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G.S.C. O.F. 1852 BIOSTRATIGRAPHIC AND MATURATION STUDIES OF THE
SCOTIAN SHELF, PART 1; SHELL PCI ET AL. ALMA F-67

BIOSTRATIGRAPHIC AND MATURATION STUDIES

OF THE SCOTIAN SHELF

PART 1

SHELL PCI et al. ALMA F-67



BIOSTRATIGRAPHIC AND MATURATION
STUDIES OF THE
SCOTIAN SHELF

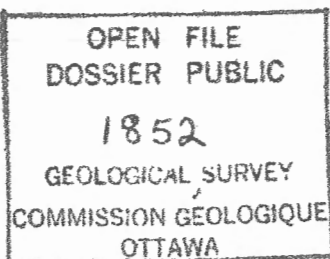
- PART 1 -

SHELL PCI et al. ALMA F-67

BY

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Part 1

Part 2

BIOSTRATIGRAPHIC AND MATURATION STUDIES

OF THE SCOTIAN SHELF

- PART 1 -

SHELL PCI et al. ALMA F-67

GSC locality: D239

Location: 43 36'18.3"N; 60 39'55.8"W

KB elevation: 24m Water depth: 68m

Casing set at: 110m, 814m, 2767m, 4380m, 4897m.

Total depth: 5054m Interval studied: 840-4935m

Palynology by: J.K. Lentin.

Micropaleontology by: S.E. Cameron.

INTRODUCTION

This report is the first in a series of five reports detailing the palynology, micropaleontology, kerogen and fluorescence analysis from four wells on the Scotian Shelf. Each speciality is presented separately in individual chapters in each of the four well reports. The rangecharts included in the pocket at the back of the reports graphically integrate the three parts of the studies. The fifth and final report will compare and correlate the four wells in the study.

Species cards with photographs of all taxa used in the palynological section of the study will be presented with the final report. Appendix A of each well report contains a complete list of photographs taken of fossils from that well. All foraminifera taxa are represented by at least one specimen, stained green and attached to a designated square in the assemblage slides. The depth and square number is given following the name of the taxa in Appendix B.

CHAPTER 1

PALYNOLOGY

One hundred thirty nine cuttings samples were studied from this well. All of the cuttings samples contained palynomorphs down to 4140 m where the well entered a barren interval. There is extensive caving of Eocene and Oligocene palynomorphs in the upper section of the well. The following biostratigraphic zonations and age determinations have been made:

- 0840-0850m Late Cretaceous undifferentiated.
- 0870-0940m *O. operculata* Zone (Campanian)
- 0960-1330m *P. truncigerum* Zone (Santonian)
- 1350-1390m *O. pulcherrimum* Zone (Coniacian)
- 1410-1450m *S. longifurcatum* Zone (Turonian)
- 1480-1730m *K. williamsii* Zone (Cenomanian)
- 1750-2210m *C. cf. vestitum* Zone (Albian)
- 2230-2920m *S. perlucida*/*H. schindewolfii* Zone (Aptian)

--Unconformity--

- 2940-3250m *A. anaphrissa* Peak Zone (Barremian)
- 3270-3490m *C. elegantulum* Zone (Hauterivian)
- 3510-3670m *P. neocomica* Zone (Valanginian/Berriasian)
- 3690-4120m Undiagnostic.
- 4140-4935m Essentially barren.

The base of this well from the last sample at 4935m to 3690m contains only dark brown to black particulate material with the exception of one sample at 4770-4780m which contains one highly degraded bisaccate pollen grain. Above this interval there are

pears to be a more or less uninterrupted depositional record in Alma F-67 from the Berriasian/Valanginian through the Late Cretaceous, with the exception of a minor unconformity resulting from the loss of the Late Barremian. The Early Cretaceous sediments have a thickness of over 1900m. They are overlain by Late Cretaceous sediments in excess of 900m in thickness.

The depositional environment, judged by the palynomorphs, shows little fluctuation and is considered to be marine throughout the well. However, because of the extensive caving it is possible that minor non-marine intervals particularly between 4935m and 3270m, have been masked.

SELECTED PALYNOMORPHS:

0840-0850m: Late Cretaceous undifferentiated.

This sample contains a mixed assemblage of Late Cretaceous and Early Tertiary palynomorphs, however, the presence of three specimens of *Dinogymnium acuninatum* indicates that the sample is not younger than Late Cretaceous.

