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GSC Open File 3458 (sheet 1 of 9)

EAST COAST BASIN ATLAS SERIES
GRAND BANKS OF NEWFOUNDLAND
BIOSTRATIGRAPHY AND MATURATION DATA 1

INTRODUCTION, LOCATION MAP, AND ZONATIONS

CONTRIBUTORS

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PREAMBLE

These sheets comprise biostratigraphic and maturation information that was compiled in 1989 for publication in the Grand Banks of Newfoundland volume of the East Coast Basin Atlas Series. However, due to priorities at the Geological Survey of Canada resulting from proposed relocation of these data. In response to renewed interest in hydrocarbon resources of the Grand Banks of Newfoundland, GSC Atlantic has chosen to complete these sheets and distribute them as GSC Open File reports.

Although every effort has been made to bring appropriate details up to date, the authors have not incorporated post-1989 information. Interested GSC Atlantic reports exist for wells analyzed in the last few years, and information on the availability of these, including electronic accessibility, can be obtained by contacting the first author on sheet 1, or the Director of GSC Atlantic.

INTRODUCTION TO ALL SHEETS

Biostratigraphic analyses of 67 exploration wells on the Grand Banks and adjacent areas have demonstrated the presence of Cambrian, Ordovician, Silurian, Devonian, Carboniferous, Triassic, Jurassic, Cretaceous, Paleogene, Neogene and Quaternary strata. Assemblages from the Devonian, Carboniferous and most of those from the Triassic-Jurassic boundary beds and lowermost Cretaceous are nonmarine, consisting primarily of spores and pollen (miospores) from higher plants. Otherwise, assemblages are mostly marine and commonly contain an abundance of organic-walled microplankton (dinoflagellates and acritarchs), foraminifera and ostracods.

The rocks analyzed consist primarily of cuttings samples, though sidewall cores and, less commonly, conventional cores were sometimes available. Thus, since the majority of analyses are based on cuttings, which often contain contaminants caved from higher in the well, almost all palynological and micropaleontologic zonal schemes for the region have been based on first appearance datums (LADs) of selected taxa.

For the most part, micropaleontological and palynological zones reported in this section are applicable primarily, if not exclusively, to offshore Canada or parts thereof. The correlation of individual zones and integrated zonal schemes from one locality to another within the region is the most meaningful application of the biostratigraphic data presented here. The zonation schemes formulated for offshore eastern Canada have been calibrated against the international standard ages with varying degrees of confidence, since equivalent assemblages and ranges are not necessarily identical from basin to basin. This calibration, as well as the regional zonation itself, is subject to re-evaluation and refinement as knowledge of the taxonomy, paleoecology and biostratigraphic ranges of the fossils improves.

The maturation studies discussed in this section include visual kerogen and vitrinite reflectance analyses. Organic geochemistry, including total organic carbon, pyrolysis-gas extract data and total C_{15+} are presented under Geochemistry.

FOSSIL GROUPS AND HISTORICAL PERSPECTIVE

Biostratigraphically useful fossils in Grand Banks strata can be subdivided into two principal groups: palynomorphs and microfossils with inorganic walls.

Palynomorphs are organic-walled microfossils and form the material basis for the science of palynology. Palynomorphs are of varied biological affinity but are conveniently studied together since their organic-walls necessitate special rock-maceration techniques for extraction. Palynomorph groups which are biostratigraphically important on the Grand Banks are miospores (pollen and spores), dinoflagellates and acritarchs.

Lower Paleozoic rocks have been demonstrated by acritarch assemblages in Phalanx P-62 in the Whale Basin and Linnet E-63 in the East Newfoundland Basin. The presence of Devonian and Carboniferous strata have been proven by miospores from wells on the Burin Platform (Hermine E-94), the Whale Basin (Gannet O-54, Sandpiper J-77 and Phalanx P-62), and the East Newfoundland Basin (Linnet E-63 and Blue H-28).

