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Palynological analysis of Elf Hermine E-94 Scotian Basin

G.L. Williams

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GEOLOGICAL SURVEY OF CANADA

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Palynological analysis of Elf Hermine E-94

Scotian Basin

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Geological Survey of Canada (Atlantic), Dartmouth

2003

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Table of Contents

Well information 1
References 3
Table 1 4
Table 2 5
Appendix A 6

Chart

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Palynological analysis of Elf Hermine E-94, Scotian Basin

G.S.C. Locality No.: D-38

Unique ID: 300 E94 45300 54150

Location: 45°39'15"N, 54°49'85"W

Elevation Sea level to R.T.: 25.9 m (85')

Water Depth: 82.6 m (271')

Total Depth: 3267.5 m (10,720')

Spud Date: 18 October 1971

Interval Studied: 341.4-664.5 m (1120-2180')

Casing Points:762 mm at 93 m (30" at 305'); 508 mm at 331.3 m (20" at 1087'); 340 mm at 986.6 m (13⅜" at 3237'); 244 mm at 1830 m (9⅝" at 6004')

Elf Hermine E-94 is on the northeastern margin of the Scotian Basin. My study is based on the palynological analysis of 31 drill cuttings samples, processed in 2000 and covering the interval 341.4-664.5 m (1120-2180').

My age determinations based on the dinoflagellate and spore/pollen assemblages are in Table 1 and Figure 1. Ages are based on comparison with known stratigraphic ranges of dinoflagellates in European sections and in other wells and core holes on the Grand Banks. Species citations are given in Appendix A.

The deepest sample examined is at 661.4-664.5 m (2170-2180') and contains *Adnatosphaeridium vittatum*. According to Williams *et al.* (1999), this species has a stratigraphic range of 54-45.4 Ma, or Ypresian-Lutetian. I consider the interval 606.6-664.5 m (1990-2180') to be Lutetian, based on the presence of *Glaphyrocysta ordinata* in the sample from 606.6-609.6 m (1990-2000'). Other dinocyst taxa having their last appearance datums (LADs) in this interval are *Adnatosphaeridium multispinosum, Glaphyrocysta exuberans* and *Wilsonidium echinosuturatum*: these further confirm the Lutetian age.

I regard 570-600.5 m (1870-1970') to be Bartonian, because of the LAD of *Areoligera undulata, Diphyes colligerum, Extratriporopollenites, Phthanoperidinium hibernium* and *Schematophora speciosa*. Species of *Extratriporopollenites* consistently have their LAD in the mid Eocene in Jeanne d'Arc Basin wells.

The Priabonian, from 551.7-563.9 m (1810-1850') is characterized by the presence of *Lentinia serrata*, which has an LAD at 33.5 Ma, close to the Priabonian-Rupelina boundary (Williams *et al.*, in press). Another species having an LAD in the Priabonian is *Wetzeliella simplex*.

A diverse dinocyst assemblage occurs in the Rupelian, which extends from 469.4-545.6 m (1540-1790'). Species with LADs in this interval are *Enneadocysta pectiniformis*, *Operculodinium divergens*, *Phthanoperidinium coreoides* and *Wetzeliella coleothrypta*. Williams *et al.* (2001) give a stratigraphic range of 36.5-29.3 Ma for *Enneadocysta pectiniformis*. The same authors give the LAD of *Operculodinium divergens* as 31.97 MA and Williams *et al.* (2001) gave the LAD of *Phthanoperidinium coreoides* as 30.7 Ma.

Middle Miocene sediments appear to immediately overlie the Rupelian in Hermine E-94, indicating that the Late Oligocene and early Miocene are absent. The Mid Miocene, apparently Serravalian, extends from 442-463.3 m (1450-1520)'. Diagnostic dinocyst species are *Cleistosphaeridium diversispinosum, Hystrichosphaeropsis obscura* and *Unipontidinium aqueductum*. According to Williams *et al.* (in press), the LAD of *Unipontidinium aqueductum* in Northern Hemisphere mid latitudes is at 13.2 Ma, that's within the Serravalian.