0870-0940m: *O. operculata* Zone (Campanian)

Ceratiopsis diebelii, *Cribroperidinium ventriosum*, *Kleithriasphaeridium loffrense*, *Chatangiella victoriensis*, *Cordosphaeridium cantharellum*, *Alterbidinium acutulum*, *Cribroperidinium edwardsii*, *Isabelidinium bakeri*, *Phelodinium magnificum*, *Tanyosphaeridium xanthiopyxides*, and *Cicatricosisporites hughesii*.

0960-1330m: *C. truncigerum* Zone (Santonian)

Oligosphaeridium pulcherrimum, *Trithyrodinium suspectum*, *Hystrichosphaeridium bowerbankii*, *Hystrichosphaeridium stellatum*, *Spinidinium clavum*, *Coronifera oceanica*, *Isabelidinium cretaceum*, *Spongodinium delitiense*, *Isabelidinium belfastense*, *Spiniferites cingulatus*, *Diconodinium arcticum*, *Dinogymnium lanceolatum*, and *Palaeohystrichophora infusorioides*.

1350-1390m: *O. pulcherrimum* Zone (Coniacian)

Oligosphaeridium pulcherrimum, *Callaiosphaeridium asymmetricum*, *Cyclonephelium hexalobosum*, *Cyclonephelium vannophorum*,

Odontochitina costata, *Appendicisporites tricornitatus*, and *Cicatricosisporites potomacensis*.

1410-1450m: *S. longifurcatum* Zone (Turonian)

Surculosphaeridium longifurcatum (very abundant), *Cicatricosisporites hallei*, *Cicatricosisporites ornatus*, and *Palaeohystrichophora infusorioides*.

1480-1730m: *K. williamsii* Zone (Cenomanian)

Kiokansium williamsii, *Florentinia cooksonii*, *Subtilisphaera rotundata*, *Xenascus plotei*, *Liliacidites dividius*, *Florentinia cooksonii*, *Oligosphaeridium totum*, *Florentinia verdieri*, *Spiniferites tripus*, *Florentinia ferox*, *Nyktericysta pentagona*, *Odontochitina rhakodes*, and *Stellatopollis largissimus*.

1750-2210m: *C. cf. vestitum* Zone (Albian)

Chichaouadinium cf. vestitum, *Nyktericysta arachnion*, *Odontochitina ancala*, *Odontochitina operculata*, *Cymososphaeridium validum*, *Tehamadinium sousensis*, *Eucommiidites minor*, *Appendicisporites problematicus*, *Appendicisporites matesovae*, *Pilosporites trichopapillosus*, *Trilobosporites marylandensis*, *Cyclonephelium chabaca*, and *Cyclonephelium hughesii*.

2230-2920m: *S. perlucida*/*H. schindewolfii* Zone (Aptian)

Hystrichosphaerina schindewolfii, *Muderongia asymmetrica*, *Hystrichosphaeridium asterigerum*, *Subtilisphaera perlucida*, *Cerbia tabulata*, and *Vesperopsis mayi*.

2940-3250m: *A. anaphrissa* Zone (Barremian)

*Muderongia simplex**, *Subtilisphaera terrula*, *Cribroperidium auctificum*, *Dingodinium cerviculum*, *Callialasporites trilobatus*, and *Kiokansium hydra*.

* The presence of *Muderongia simplex* at 2940m indicates that the upper portion of the *A. anaphrissa* Zone is missing and that the Aptian rests unconformably on the Middle Barremian.

3270-3490m: *C. elegantulum* Zone (Hauterivian)

Gonyaulacysta kostromiensis, *Occisucysta* cf. *balios*, *Oligosphaeridium porosum*, *Batioladinium jaegeri*, *Batioladinium longicornutum*, *Coronifera albertii*, *Stiphrosphaeridium arbustum*, *Spiniferites lenzii*, and *Pyxidinospis* sp. #TA.

3510-3670m: *P. neocomica* Zone (Valanginian/Berriasian)

Phoberocysta neocomica, *Achomosphaera verdieri*, *Batioladinium micropodum*, *Stiphrosphaeridium dictyophorum*, and *Sentusidinium rioultii*.

3690-4120m: Undiagnostic.

This interval contains no diagnostic species. The preservation is extremely poor suggesting that the few fossils which can be recognized may be caved.

4120-4935m: Essentially Barren.

This interval contains a single, poorly preserved bisaccate pollen grain at 4770-4780m but is otherwise barren of palynomorphs.