Palynomorphs have been used extensively to date and zone Mesozoic-Cenozoic strata in the Grand Banks and adjacent areas. Several palynomorph groups have been employed, although emphasis has been placed on the dinoflagellates. The first palynozonation for the report area was proposed by Jansa et al. (1974) and Williams (1975). This scheme was refined and described in a series of biostratigraphic charts for the Grand Banks by Williams in Bujak and Williams (1977-Jurassic, 1979-Cretaceous). The resulting composite zonation constituted the framework against which 67 wells from offshore eastern Canada (including many from this region) were analyzed and reported in Barss et al. (1979). Subsequent work by palynologists of the Geological Survey of Canada and by contractors to the GSC have led to refined (but not yet fully described) palynological zonations for selected areas and parts of the section (see Bujak - Davies Group Ltd. (1988), Williams et al. [1990]) and zonation charts in this work.

Inorganic-walled microfossils which have been used to date and zone Mesozoic-Cenozoic strata in the Grand Banks and adjacent areas are foraminifera, ostracods, nannoplankton (coccolithophorids and discoasters) and calpionellids.

A threefold foraminiferal zonation, using planktonic, calcareous benthic and agglutinated benthic foraminifera for the Scotian Shelf was proposed by Ascoli (1976). This was initially tested and refined on 22 wells in offshore Grand Banks by Ascoli (1981, 1984), Ascoli et al. (1986) and Williams et al. (1990). Gradstein and Agterberg (1982) dated the Tertiary in six wells of the Scotian Basin on the basis of analyses of foraminiferal assemblages. Three of these wells are located on the northeastern edge of the Scotian Basin, within the area of the present sites. Williamson (1987) carried out a quantitative foraminiferal biostratigraphic analysis of 13 East Newfoundland Basin wells in spacific. In the area of this atlas, formal elements of this zonation have been reported only from Hermine E-94 and Sandpiper 2J-77.

In the alphanumeric codes for the palynological zones "D" represents Scotian Shelf (for which the GSC zonation was originally defined), "CB" represents Cape Breton Trough (Bay St. George), "P" represents Grand Banks, "PP" represents palynology, "O" represents Oxfordian, "K" represents Jurassic (although note that the first "Jurassic" zone is indicated in Figure 2 as extending below the Triassic-Jurassic boundary), "T" represents Cretaceous, "T" represents Tertiary and "E" represents zones proposed by E. H. Davies. The zones are numbered from bottom to top within each geologic period. Subzones are indicated by a suffixed letter.

NANNOPLANKTON ZONATION

Figure 5, the zonation of Doeven (1983) based on nannofossils (Nannoplankton and discoasters), is the only scheme for this fossil group yet published for offshore eastern Canada. Doeven applied fourteen zones, all previously described from other regions, to the Albian-Maastrichian section in the Hibernia area. Of these, he analysed, the depths in metres from a composite table of the top and bottom samples from each zone are indicated for each well. Although, as noted Doeven (1983, Figure 18) gave sample depths for stage boundaries rather than zone boundaries; note for example the data given for the Coniacian-Santonian boundary in Heron H-73. In cases where a zone is represented by a single sample, the depth of that sample is indicated rather than top and bottom depths; note, for example, the Nephrolithus frequens Zone in Adolphus D-50. Doeven (unpublished GSC internal report) also analyzed a single sample from Emerillon C-56; this analysis is included to the right in this figure.

In the alphanumeric zone codes, "D" represents Doeven, "NP" represents nannoplankton and "C" represents Cretaceous. The zones are numbered from bottom to top (DNPC1 to DNPC14). Informal subzones are indicated by the subdivision of DNPC2 into DNPC2A and DNPC2B and of DNPC3 into DNPC3A and DNPC3B.

MICROPALEONTOLOGICAL ZONATIONS

Figure 6 shows the zonations for various inorganic walled microfossil groups. This table presents the latest versions of the zonations as reported in Williams et al. (1990) which are based on the zonations in Ascoli (1976, 1981, and 1984), Ascoli et al. (1984) and Jansa et al. (1980). Although there is some overlap, the planktonic and calcareous benthic foraminiferal zonations are more applicable in strata deposited in outer neritic and bathyal environments, and the arenaceous benthic foraminiferal and ostracod zonations are most applicable to inner neritic deposits. The calpionellid zonation presented in Table 6 is the standard European zonation (Allemann et al., 1971) for these microfossils.