The overlying Upper Miocene extends from 435.9 m (1430') to the highest sample examined at 341.4 m (1120'). Although there are few age diagnostic taxa in the cuttings sample at 341.4-344.4 m (1120-1130'), the presence of *Reticulatosphaera actinocoronata* is taken to indicate a late Miocene age. Williams *et al.* (in press)) extend this taxon into the earliest Pliocene (to 4.18 Ma) in other mid latitude areas of the Northern Hemisphere.

Comparison with the age determinations of Williams and Bujak (1977) shows some significant discrepancies (Table 2). These authors did not recognize any major breaks in the section from 341.4-664.8 m (1120-2180') and considered the age of their youngest sample at 335.3-344.4 m (1100-1130') to be Late Miocene.

What is the explanation for these differences of opinion? All the studies were based on analyses of cuttings samples. But the present study benefitted from three distinct advantages: detailed resampling of the section with samples representing composite 10' intervals; reprocessing; and the considerably refined knowledge of dinocyst ranges that has evolved over the last twenty-five years (Powell, 1992; Stover *et al.*, 1996; Williams *et al.*, 1999, 2001, in press). The importance of reprocessing cannot be overemphasized. Because of this, I identified numerous taxa that were absent from the samples processed in the 1970s. This, plus more precise knowledge of stratigraphic ranges, helped me recognize a major break in the section.

Paleoenvironmental interpretations are always difficult when based on cuttings but some generalizations can be made. Species of *Spiniferites* are common in the samples from 652.3-655.3 m (2140-2150') and 634-637 m (2080-2090'), indicating an open marine, possibly outer shelf environment. Dinocysts are abundant in the interval 606.6-609.6 m (1990-2000') and the increase in *Lingulodinium machaerophorum* suggests a more inshore regime, with possibly anoxic conditions as indicated by *Thalassiphora pelagica.*

At 588.3-591.3 m (1930-1940') and 560.8-563.9 m (1840-1850') *Cleistosphaeridium diversispinosum* is abundant. Between these two depths, the interval (579.1-570 m; 1900-1870') contains common *Spiniferites ramosus*, presumably indicating more open marine conditions. From 551.7-554.7 m (1810-1820') and 524.3-527.3 m (1720-1730') there is an influx of pollen, with *Pinus* being dominant in the latter sample. Since *Pinus* is windborne, it suggests the prevelant winds were blowing from onshore.

Between 524.3 and 442 m (1720 and 1450') three are no obvious patterns, but the sample at 432.8-435.9 m (1420-1430') contains abundant *Pinus*. Near shore or nutrient-poor regimes are suggested by the paucity of dinocysts and the high concentrations of wood in the interval 426.7-378 m (1400-1240'). *Pinus* again is abundant in the sample from 350.5-353.6 m (1150-1160') and is accompanied by an

increase in dinocysts, suggesting more open marine environments.

My study of the recently processed samples suggests that more detailed biostratigraphy is possible, especially if wells are resampled. Consequently, I recommend that in all future studies of wells only samples processed in the last few years be used.

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3 Febuary 2003

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c.c. A.E. Jackson, MRG Subdivision, Dartmouth
MRG Subdivision Files, Dartmouth
CNSOPB, Dartmouth (attention M.-J. Verrall)

Table 1. Age determinations in present study of Hermine E-94.

Age		Depth
MIOCENE	LATE	341.4-435.9 m (1120-1430')
	MID (SERRAVALLIAN)	442-463.3 m (1450-1520')
OLIGOCENE	RUPELIAN	469.4-545.6 m (1540-1790')
EOCENE	PRIABONIAN	551.7-563.9 m (1810-1850')
	BARTONIAN	570-600.5 m (1870-1970')
	LUTETIAN	606.6-664.5 m (1990-2180')

Table 2. Comparison of age determinations in biostratigraphic studies of Hermine E-94.

