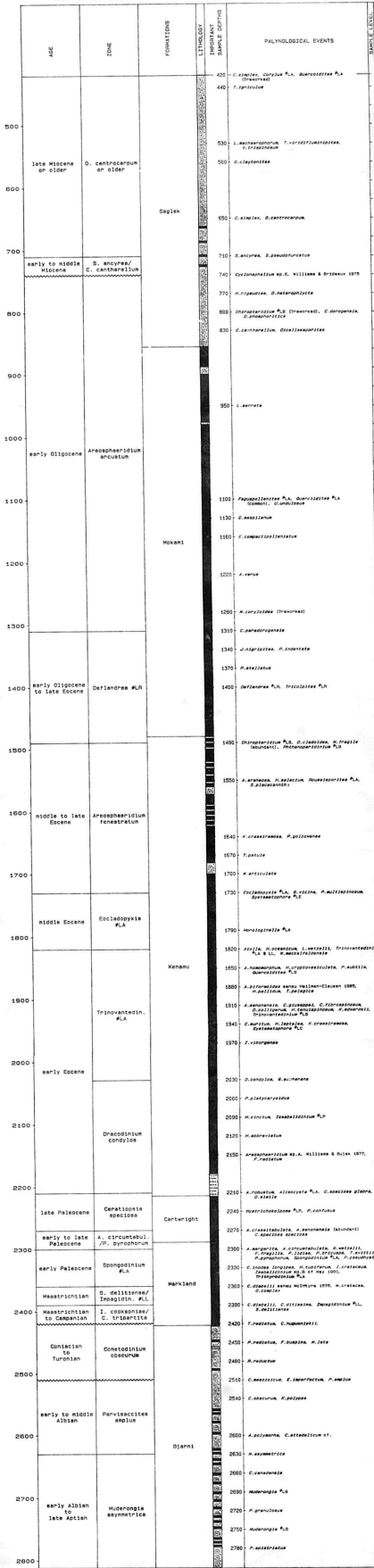
SCIENTIST: Bujak Davies Group
DATE: April 1987
SCALE: 1 inch = 208.3 feet