Figure 7 shows the foraminiferal zonations for Jurassic strata on the Grand Banks as developed by Gradstein (1977) and Stam (1986). The application of Gradstein's zonation is given on the right, with depths in metres to the tops and bottoms of the zones in specific wells indicated.

The ages against which the zonations in Figures 6 - 7 have been calibrated follow the scheme for the "Decade of North American Geology" (DNAG) project (Palmer, 1983). In the alphanumeric codes for the inorganic-walled microfossil zones, "FP" represents planktonic foraminifera, "CP" represents calcareous benthic foraminifera, "AP" represents agglutinated benthic foraminifera, "OS" represents ostracods, "CPI" represents calpionellids, "J" represents Jurassic, "C" represents Cretaceous and "T" represents Tertiary. Apart from the calpionellid zones, which are numbered CP1 to CP5 upwards through the Jurassic-Cretaceous boundary beds, the zones are numbered from bottom to top within each period.

REFERENCES

Alleman, F., Catalano, R., Fares, F. and Remane, J. 1971: Standard calpionellid zonation (Upper Tithonian-Valanginian) of the Western Mediterranean Province; in A. Farinacci (ed.), Proceedings of the Second Planktonic Conference, Roma, 1970, v. 2, p. 1337-1340.

Ascoli, P. 1976: Foraminiferal and ostracod biostratigraphy of the Mesozoic-Cenozoic, Scotian Shelf, Atlantic Canada; in First International Symposium on Benthonic Foraminifera of Continental Margins, Part B, Paleoecology and Biostratigraphy, C. T. Schafer and R. Pelletier (eds.); Maritime Sediments, Special Publication no. 1, p. 653-771.

Ascoli, P., 1981: Foraminiferal-ostracod Late Jurassic biozonation of the Scotian Shelf; Geological Survey of Canada, Open File, 753, 32 p.

Ascoli, P. 1984: Epistomina biostratigraphy across the Jurassic-Cretaceous boundary on the northeastern Atlantic Shelf; in Benthos '83, Second International Symposium on Benthonic Foraminifera, J. Lerouxel (ed.), Pau and Bordeaux, France, April 1983, p. 27-34.

Ascoli, P., Poag, C. W. and Remane, J. 1984: Microfossil zonation across the Jurassic-Cretaceous boundary of the Atlantic margin of North America; in Jurassic-Cretaceous Biochronology and Paleogeography of North America, G. E. G. Westermann (ed.); Geological Association of Canada, Special Paper 27, p. 31-46.

Barss, M. S. and Hacquebard, P. A. 1967: Age and the stratigraphy of the Pictou Group in the Maritime Provinces as revealed by fossil spores; in Collected Papers on Geology of the Atlantic Region - High Lilly Memorial Volume, E. R. W. Neale and H. Williams (eds.); Geological Association of Canada, Special Paper 4, p. 267-282.

Barss, M. S., Bujak, J. P., Wade, J. A. and Williams, G. L. 1980: Age, stratigraphy, organic matter type and colour, and hydrocarbon occurrences in 67 wells, offshore eastern Canada; Geological Survey of Canada, Open File 714, 58 p.

Barss, M. S., Bujak, J. P. and Williams, G. L. 1979: Palynological zonation and correlation of 67 wells, eastern Canada; Geological Survey of Canada, Paper 79-24, 118 p.

Bayliss, G. S. 1975: Chemical changes attendant with thermal alteration of organic materials following exposure; in Program with Abstracts, American Association of Stratigraphic Palynologists, Eighth Annual Meeting, Houston.

Bujak, J. P., Barss, M. S. and Williams, G. L. 1977a: Offshore eastern Canada - Part I: offshore east Canada's organic type and colour and hydrocarbon potential; The Oil and Gas Journal, v. 75, no. 14, p. 198-202.