Chapter 2

MICROPALAEONTOLOGY

One hundred and forty cuttings samples were studied for micropaleontology from Alma F-67. All but two of the samples contain fossils. The following biostratigraphic zonations have been made:

0840-0850m	Middle Eocene.
0870-1060m	Maastrichtian
1080-1210m	Campanian
1260-1330m	Santonian
1350-1390m	Coniacian
1410-1420m	Turonian
1440-1940m	Cenomanian
1960-2210m	Albian
2230-2290m	Aptian
2410-2510m	Undiagnostic
2535-2840m	Barremian
2880-3250m	Undiagnostic
3270-3520m	Hauterivian
3540-4000m	Berriasian/Valanginian
4020-4180m	Tithonian
4200-5052m TD	Kimmeridgian to Tithonian

The paleoenvironment of the Kimmeridgian to Tithonian interval fluctuates between inner neritic and marginal marine. The Tithonian is considered to be outer neritic. The Berriasian through Hauterivian fluctuates between outer and inner neritic with possible lacustrine deposits at the base of the Hauterivian

to Barremian interval and marginal marine conditions at the top of that interval. The Barremian is outer neritic in the lower part and inner neritic in the upper part. The Aptian to Barremian interval was deposited in a brackish to marginal marine environment. The remainder of the well was deposited in an environment which fluctuates between outer neritic to marginal marine.

SELECTED FOSSILS:

0840-0850m: TERTIARY - Middle Eocene

FORAMINIFERA: *Guembelitra columbiana*, *Siphonina claibornensis*, *Siphoninella claibornensis*, *Lenticulina alato-limbatus*.

ENVIRONMENT OF DEPOSITION: Diverse planktonic and benthonic foraminifera, outer neritic indicated.

0870-1060m: CRETACEOUS - Maastrichtian.

FORAMINIFERA: *Planularia dissona*, *Rosita fornicata*, *Gyroidinoides imitata*, *Globigerinelloides multispina*, *Heterohelix striata*, *Praebulimina carseyae*, *Gaudryina rudita*, *Pullenia cretacea*, *Hoeuglundina supracretacea*, *Globotruncana arca*, *Praeglobobulimina aspera*, *Heterohelix glabrans*, *Guembelitra cretacea*, *Gavelinella correcta*, *Gavelinella pseudopapillosa*, *Globotruncana orientalis*, *Lenticulina navarroensis*, *Dentalina* cf. *basiplanata*, *Vaginulina cretacea*, *Dorothia* cf. *conula*, *Rosita contusa*, *Bolivina incrassata*, *Pulsiphonina prima*, *Archaeoglobigerina blowi*, *Praeglobobulimina kickapooensis*, *Dorothia bulletta*, *Globotruncanita* cf. *angulata*, *Globotruncana rosetta*, *Rugoglobigerina* cf. *rotundata*, *Spiroplectammina semicomplanata*, *Pseudouvigerina triangularis*, *Marginulina curvatura*, *Archaeoglobigerina cretacea*, *Rugoglobigerina rugosa*, *Globotruncanella petaloidea*, *Pseudoguembelina costulata*, *Pseudotextularia deformis*, *Pseudotextularia elegans*, *Racemiguembelina powelli*, *Gansserina gansseri*, *Globotruncana aegyptiaca*, *Globotruncana insignis*, *Rosita plicata*, *Globotruncana ventricosa*, *Globotruncanita stuarti*, *Bolivina incrassata gigantea*. OSTRACODES: *Rehacythereis communis*, *Loxoconcha levinsoni*, *Monoceratina* cf. *nitida*, *Cuneoceratina pedata*, *Loxoconcha* cf. *fletcheri*, *Brachycythere rhomboidalis*, *Nigeria arachoides*, *Haplocytheridea plummeri*.

ENVIRONMENT OF DEPOSITION: Upper part of interval is inner neritic, low diversity of benthonic foraminifera, rare

planktonics, few ostracodes, much Eocene caving. Middle and bottom of interval is outer neritic, highly diversified benthonic and planktonic foraminifera, deeper water ostracodes, much Eocene caving.

1080-1240m: Campanian

FORAMINIFERA: *Valvulineria allomorphinoides*, *Arenobulimina* cf. *americana*, *Gyroidinoides girardana*, *Allomorphina navarroana*, *Praebulimina reussi*, *Rugoglobigerina hexacamerata*, *Pseudoguembelina excolata*, *Gaudryina laevigata*, *Osangularia navarroana*, *Pseudouvigerina seligi*, *Lagena* cf. *hexagona*, *Arenobulimina americana*, *Rosita patelliformis*, *Pseudoguembelina palpebra*, *Bolivinoidea draco miliaris*, *Ammobaculites stephensoni*, *Anomalinoidea* cf. *henbesti*, *Pullenia americana*, *Gavelinella spissocostata*, *Tritaxia capitosa*, *Globorotalites micheliniana*, *Globotruncana elevata*, *Globotruncana bulloides*, *Planoglobulina glabrata*, *Pseudonodosaria manifesta*, *Dorothia* cf. *retusa*, *Stensioina pommerana*. OSTRACODES: *Brachycythere ovata*, *Brachycythere rhomboidalis*, *Loxocorcha cretacea*, *Xestoleberis opina*, *Fissocarinocythere pidgeoni*, *Phacorhabdotus pokornyi*.