Age		Bartlett 1972	Williams and Bujak 1977	Herein
PLEISTOCENE		117.3-381 m (385-1250')		
PLIOCENE		381-435.9 m (1250-1430')		
MIOCENE	L	435.9-554.7 m (1430-1820')	335.3-426.7 m (1100-1400')	341.4-435.9 m (1120-1430')
	M		454.2-481.6 m (1490-1580')	442-463.3 m (1450-1520')
	E		509-518.2 m (1670-1700')	
OLIGOCENE	L	554.7-637 m (1820-2090')	536.5-545.6 m (1760-1790')	
	E		563.9-627.9 m (1850-2060')	469.4-545.6 m (1540-1790')
EOCENE	P	637-1033.3 m (2090-3390')	646.2-765.1 m (2120-2510')	551.7-563.9 m (1810-1850')
	B			570-600.5 m (1870-1970')
	L			606.6-664.5 m (1990-2180')
	Y			

Appendix A

References for dinoflagellate citations are from Williams *et al.* (1999). Informal taxa will be illustrated in one of the proposed palyatlases.

Achomosphaera andalousiensis (Eisenack, 1954b) Davey and Williams, 1966a
Adnatosphaeridium multispinosum Williams and Downie, 1966c
Adnatosphaeridium vittatum Williams and Downie, 1966c
Apectodinium homomorphum (Deflandre and Cookson, 1955) Lentin and Williams, 1977b
Areoligera undulata Eaton, 1976
Baltisphaeridium "scalenofurcatum"
Batiacasphaera micropapillata Stover, 1977
Caryapollenites spp.
Charlesdowniea proserpina van Mourik *et al.*, 2001
Chiropteridium galea (Maier, 1959) Sarjeant, 1983
Cleistosphaeridium diversispinosum Davey *et al.*, 1966
Cordosphaeridium cantharellus (Brosius, 1963) Gocht, 1969
Cordosphaeridium gracile (Eisenack, 1954b) Davey and Williams, 1966b
Cribroperidinium "major"
Dapsilidinium pastielsii (Davey and Williams, 1966b) Bujak *et al.*, 1980
Deflandrea heterophlycta Deflandre and Cookson, 1955
Deflandrea phosphoritica Eisenack, 1938b
Diconodinium arcticum Manum and Cookson, 1964
Diphyes colligerum (Deflandre and Cookson, 1955) Cookson, 1965a
Diphyes pseudoficusoides Bujak 1994
Distatodinium "cavatum" Zevenboom and Santarelli *in* Zevenboom, 1995
Dracodinium varielongitudum (Williams and Downie, 1966b) Costa and Downie, 1979
Enneadocysta "annulata"
Enneadocysta multicornuta (Eaton, 1971) Stover and Williams, 1995
Enneadocysta pectiniformis (Gerlach, 1961) Stover and Williams, 1995
Extratriporopollenites spp.
Glaphyrocysta divaricata (Williams and Downie, 1966c) Stover and Evitt, 1978
Glaphryocysta exuberans (Deflandre and Cookson, 1955) Stover and Evitt, 1978
Glaphyrocysta ordinata (Williams and Downie, 1966c) Stover and Evitt, 1978
Glaphyrocysta spineta (Eaton, 1976) Stover and Evitt, 1978
Gramineae spp.
Heteraulacacysta "stoveri"
Homotryblium floripes (Deflandre and Cookson, 1955) Stover, 1975
Homotryblium tenuispinosum Davey and Williams, 1966b
Hystrichokolpoma cinctum Klumpp, 1953
Hystrichokolpoma rigaudiae Deflandre and Cookson, 1955
Hystrichokolpoma salacium Eaton, 1976
Hystrichosphaeropsis obscura Habib, 1972
Hystrichostrogylon clausenii Bujak, 1994
Hystrichostrogylon membraniphorum Agelopoulos, 1964
Hystrichostrogylon "procerus"
Impagidinium spp.
Invertocysta tabulata Edwards, 1984
Lentinia "glabra"
Lentinia serrata Bujak *in* Bujak *et al.*, 1980
Melitasphaeridium choanophorum (Deflandre and Cookson, 1955) Harland and Hill, 1979