Bujak, J. P., Barss, M. S. and Williams, G. L. 1977b: Offshore eastern Canada - Part II: organic type and colour and hydrocarbon potential; The Oil and Gas Journal, v. 75, no. 15, p. 96-100.

Bujak Davies Group Ltd. 1988: Palynological analyses of some offshore Newfoundland wells; Geological Survey of Canada, Open Files 1869-1885.

Bujak, J. P. and Williams, G. L. 1977: Jurassic palynostratigraphy of offshore eastern Canada; in Biostratigraphic Micropaleontology of Atlantic Basin and Borderlands, P. M. Swain (ed.); Elsevier Scientific Publishing Company, New York, p. 321-339.

Bujak, J. P. and Williams, G. L. 1978: Cretaceous palynostratigraphy of offshore southeastern Canada; Geological Survey of Canada, Bulletin 297, 19 p.

Cascalho, J. M., Doman, J. and Portbault, B. 1977: Relationships between maturation of organic matter and geothermal gradient, as exemplified in Canadian eastcoast offshore wells; Bulletin of Canadian Petroleum Geology, v. 25, p. 174-194.

Doeven, P. H. 1983: Cretaceous nannofossil stratigraphy and paleoecology of the northwestern Atlantic margin; Geological Survey of Canada, Bulletin 356, 69 p.

Enkre, W. B. 1985: A synopsis of hydrocarbon maturation data for the East Newfoundland Basin; Geological Survey of Canada, Open File 1178, 105 p.

Gradstein, F. M. 1977: Biostratigraphy and biogeography of Jurassic Grand Banks foraminifera; in First International Symposium on Benthonic Foraminifera of Continental Margins; Part B: Paleoecology and Biostratigraphy, C. T. Schafer and R. B. Pelletier (eds.); Maritime Sediments, Special Publication no. 1, p. 557-583.

Gradstein, F. M. and Agterberg, F. P. 1982: Models of Cenozoic foraminiferal stratigraphy, northwestern margin of the Atlantic Basin; in Quantitative Stratigraphic Correlation, J. M. Cubitt and R. A. Reyment (eds.); John Wiley and Sons, Ltd., Chichester, England, p. 119-173.

Grant, A. C., McAlpine, K. D. and Wade, J. A. 1986: The continental margin of eastern Canada - geological framework and petroleum potential; in Future Petroleum Provinces of the World, M. T. Halbouty (ed.); Memoir - American Association of Petroleum Geologists, p. 177-206.

Hacquebard, P. A. 1972: The Carboniferous of eastern Canada; Compte Rendu, Septieme Congres International de Stratigraphie et de Géologie du Carbonifère, Krefeld, p. 69-90.

Harland, W. B., Armstrong, R. L., Cox, A. V., Craig, L. E., Smith, A. G. and Smith, D. G. 1990: A Geologic Time Scale 1989; Cambridge University Press, Cambridge, England, 263 p.

Jansa, L. F., Remane, J. and Ascoli, P. 1980: Calpionellid and foraminiferal-ostracod biostratigraphy across the Jurassic-Cretaceous boundary, offshore eastern Canada; Revista Italiana di Paleontologia e Stratigrafia, v. 86, n. 1, p. 87-126.

Jenkins, W. A. M., Ascoli, P., Gradstein, F. M., Jansa, L. F., and Williams, G. L. 1974: Stratigraphy of the Amoco-Mobil Portland P-89, Grand Banks of Newfoundland; Geological Survey of Canada, Paper 74-61, 12 p.

Palmer, A. R. 1983: The Decade of North American Geology 1983 Geologic Time Scale; Geology, v. 11, p. 503-504.

Stam, B. 1986: Quantitative analysis of Middle and Late Jurassic foraminifera from Portugal and its implications for the Grand Banks of Newfoundland. Utrecht Micropaleontological Bulletins, no. 34, 169 p.