ENVIRONMENT OF DEPOSITION: Upper part of interval is probably inner part of the outer neritic, fairly diverse benthonic foraminifera and ostracodes. Lower part still outer neritic but somewhat deeper with increased diversity of benthonic and planktonic species, fewer ostracodes.

1260 - 1330m: Santonian

FORAMINIFERA: *Globorotalites multiseptus*, *Reussella szajnochae*, *Anomalinoidea* cf. *henbesti*, *Ammodiscus cretaceus*, *Lenticulina munsteri*, *Marginotruncana coronata*, *Frondicularia lanceola bidentata*, *Dicarinella asymetrica*, *Marginotruncana marginata*, *Whiteinella baltica*, *Marginotruncana pseudolinneiana*, *Whiteinella paradubia*, *Globorotalites multiseptus*, *Stensioina esculpta esculpta*, *Gaudryina austinana*, *Marssonella trochus*. OSTRACODES: *Krithe swaini*, *Cuneoceratina pedata*.

ENVIRONMENT OF DEPOSITION: Upper part of interval is inner neritic, low diversity of benthonics, no planktonics, fish otoliths present. Lower part is outer neritic, high diversity of planktonics and good diversity of benthonics, markedly chalky facies.

1350-1390m: Coniacian

FORAMINIFERA: *Dicarinella primitiva*, *Marginotruncana schneegansi*, *Saracenaria triangularis*, *Glomospira corona*, *Hedbergella delroiensis*, *Dicarinella imbricata*. OSTRACODES: *Cythereis dallasensis rhachis*.

ENVIRONMENT OF DEPOSITION: From the upper to lower part of the interval there is a shallowing trend from outer neritic to mid neritic, marked reduction in planktonic and benthonic diversity from upper to lower part. Plant debris and rootlets occur at base of interval.

1410-1420m: Turonian

FORAMINIFERA: *Gavelinella tourainensis*, *Dorothia* af. *filaformis*, *Dicarinella algeriana*, *Lingulogavelinella turonica*, *Helvetoglobotruncana helvetica*. OSTRACODES: *Cythereis* af. *sagena*.

ENVIRONMENT OF DEPOSITION: Middle neritic environment, low diversity of benthonics and planktonics, increase in gastropods, bivalves.

1440-1940m: Cenomanian

FORAMINIFERA: *Ammobaculites comprimatus*, *Marssonella* cf. *trochus*, *Rotalipora* cf. *deECKEi*, *Hedbergella delroiensis*, *Gavelinella cenomanica*, *Epistomina* cf. *charlottae*, *Lenticulina* cf. *gaultina*, OSTRACODES: *Cythereis eaglefordensis*, *Protocythere* cf. *speetonensis*, *Cythereis ornatissima*, *Schuleridea jonesiana*, *Rehacythereis sandidgei*, *Rehacythereis reticulata*, *Eocytherop-teron* cf. *semiconstrictum*.

ENVIRONMENT OF DEPOSITION: Upper part of interval is inner neritic, limited diversity of benthonics and poor representation of planktonics, increase in ostracodes, bivalves. Lower part marginal marine, agglutinated forms more dominant in lower part, common ostracodes and plant debris.

1960-2210m: Albian

FORAMINIFERA: *Epistomina* cf. *chapmani*, *Tritaxia singularis*. OSTRACODES: *Protocythere speetonensi*.

ENVIRONMENT OF DEPOSITION: Upper part of interval is marginal marine, low diversity of fauna, no planktonics, simple agglutinating forms, plant rootlets. Lower part is inner neritic, contains a few more calcareous benthonic foraminifera.

2230-2390m: Aptian

FORAMINIFERA: *Gavelinella* cf. *barremiana*, *Epistomina spinulifera*, *Tritaxia pyramidata*, *Tritaxia singularis*, *Gavelinella* cf. *brielsensis*, *Lenticulina nodosa*, *Epistomina cretosa*.