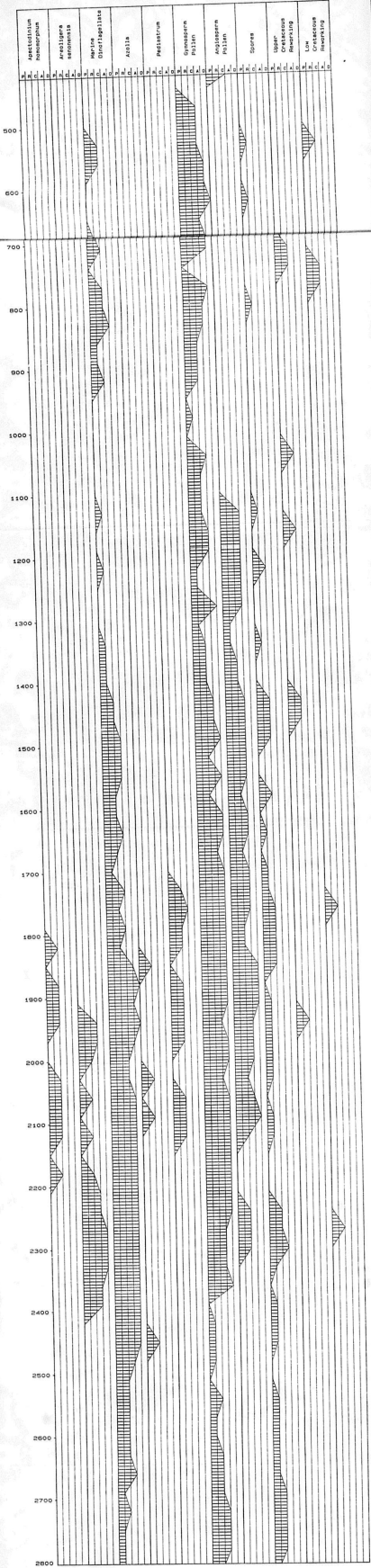
AGE	ZONE	FORMATIONS	LITHOLOGY	IMPORTANT SAMPLE DEPTHS	PALYNOLOGICAL EVENTS	SAMPLE LEVEL
				1300	<i>F. ancyrea</i> , <i>S. haplophrea</i> , <i>F. spicifera</i>	
				1340	<i>A. obtusiloba</i>	
				1420	<i>C. cantharellum</i>	
1507.3	early Miocene or older			1490	<i>Phthalosporidium</i> sp. indet.	
				1520	<i>P. indentata</i>	
1715.6		Seplek		1820	<i>C. guineense</i>	
1923.9				2040	<i>Quercoidites</i> #LA	
2132.2				2110	<i>S. pinnatus gracilis</i>	
				2210	<i>S. dissectus</i> , <i>P. stellatus</i>	
2340.5				2310	<i>J. integratus</i> , <i>P. comatus</i> , <i>S. spinatus</i>	
2548.8				2470	<i>Dicranosporites</i> , <i>Brachysporosporites</i>	
2757.1	late Oligocene to late Eocene	no zonal assignment				
2965.4		Mokani				
3173.7				3290	<i>L. laevigatus</i> #LA	
3382.0				3580	<i>C. spinosus</i> , <i>Faguetiella</i> #LA, <i>Retriocollites</i> #L	
3590.3				3690	<i>A. ancyrea</i> , <i>C. fibropinnatus</i> , <i>Corylus</i> #LA, <i>Diphyocystis</i> sp. indet., <i>L. serrata</i>	
3798.6				3940	<i>S. viciina</i> , <i>H. pinnatus</i> , <i>Pezomachus</i> #LB, <i>M. ovata</i>	
4006.9				4120	<i>A. sphaerata</i>	
4215.2				4210	<i>A. homomorphus</i> , <i>C. samadonensis</i> , <i>Z. scaberrimus</i> (Graham), <i>P. jactitans</i>	
4423.5	middle to late Eocene	Apoosphaeridium fenestratum		4300	<i>M. conyzae</i>	
				4390	<i>S. auritus</i> , <i>F. plana</i> , <i>M. reticulata</i>	
4631.8				4480	<i>A. reticulatus</i> , <i>Z. placanthes</i>	
4840.1				4680	<i>Cakranosporites</i> #LA	
		Kenahu		4930	<i>F. laevigata</i> #LA	
5048.4	middle Eocene	Eocladopyxis #LA		5010	<i>A. homomorphus</i> , <i>C. doreana</i> , <i>M. saccatus</i> , <i>Hystrichosporites</i> #L, <i>Systematophora</i> #L, <i>F. verticillata</i>	
				5100	<i>P. subitica</i> , <i>F. patula</i> , <i>Trinoveboracium</i> #LA	
5256.7		Trinovantedin. #LA		5280	<i>Asella</i> , <i>D. condylos</i> , <i>M. tenuispinosus</i> , <i>L. virens</i> #L	
5465.0	early Eocene	Dreacadinium condylos		5460	<i>D. clausenii</i> , <i>D. divanicatum</i>	
5673.3				5550	<i>A. rugosus</i> , <i>A. homomorphus</i> (abundant), <i>A. senonensis</i> (common), <i>M. patula</i> , <i>M. neocladopyxis</i>	
				5620	Very little karragen or palynomorph recovery in all cuttings samples below 5620	
5881.6	late Paleocene	Ceratopsis speciosa Alisocysta circumscissata		5712	<i>C. apoclyse</i>	
				5800	<i>A. circumscissata</i>	
	Maastrichtian	Impagidium #L		5876	<i>A. nutula</i> , <i>C. clausenii</i> , <i>M. cretaceus</i>	
6089.9	no age assignment	no zonal assignment	volcanic rocks	6034		