Staplin, F. L. 1969: Sedimentary organic matter, organic metamorphism and oil and gas occurrence; Bulletin of Canadian Petroleum Geology, v. 17, p. 47-66.

Utting, J. 1980: Palynology of the Windsor Group (Mississippian) in a borehole at Steelaction, Shubenacadie Basin, Nova Scotia; Canadian Journal of Earth Sciences, v. 17, p. 1031-1045.

Williams, G. L. 1975: Dinoflagellate and spore stratigraphy of the Mesozoic-Cenozoic, offshore eastern Canada; in Offshore Geology of Eastern Canada, Volume 2, Regional Geology, W. J. M. van der Linden and J. A. Wade (eds.); Geological Survey of Canada, Paper 74-30, v. 2, p. 107-161.

Williams, G. L., Ascoli, P., Barss, M. S., Bujak, J. P., Davies, E. H., Fensome, R. A. and Williamson, M. A. 1990: Biostratigraphy and related studies, Chapter 3 in Geology of the Continental Margin of Eastern Canada, M. J. Keen and G. L. Williams (eds.); Geological Survey of Canada, Geology of Canada, no. 2 (also Geological Society of America, The Geology of North America, v. I-1).

Williams, G. L. and Bujak, J. P. 1977: Cenozoic palynostratigraphy of offshore eastern Canada; in Contributions of Stratigraphic Palynology (with emphasis on North America), Volume 1, Cenozoic Palynology, W. C. Elsik (ed.); American Association of Stratigraphic Palynologists, Contributions Series, no. 5A, p. 14-47.

Williamson, M. A. 1987: A quantitative foraminiferal biozonation of the Late Jurassic and Early Cretaceous of the East Newfoundland Basin; Micropaleontology, v. 33, p. 37-65.