ENVIRONMENT OF DEPOSITION: Upper part of interval is inner neritic, some calcareous and agglutinating foraminifera. Middle part is marginal marine, simple agglutinating foraminifera dominate, coal lumps are also present. Lower part is inner neritic again, relatively diverse benthonic foraminifera.

2410-2510m: Undiagnostic

No diagnostic *in situ* microfauna.

ENVIRONMENT OF DEPOSITION: No diagnostic *in situ* microfauna was recovered, presence of coal, plant rootlets and wood debris in moderate amounts suggest a brackish to marginal marine environment.

3535-2840m: Barremian

FORAMINIFERA: *Gaudryinella tealbyensis*, *Epistomina cretosa*, *Epistomina hechti*, *Marssonella kummi*, *Verneuilioides neocomiensis*, *Lenticulina* cf. *ouachitaensis*, *Lenticulina heirermanni*, *Lenticulina praegaultina*, *Epistomina ornata*, *Epistomina* cf. *carcolla*, *Caucasella hoterivica*, *Marginulinopsis humilus*, *Pseudonodosaria humilus*, *Lenticulina* cf. *kugleri*, *Lenticulina ouachensis*.

ENVIRONMENT OF DEPOSITION: Upper part of interval is inner neritic, low diversity of foraminifera. Lower part is outer neritic, more diverse faunas.

2880-3250m: Undiagnostic

No diagnostic *in situ* microfauna.

ENVIRONMENT OF DEPOSITION: Marginal marine facies with poor *in situ* faunas; possibly a lacustrine environment at base, coal lumps, goethite and limonite.

3270-3520m: Hauterivian

FORAMINIFERA: *Gaudryinella tealbyensis*, *Marssonella kummi*, *Lenticulina nodosa*, *Epistomina hechti*, *Epistomina cretosa*, *Epistomina ornata*, *Lenticulina praegaultina*, *Caucasella hoterivica*, *Epistomina caracolla*, *Trocholina* af. *infragranulata*, *Marginulinopsis humilus*, *Pseudonubeculina nodulosa*, *Marginulinopsis humilus*, *Planularia crepidularis*, *Lenticulina saxonica saxonica*, *Lenticulina kugleri*, *Lenticulina heiermanni*, *Vaginulina recta*, *Marginulinopsis sigali*, *Marssonella* cf. *oxycona*.

ENVIRONMENT OF DEPOSITION: Upper part of interval is inner neritic environment. Lower part is outer neritic, benthonic diversity greater.

3540-4000m: Valanginian - Berriasian

FORAMINIFERA: *Epistomina* cf. *caracolla*, *Lenticulina nodosa*, *Marssonella* cf. *oxycona*, *Planularia crepidularis*, *Lenticulina guttata*, *Marginulinopsis sigali*, *Lenticulina saxonica saxonica*, *Lenticulina* cf. *saxonica bifurcilla*, *Conorotalites* cf. *bartensteini*, *Tristix insigne*, *Caucasella hoterivica*, *Lingulina nodosaria*, *Conorboides hofkeri*, *Vaginulinopsis reticulosa*, *Marssonella hauteriviana*, *Ammodiscus cretaceus*.

ENVIRONMENT OF DEPOSITION: Upper part of interval is outer neritic, benthonic faunas highly diversified. Lower part is inner neritic, less diversity of fauna, coprolites.

4020-4180m: JURASSIC - Tithonian

FORAMINIFERA: *Epistomina uhligi*, *Epistomina stellicostata*, *Ammodiscus cretaceus*.

ENVIRONMENT OF DEPOSITION: Outer neritic, fairly diverse benthonic fauna.

4200-5052m TD: Tithonian to Kimmeridgian

FORAMINIFERA: *Epistomina uhligi*, *Epistomina stellicostata*.

ENVIRONMENT OF DEPOSITION: Fluctuating inner neritic and marginal marine environment, microfaunal diversity reduced. No microfauna was recovered in places, suggesting marginal marine conditions existed from time to time, pellets occurred here.

INTRODUCTION

Kerogen analysis has been completed on eighteen samples prepared by the Geological Survey. These samples, spaced at approximately 200 meter intervals in the well section, have been examined for kerogen type, determination of the thermal alteration index (TAI), and epifluorescence. The data from these analyses are presented on analysis sheets provided by the Geological Survey and are included as Appendix C. A summary of each analysis follows.