Melitasphaeridium pseudorecurvatum (Morgenroth, 1966a) Bujak *et al.*, 1980
Nematosphaeropsis lemniscata Bujak, 1984
Operculodinium divergens (Eisenack, 1954b) Stover and Evitt, 1978
Operculodinium eirikianum Head *et al.*, 1989b
Palaeocystodinium golzowense Alberti, 1961
Pentadinium goniferum Edwards, 1982
Pentadinium laticinctum Gerlach, 1961
Phthanoperidinium coreoides (Benedek, 1972) Lentin and Williams, 1976
Phthanoperidinium echinatum Eaton, 1976
Phthanoperidinium "hibernium"
Phthanoperidinium levimurum Bujak *in* Bujak *et al.*, 1980
Phthanoperidinium multispinum Bujak *in* Bujak *et al.*, 1980
Reticulatosphaera actinocoronata (Benedek, 1972) Bujak and Matsuoka, 1986
Rhombodinium draco Gocht, 1955
Rhombodinium perforatum (Jan du Chêne and Châteauneuf, 1975) Lentin and Williams, 1977b
Rottnestia borussica (Eisenack, 1954b) Cookson and Eisenack, 1961b
Samlandia chlamydophora Eisenack, 1954b
Schematophora speciosa Deflandre and Cookson, 1955
Spiniferites crassipollis (Deflandre and Cookson, 1955) Sarjeant, 1970
Spiniferites ovatus Matsuoka, 1983b
Spiniferites "procerus"
Spiniferites pseudofurcatus (Klumpp, 1953) Sarjeant, 1970
Sumatradinium druggii Lentin *et al.*, 1984
Sumatradonium soucouyantiae de Verteuil and Norris, 1992
Systematophora ancyrea Cookson and Eisenack, 1965a
"Talladinium" coleothryptum
Taraxacum spp.
Thalassiphora pelagica (Eisenack, 1954b) Eisenack and Gocht, 1960
Tuberculodinium vancampoae (Rossignol, 1962) Wall, 1967
Unipontidinium aquaeductum (Piasecki, 1980) Wrenn, 1988
Wetzeliella ovalis Eisenack, 1954b
Wetzeliella simplex (Bujak, 1979) Lentin and Vozzhennikova, 1989
Wetzeliella spinula (Bujak, 1979) Lentin and Vozzhennikova, 1989
Wetzeliella symmetrica Weiler, 1956
Wilsonidium echinosuturatum (Wilson, 1967c) Lentin and Williams, 1976

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D38 Elf HERMINE E-94

KB: 25.9 m.; WD: 82.6 m.; TD: 3267.5 m.

Well Logs

Depth (metres below KB)

GAMMA (API Units): 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170

DENSITY (Kg/m3): 1600 1700 1800 1900 2000 2100 2200 2300 2400 2500 2600 2700 2800