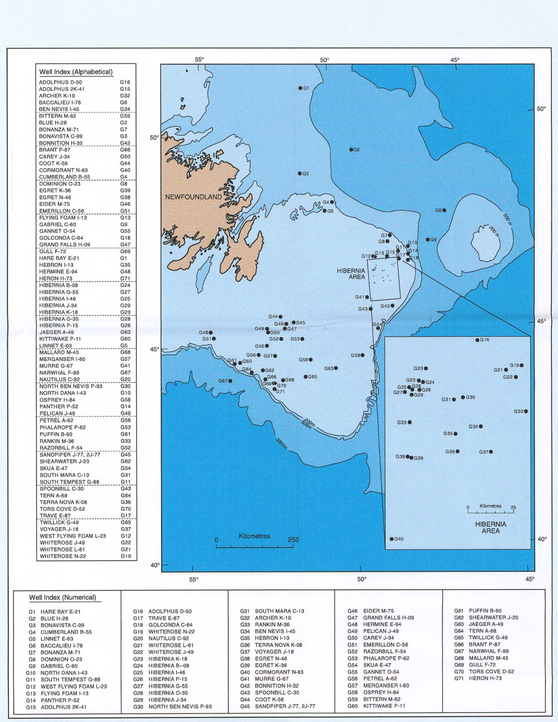

FIGURE 1. Well location map and index

GEOCHRONOLOGIC UNIT			ZONE CODE	ZONE NAME	TYPE SECTION WELL	TYPE SECTION DEPTH (m)	SUBZONE CODE	SUBZONE NAME	TYPE SECTION
TERTIARY – NEOGENE	Miocene	L	SPT 10	*Reticulatosphaera actinocoronata*	Puffin B-90	570 - 1100			
		M	SPT 9	*Pentaphorus falciohnium*	Puffin B-90	1118 - 1567			
		E	SPT 8	*Apteodinium spiridoides*	Oneida O-25	393 - 471			
TERTIARY – PALEOGENE	Oligocene	L	SPT 7	*Chiropteridium galea*	Sable Island C-67	478 - 699			
		E	SPT 6	*Deflandrea heterophycta*	Puffin B-90	1713 - 1995	SPT 6B	*Cordosphaeridium funiculatum*	
							SPT 6A	*Glaphyrocysta* sp.	
	Eocene	L	SPT 5	*Diphyes colligerum*	Puffin B-90	2026 - 2175			
		M	SPT 4	*Nematosphaeropsis reticulensis*	Par: Am shallow core#2	82.6 - 104.9			
		E	SPT 3	*Areoligera* cf.	Sable Island C-67	971 - 1088			
	Paleocene	L	SPT 2	*Cerodinium speciosum*	Sable Island C-67	1111 - 1160			
		E	SPT 1	*Palaeopendinium pyrophorum*	Oneida O-25	696 - 732			
CRETACEOUS – LATE	Maastrichtian		SPC 11	*Dinogymnium euclairense*	Naskapi N-30	358 - 469			
	Campanian		SPC 10	*Odontochitina operculata*	Puffin B-90	2292 - 2408	SPC 10A	*Trichodinium castanea*	
	Santonian		SPC 9	*Pervosphaeridium? truncigerum*	Puffin B-90	2423 - 2618			
	Coniacian		SPC 8	*Oligosphaeridium pulcherriimum*	Naskapi N-30	821 - 858			
	Turonian		SPC 7	*Surculosphaeridium longifurcatum*	Oneida O-25	1387 - 1408			
	Cenomanian		SPC 6	*Kiokansium williamsi*	Sable Island C-67	1562 - 1750			
CRETACEOUS – EARLY	Albian		SPC 5	*Chichaoudinium cf. vestitum; Exostomidiae minor*	Sable Island C-67	1781 - 2476	SPC 5B	*Rugubivesiculites rugosus*	Sable Island C-67 1781 - 1945
	Aptian		SPC 4	*Subtilisphaera perlucida/ Hystrichosphaerina schindewolfi*	Sable Island C-67	2476 - 2798	SPC 4A	*Circulodinium attadaticum*	Naskapi N-30 1324 - 1436
	Barremian		SPC 3	*Pseudoceratium anaphristeum*	Naskapi N-30	1455 - 1471			
	Hauterivian		SPC 2	*Clenidodinium elegantulum*	Sable Island C-67	3220 - 3700			
	Valanginian		SPC 1	*Phoberocysta neocomica*	Puffin B-90	3706 - 4702			
	Berriasian								
JURASSIC – LATE	Portlandian		SPJ 10	*Dichadogonyaulax pannea*	Mohawk B-93	1620 - 1644			
	Kimmeridgian		SPJ 9	*Rhynchodiniopsis cladophora*	Oneida O-25	3049 - 3353			
	Oxfordian		SPJ 8	*Gonyaulacysta jurassica*	Naskapi N-30	1948 - 2009	SPJ 8A	*Compositosphaeridium polonicum*	
JURASSIC – MIDDLE	Callovian		SPJ 7	*Valensiella vermiculata*	Naskapi N-30	2009 - 2131	SPJ 7B	*Stephanelytron sotzburgiensis*	
							SPJ 7A	*Cleistosphaeridium? tribuliferum*	
	Bathonian		SPJ 6	*Dichadogonyaulax filapicata*	Biram M-62	2012 - 2509			
	Bajocian			*Mancodinium semitabulatum*	Eider M-75	2605 - 3121			
	Aalenian		SPJ 5	*Nannoceratopsis gracilis*	Murre G-67	1966 - 2399			
	Toarcian		SPJ 4	*Nannoceratopsis pellucida*	Eurydice P-36	938 - 785			
JURASSIC – EARLY	Pliensbachian		SPJ 3	*Crypto/Leptodinium cf. inaccidens*	Eurydice P-36	938 - 785			
	Sinemurian		SPJ 2	*Cycadophites subgranulosus*	Eurydice P-36	805 - 2687			
	Hettangian		SPJ 1	*Corniculina meyeriana*	Eurydice P-36	2719 - 2967			
L. TRIASSIC	Rhaetian								