KEROGEN

It is difficult to get a true picture of the kerogen maceral distribution in the 840m-2600m section due to the overwhelming abundance of finely disseminated, largely amorphous material which is classified on the GSC chart as NONRECOGNIZABLE DEBRIS. It probably consists of degraded phyrogen and some undigested clay mineral and it has contaminated many of the samples below 1000m.

From 2810m to 4480m (lowest sample available) the samples are relatively clean and are dominated by phyrogen and melanogen. The phyrogenic debris at and below 3580m is corroded and the structures are less obvious.

Recognisable algae and amorphous sapropel were not seen in the slides and the hylogen (spores, pollen, dinocysts and cuticle) varied from trace amounts to 15% of the total kerogen. Particularly high values were recorded at 1420m, 1640m, 2810m and 3460m. However, the overall impression is that the kerogens in this well are gas-prone.

THERMAL ALTERATION INDEX

A series of color readings was taken on spores wherever possible and the results are presented on the chart. Where values fall between two TAI values, both are plotted. True colors were difficult to determine in the 840m and 1000m samples because the extremely rare Tertiary pollen appears to have been "stained" in situ, a feature also seen in the Tertiary of the North Sea.

The color-value distribution down to 1640m is distinctly bimodal. Caved Tertiary pollen cluster around TAI 1+ and the in situ Cretaceous fraction forms a group of values around TAI 1+ to 2-. In many of the samples there is a significant number of palynomorphs exhibiting slightly higher TAI readings than the interpreted values. These are possibly reworked or oxidized prior to deposition.

The maturity values are in the immature 1+ to 2- range down to approximately 2420m. By 2810m, the majority of the spores and pollen indicate maturity levels equivalent to TAI 2. At 3580m, a TAI 2+ component appears and the values change fairly rapidly to TAI 3- by 3850m.

Although it appears from these values that there is a distinct increase at approximately 3730m, the spore colors reveal a linear progression. This anomaly between what is seen and what appears on the chart is a result of the scale used. It must be emphasized that the Geochem Laboratories TAI scale does not recognize subtle color changes. For example, TAI 2 to 2+ represents Ro values of 0.6-0.9% and TAI 3- is equivalent to an Ro value of 1%.

Most of the section below 2600m appears to be in the oil-window with maturity values greater than TAI 2. However, the kerogen indicates that the section is gas-prone rather than oil-prone. The oil-preservation floor had not been reached in the 4480m sample. The zone of peak generation is considered to be from 2210m to the last sample studied. The TAI values at and below 3730m indicate that the section is mature enough to generate wet gas. Maturity values sufficiently high to generate significant quantities of dry gas are not present in the study-section.

FLUORESCENCE

The epifluorescence character of individual samples mirrors the kerogen composition and maturity determined in transmitted white light. Bright to moderately bright yellow colors distinguish the sapropels down to 1420m. Some of this material is cavings contamination. The dinocyst fragments are usually brighter and are occasionally greenish-yellow. These bright colors show up as cavings contaminants down to 2810m.

As the section is penetrated and the maturity values progress through TAI 2 to 2+, the fluorescence colors shift through yellow to yellow-orange and the intensity drops to "moderate" levels. At 3580m, there is a decrease in intensity to "medium-dull" and some palynomorphs are distinctly orange. At and below 3850m, fluorescence appears to have ceased for all practical purposes. However, some residual fluorescence may be masked by the fluorescing mounting medium.

The oil window indicated by fluorescence is comparable to that indicated by the kerogen analysis (between 1000m and the last sample examined).

APPENDIX A

PHOTOGRAPHIC RECORD

Aima F-67

#	Name	Well #	Depth	Coordinate
J-1	Rugubivesiculites rugosus	D239	0870-0880m	196.2 x 16.5
J-2	Spiniferites ramosus	D239	0870-0880m	104.8 x 12.5
J-3	Aptea anaphresia	D239	0870-0880m	116.2 x 8.2
J-4	Alterbidinium sp. #TA	D239	0870-0880m	117.0 x 5.0
J-5	Cribroperidinium ventriosum	D239	0870-0880m	105.0 x 3.9
J-6	Kleithriasphaeridium loffrense	D239	0870-0880m	115.8 x 3.5
J-7	Rouseisporites cf. sp. 1 Bebout	D239	0900-0910m	99.0 x 20.9
J-8	Cicatricosisporites frucatus	D239	0900-0910m	115.8 x 19.0
J-9	Chatengiella victoriensis	D239	0900-0910m	108.0 x 13.5
J-10	Hystriosphaeeridium tubiferum	D239	0900-0910m	100.0 x 12.5
J-11	Osmundacidites comaumensis	D239	0900-0910m	104.5 x 11.8
J-12	Leptodinium cf. delicatum	D239	0900-0910m	108.0 x 3.1
J-13	Florentinia sp. #TA	D239	0900-0910m	100.8 x 2.8
J-14	Isabelidinium bakeri	D239	0930-0940m	107.9 x 24.8
J-15	Tanyosphaeridium xanthiopyxides	D239	0930-0940m	108.0 x 14.6
J-16	Cribroperidinium edwardsii	D239	0930-0940m	103.9 x 11.4