SONIC (dt): 600 500 400 300 200

320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680

Lithostratigraphy after MacLean,B.C. & Wade,J.A. 1993

BANQUEREAU FORMATION

Age		Lithology	Samples	Palynology
MIOCENE	LATE		P37217 341.4-344.4 m.	*Achomosphaera andalousiensis* (LAD 0.01 Ma), *Invertocysta tabulata* (LAD 2,55 Ma) *Reticulatosphaera actinocoronata* (LAD 4.18 Ma), *Taraxacum* sp.
			P37218 350.5-353.6 m.	*Osmundacidites* sp., *Spiniferites ovatus*
			P37219 359.7-362.7 m.	*Melitasphaeridium choanophorum* (LAD 3.75 Ma), *Tuberculodinium vancampoae*
			P37220 368.8-371.9 m.	*Caryapollenites* sp., *Operculodinium eirikianum* (LAD 2.35 Ma)
			P37221 378.0-381.0 m.	*Diconodinium arcticum* (reworked)
			P37222 387.1-390.1 m.	*Gramineae* sp.
			P37223 396.2-399.3 m.	
			P37224 405.4-408.4 m.	*Impagidinium* sp.
			P37225 414.5-417.6 m.	*Batiacasphaere micropapillata* (LAD 3 Ma)
			P37226 423.7-426.7 m.	*Nematosphaeropsis lemniscata*
			P37227 432.8-435.9 m.	*Cleistosphaeridium diversispinosum, Hystrichosphaeropsis obscura* (LAD 7.34 Ma)
	MID (SERRAVALLIAN)		P37228 442.0-445.0 m.	*Dapsilidinium pastielsii* (LAD 7.1 Ma), *Hystrichokolpoma rigaudiae* *Sumatradinium soucouyantiae* (LAD 8.46 Ma), *Systematophora ancyrea* *Unipontidinium aquaeductum* (LAD 12.16 Ma)
			P37229 460.3-463.3 m.	*Palaeocystodinium golzowense* (LAD 9.0 Ma), *Spiniferites crassipellis* *Sumatradinium druggii*
			P37230 469.4-472.4 m.	*Chiropteridium galea, Corrudinium* sp., *Distatodinium cavatum* *Enneadocysta* sp., *Homotryblium floripes, Phthanoperidinium coreoides* (LAD 30.7 Ma)
			P37231 478.5-481.6 m.	*Operculodinium divergens* (LAD 31.97 Ma) *Pentadinium laticinctum, Spiniferites pseudofurcatus*
OLIGOCENE	RUPELIAN		P37232 506.0-509.0 m.	*Wetzeliella coleothrypta*
			P37233 518.2-521.2 m.	*Cribroperidinium major, Deflandrea heterophlycta, Enneadocysta pectiniformis*
			P37234 524.3-527.3 m.	*Heteraulacacysta stoveri, Thalassiphora pelagica, Wetzeliella symmetrica*
			P37235 542.5-545.6 m.	*Deflandrea phosphoritica, Charlesdowniea proserpina*
			P37236 551.7-554.7 m.	*Lentinia glabra, Lentinia serrata*
EOCENE	PRIABONIAN		P37237 560.8-563.9 m.	*Cordosphaeridium cantharellus, Enneadocysta multicornuta, Rhombodinium draco* *Samlandia chlamydophora, Wetzeliella simplex*
	BARTONIAN		P37238 570.0-573.0 m.	*Areoligera undulata, Diphyes colligerum* *Schematophora speciosa, Wetzeliella spinula*
			P37239 579.1-582.2 m.	*Enneadocysta "annulata", Extratriporopollenites* *Phthanoperidinium levimurum, Phthanoperidinium multispinum*
			P37240 588.3-591.3 m.	*Cleistosphaeridium diversispinosum* (abundant), *Homotryblium tenuispinosum* *Hystrichokolpoma salacium, Phthanoperidinium "hibernium", Wetzeliella ovalis*
			P37241 597.4-600.5 m.	*Apectodinium homomorphum* (one specimen)(38.7 Ma), *Dracodinium varielongitudum* (one specimen) *Hystrichostrogylon membraniphorum* (37 Ma), *Pentadinium goniferum*
			P37242 606.6-609.6 m.	*Rottnestia borussica* (one specimen)(37 Ma) *Baltisphaeridium scalenofurcatum, Diphyes pseudoficusoides* *Glaphyrocysta ordinata* (45.8 Ma), *Glaphyrocysta spinata* (one specimen) *Hystrichokolpoma cinctum, Hystrichostrogylon "procerus", Phthanoperidinium echinoideum*
	LUTETIAN		P37243 634.0-637.0 m.	*Adnatosphaeridium multispinosum, Cordosphaeridium gracile, Glaphyrocysta divaricata* *Glaphyrocysta exuberans, Hystrichostrogylon clausenii, Melitasphaeridium pseudorecurvatum* *Spiniferites procerus, Wilsonidium echinosuturatum*
			P37244 643.1-646.2 m.	
			P37245 652.3-655.3 m.	*Rhombodinium perforatum*
			P37246 661.4-664.5 m.	*Adnatosphaeridium vittatum*

LEGEND: Shale; Siltstone; Sandstone; Cuttings

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