FIGURE 2. Mesozoic-Cenozoic palynological zonations developed at GSC

GEOCHRONOLOGIC UNIT			G.S.C. ZONE	ZONE CODE	ZONE NAME	SUBZONE CODE
CRETACEOUS – MIDDLE	Turonian		SPC 7	GPCE 10	*Surculosphaeridium longifurcatum*	GPCE 10B
						GPCE 10A
	Cenomanian		SPC 6	GPCE 9	*Kiokansium williamsii*	GPCE 9B
						GPCE 9A
CRETACEOUS – EARLY	Albian		SPC 5	GPCE 8	*Chichaoudinium sp.A*	GPCE 8C
						GPCE 8B
						GPCE 8A
				GPCE 7	*Stielatopollis sp.A*	GPCE 7C
						GPCE 7B
						GPCE 7A
	Aptian		SPC 4	GPCE 6	*Parvisaccites amplus*	GPCE 6C
						GPCE 6B
						GPCE 6A
	Barremian		SPC 3	GPCE 5	*Subtilisphaera terrula*	GPCE 5D
						GPCE 5C
						GPCE 5B
	Hauterivian		SPC 2			GPCE 5A
				GPCE 4	*Muderongia staurota*	GPCE 4C
						GPCE 4B
						GPCE 4A
	Valanginian		SPC 1	GPCE 3	*Pseudoceratium pelliferum*	GPCE 3D
						GPCE 3C
						GPCE 3B
						GPCE 3A
				GPCE 2	*Cerebropollenites macroverrucosus*	GPCE 2B
						GPCE 2A
	Berriasian			GPCE 1	*Dichadogonyaulax panneum*	GPCE 1C
						GPCE 1B
						GPCE 1A
JURASSIC – LATE	Portlandian		SPJ 10			
	Kimmeridgian		SPJ 9	GPJE 13	*Glossodinium dimorphum*	GPJE 13B
						GPJE 13A
				GPJE 12	*Subtilisphaera? paeminosa*	GPJE 12C
						GPJE 12B
						GPJE 12A
				GPJE 11	*Pilosisporites sp.A*	GPJE 11C
						GPJE 11B
						GPJE 11A
	Oxfordian		SPJ 8	GPJE 10	*Scrimiodinium crystallinum*	GPJE 10B
						GPJE 10A
				GPJE 9	*Gonyaulacysta jurassica jurassica*	GPJE 9B
						GPJE 9A
JURASSIC – MIDDLE	Callovian		SPJ 7	GPJE 8	*Gonyaulacysta jurassica adecta*	GPJE 8B
						GPJE 8A
				GPJE 7	*Dichadogonyaulax sellwoodii*	GPJE 7B
						GPJE 7A
	Bathonian		SPJ 6	GPJE 6	*Dichadogonyaulax? filapicata*	GPJE 6B
						GPJE 6A

FIGURE 3. Detailed palynological zonation for parts of the Jurassic and Cretaceous developed by E.H. Davies

GEOCHRONOLOGIC UNIT			LITHOSTRAT. UNIT	SPORE ZONE After Barss and Hacquebard (1967), Hacquebard (1972), and Williams et al. (1990)	FIELD LITTING	ZONE CODE
PERMIAN – EARLY	Kungurian		PICTOU GROUP	*Vittatina*	E	CBPZ 18
	Artinskian					
	Sakmarian					
	Asselian					
PENNSYLVANIAN – LATE	Stephanian		CUMBERLAND GROUP	*Potonieisporites*	D	CBPZ17
	Westphalian	D		*Thymospora*	C	CBPZ16
		C		*Torispora*	B	CBPZ15
		B	CANSO GROUP	*Vestispora*	A	CBPZ14
		A		*Verrucosisporites cancellata*	G	CBPZ13
	Namurian			*Lycospora acme*	F	CBPZ12
				Reticulatisporites polygonalis	E	CBPZ11
				Potonieisporites elegans	D	CBPZ10
CARBONIFEROUS – EARLY	Namurian		WINDSOR GROUP	*Vallatisporites ciliaris*	B/C	III CBPZ 9
	Visean			*Rugospora* spp.	A	II CBPZ 8B
						I CBPZ 8A
MISSISSIPPIAN – EARLY	Tournaisian		HORTON GROUP	*Vallatisporites vallatus*	G	CBPZ 7
				Tumulispore malevkensis	F	CBPZ 6
				Cyclogranisporites equipensis	E	CBPZ 5
				H.sphaeratus-Hystrichosporites sp.	D	CBPZ 4
	Famennian			*Retispora lepidophyta*	C	CBPZ 3
DEVONIAN – LATE	Frasnian			*Hystrichosphaeridis multifurcatus*	B	CBPZ 2
	Givetian					
DEVONIAN – MIDDLE	Eifelian			*Emphanisporites annulatus*	A	CBPZ 1
DEVONIAN – EARLY	Emsian					