J-17	<i>Areoligera senonensis</i>	D239	0960-0970m	109.0 x 18.0
J-18	<i>Inundatisporis vermiculisporites</i>	D239	0960-0970m	114.2 x 16.3
J-19	<i>Svalbardella</i> (?) #TA	D239	0960-0970m	111.0 x 15.5
J-20	<i>Oligosphaeridium pulcherrimum</i>	D239	0960-0970m	110.0 x 3.8
J-21	<i>Trithyrodinium suspectum</i>	D239	0990-1000m	113.0 x 10.6
J-22	<i>Deltoidospora australis</i>	D239	0990-1000m	102.2 x 4.0
J-23	<i>Aquilapollenites</i> sp.	D239	1020-1030m	109.9 x 10.5
J-24	<i>Stereisporites antiquasporites</i>	D239	1020-1030m	111.2 x 6.2
J-25	<i>Achomosphaera ramulifera</i>	D239	1080-1090m	101.8 x 17.0
J-26	<i>Hystrichosphaeridium stellatum</i>	D239	1080-1090m	108.0 x 4.6
J-27	<i>Hystrichosphaeridium bowerbankii</i>	D239	1080-1090m	112.5 x 13.0
J-28	<i>Ceratiopsis speciosa</i>	D239	1110-1120m	107.0 x 17.0
J-29	<i>Ceratiopsis diebelii</i>	D239	1110-1120m	110.0 x 13.0
J-30	<i>Glaphyrocysta semitectum</i>	D239	0840-0850m	107.2 x 5.0
J-31	<i>Spinidinium clavum</i>	D239	1140-1150m	104.0 x 20.5
J-32	<i>Glaphyrocysta exhuberans</i>	D239	1140-1150m	111.0 x 15.2
J-33	<i>Spiniferites septatus</i>	D239	1140-1150m	100.2 x 4.2
J-34	<i>Coronifera oceanica</i>	D239	1200-1210m	109.0 x 18.0
J-35	<i>Ceratiopsis</i> sp. #TA	D239	1200-1210m	107.2 x 11.0
J-36	<i>Cyclonephelium</i> cf <i>distinctum</i>	D239	1230-1240m	116.0 x 14.9
J-37	<i>Alterbidinium acutulum</i>	D239	1230-1240m	104.2 x 13.0
J-38	<i>Alberbidinium</i> sp. #TA	D239	1260-1270m	111.0 x 17.6

J-39	Isabelidinium cretaceum	D239	1260-1270m	113.1 x 14.8
J-40	Spongodinium delitiense	D239	1260-1270m	100.2 x 7.0
J-41	Spiniferites cingulatus	D239	1260-1270m	116.0 x 6.0
J-42	Radialisporis radiatus	D239	1290-1300m	99.5 x 17.5
J-43	Diconodinium arcticum	D239	1290-1300m	116.0 x 12.2
J-44	Dinogymnium lanceolatum	D239	1290-1300m	113.2 x 10.0
J-45	Dinogymnium sp. #TA	D239	1290-1300m	116.1 x 9.0
J-46	Palaeohystrichophora infusorioides	D239	1320-1330m	109.2 x 20.5
J-47	Isabelidinium belfastense	D239	1350-1360m	103.2 x 17.5
J-48	Appendicisporites tricornitus	D239	1350-1360m	117.2 x 16.0
J-49	Cyclonephelium hexalobosum	D239	1350-1360m	99.3 x 11.3
J-50	Cyclonephelium vannophorm	D239	1350-1316m	116.2 x 7.5
J-51	Cicatricosisporites potomacensis	D239	1350-1360m	104.8 x 3.5
J-52	Xenascus ceratioides	D239	1380-1390m	115.8 x 13.9
J-53	Surculosphaeridium longifurcatum	D239	1410-1420m	99.9 x 19.0
J-54	Cicatricosisporites ornatus	D239	1410-1420m	100.0 x 16.6
J-55	Odontochitina costata	D239	1410-1420m	111.8 x 15.5
J-56	Cicatricosisporites hughesii	D239	1410-1420m	109.0 x 13.1
J-57	Erlansonisporites cf. sparassis	D239	1410-1420m	111.6 x 8.0
J-58	Kiokansium polypes	D239	1440-1450m	101.0 x 17.2