PALYNOLOGICAL ANALYSIS CHART
BUJAK DAVIES GROUP

CLIENT: G.S.C.
WELL: North Bjarni 5-06
AREA: Labrador Shelf

SCIENTIST: Bujak Davies Group
DATE: April 1987
SCALE: 1 cm = 25 metres

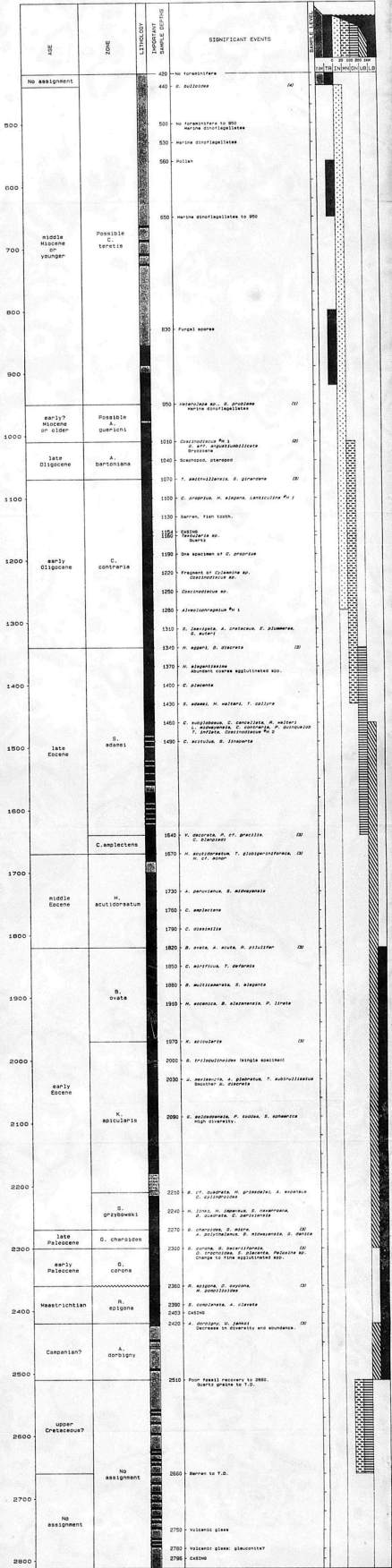




MICROPALEONTOLOGICAL ANALYSIS CHART
BUJAK DAVIES GROUP

CLIENT: G.S.C.
WELL: North Bjarni F-06
AREA: Labrador Shelf

SCIENTIST: Bujak Davies Group
DATE: April 1987
SCALE: 1 cm = 25 metres

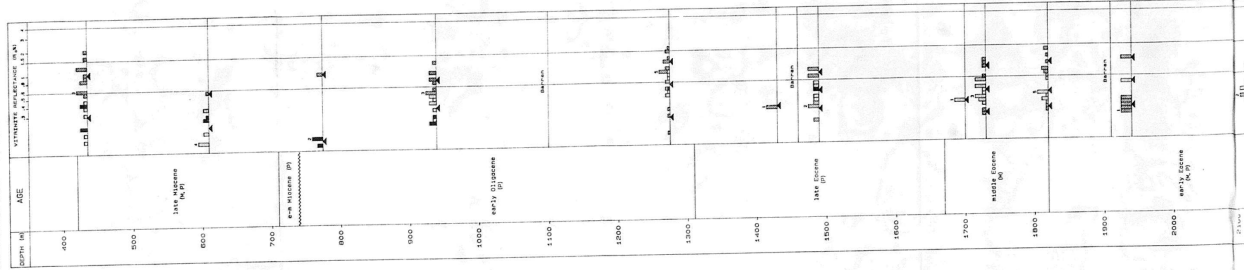


BUJAK DAVIES GROUP KEROGEN: North Bjarni F-06

DEPTH (ft)	AGE	THERMAL ALTERATION INDEX					KEROGEN TYPE
		1	2	3	4	5	
400							
500							
600	late Miocene (M, P)						
700							
800	early Miocene (P)						
900							
1000	early Oligocene (P)						
1100							
1200							
1300							
1400							
1500	late Eocene (P)						
1600							
1700							
1800	middle Eocene (M)						
1900							
2000	early Eocene (M, P)						
2100							
2200							
2300	late Paleocene (M, P)						
2400	Maast. (M, P)						
2500	Coniacian to Turonian (P)						
2600	early Albian (P)						
2700	early Albian to late Aptian (P)						
2800							
2900							

.3 .4 .5 .6 .7 .8 .9 1.0 1.1 1.2 1.3 1.4
 VETRINETE REFLECTANCE (R_v) + KEROGEN TYPE

BUJAK DAVIES GROUP VITRINITE: North Bjarni F-06



27.100

2200

late Paleocene
(M, P)

2300

Maastr. (M, P)

Maastr.-Camp. (P)

2400

Coniacian to
Turonian (P)

2500

early Albian
(P)

2600

early Albian to
late Aptian (P)

2700

2800

2900



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Cored
Surf
In Situ
Recessed