FIGURE 4. Palynological zonation for the late Paleozoic of eastern Canada

GEOCHRONOLOGIC UNIT			ZONE CODE	ZONE	HERON H-73	OSPREY H-84	ADOLPHUS D-50	EMERILLON C-56
Tert.	Maastrichtian	*Nephrolithus frequens*	DNPC 14					
		Lithraphidites quadratus	DNPC 13					
	Campanian	*Arkhangelskiella cymbiformis*	DNPC 12					
		Quadrum trifidum	DNPC 11					
		Quadrum gothicum	DNPC 10					
		Ceratolithoides aculeus	DNPC 9					
CRETACEOUS – LATE	Santonian	*Broinsonia parca*	DNPC 8	1789	838		2829	
				1859	884		2880	
	Coniacian	*Eiffellithus hayii*	DNPC 7	1908	1003		2897	
	Turonian	*Micrantholithus hoblynii*	DNPC 6	2949				
		NO ZONE DESIGNATED		2973				
	Cenomanian			2079	1012		3048	
		(Marthasterites furcatus)	DNPC 6	2097			3057	
CRETACEOUS – EARLY	Albian	*Eiffellithus eximius*	DNPC 5			1039 1049	3078	
		Quadrum gartneri	DNPC 4	2289			3088	
		Lithraphidites acutum	DNPC 3b			1058	3108	
		Eiffellithus turriseiffelii	DNPC 3a		3123 3143	3199 3230		
			DNPC 2b		3313			
			DNPC 2a		3322 3525			
		Prediscosphaera columnata	DNPC 1		3536 3658			

FIGURE 5. Nannoplankton zonation

GEOCHRONOLOGIC UNIT			PLANKTIC	ZONE CODE	CALCAREOUS BENTHIC	ZONE CODE	ARENACEOUS BENTHIC	ZONE CODE	OSTRACODA	ZONE CODE	CALPIONELLIDS	ZONE CODE
EARLY - MIDDLE TERTIARY	Miocene	L	*Globorotalia gr. margaritae*	PFT 11	*Lenticulina americana*	CFT 5						
		E	*Globorotalia praemenardii*	PFT 10								
	Oligocene	L	*Catapsydrax dissimilis*	PFT 9	*Siphogenerina transversa*	CFT 4						
		E	*Globorotalia opima opima*	PFT 8	*Uvigerina galloway/ Siphonina advena*	CFT 3						
			Globigerina ampliapertura	PFT 7								
	Eocene	M	*Turborotalia cerroazulensis*	PFT 6	*Ceratobulimina aff. eximia*	CFT 2						
			Acarinina bullbrooki	PFT 5								
		L	*Morozovella subbotinae*	PFT 4	*Anomalinoides midwayensis* * *Gavelinella danica*	CFT 1	*Spiroplectammina spectabilis* *Textilina plummerae*	AFT 1				
			Morozovella lensiensis	PFT 3								
			Planorotalites pseudomenardii	PFT 2								
	Paleocene	M	*Morozovella pseudobulloides*	PFT 1								
		E			*Stensioina pommerana* * *Globorotalitina micheliniana*	CFC 14	*Tritaxia gr. triletera*	AFC 9	*Veenia multipora* * *Phacorhabdotus simplex*	OSC 13		
LATE CRETACEOUS	Maastrichtian		*Globotruncana