J-59	<i>Cicatricosisporites hallei</i>	D239	1440-1450m	104.0 x 16.5
J-60	<i>Cleistosphaeridium multispinosum</i>	D239	1440-1450m	114.8 x 16.2
J-61	<i>Callaiosphaeridium asymmetricum</i>	D239	1440-1450m	105.2 x 12.0
J-62	<i>Surculosphaeridium longifurcatum</i>	D239	1410-1420m	99.9 x 19.0
J-63	<i>Microdinium cf setosum</i>	D239	1440-1450m	105.0 x 6.2
J-64	<i>Liliacidites dividiuus</i>	D239	1440-1450m	85.8 x 6.0
J-65	<i>Hystrichodinium voigtii</i>	D239	1480-1490m	101.0 x 19.5
J-66	<i>Oligosphaeridium pulcherrimum</i>	D239	1480-1490m	108.5 x 18.8
J-69	<i>Cyclonephelim distinctum</i>	D239	1480-1490m	109.5 x 14.8
J-70	<i>Florentinia cooksonii</i>	D239	1480-1490m	99.6 x 13.1
J-71	<i>Xenascus plotei</i>	D239	1480-1490m	101.2 x 12.9
J-72	<i>Kiokansium williamsii</i>	D239	1480-1419m	108.2 x 15.2
J-73	<i>Oligosphaeridium complex</i>	D239	1480-1490m	109.0 x 12.0
J-74	<i>Subtilisphaera rotundata</i>	D239	1480-1490m	105.2 x 12.0
J-75	<i>Rugubivesiculites reugosus</i>	D239	1480-1490m	110.5 x 9.5
J-76	<i>Ischyosporites disjunctus</i>	D239	1510-1520m	101.0 x 18.1
J-77	<i>Xenascus sp. #TA</i>	D239	1510-1520m	102.0 x 16.5
J-78	<i>Sestrosporites pseudoalveolatus</i>	D239	1510-1520m	102.5 x 10.0
J-79	<i>Cleistrosphaeridium sp. #TA</i>	D239	1510-1520m	98.5 x 9.8
J-80	<i>Palaeohystrichophora infusoriodes</i>	D239	1510-1520m	113.0 x 3.2

J-81	<i>Psilatricolpites parvulus</i>	D239	1510-1520m	77.2 x 6.0
J-82	<i>Oligosphaeridium totum</i>	D239	1540-1550m	100.0 x 15.5
J-83	<i>Cleistosphaeridium polypes s.s.</i>	D239	1540-1550m	98.0 x 11.6
J-84	<i>Canningia</i> sp. #TA	D239	1540-1550m	113.4 x 9.8
J-85	<i>Palaeoperidinium</i> sp. #TA	D239	1540-1550m	103.1 x 7.9
J-86	<i>Chlamydonophorelly nyei</i>	D239	1540-1550m	109.0 x 7.0
J-87	<i>Concavisporites jurienensis</i>	D239	1540-1550m	78.9 x 10.9
J-88	<i>Florentinia verdieri</i>	D239	1570-1580m	107.5 x 16.0
J-89	<i>Spiniferites tripus</i>	D239	1570-1580m	107.0 x 12.0
J-90	<i>Taxodiaceapollenites hiatus</i>	D239	1570-1580m	87.0 x 10.5
J-91	<i>Lycopodiacidites canaliculatus</i>	D239	1570-1580m	90.0 x 10.0
J-92	<i>Pterodinium</i> #TA	D239	1630-1640m	109.0 x 15.0
J-93	<i>Aptea</i> #TA	D239	1630-1640m	103.0 x 15.0
J-94	<i>Balmeisporites glenelgensis</i>	D239	1630-1640m	112.9 x 12.0
J-95	<i>Appendicisporites matesovae</i>	D239	1630-1640m	104.2 x 11.0
J-96	<i>Gleicheniidites senonicus</i>	D239	1630-1640m	97.8 x 10.0
J-97	<i>Caligodinium aceras</i>	D239	1660-1670m	102.9 x 11.8
J-98	<i>Tenua hystrix</i>	D239	1690-1700m	111.3 x 18.5
J-100	<i>Nyktericysta</i> sp. #TA	D239	1690-1700m	99.2 x 15.0
J-101	<i>Nyktericysta pentagona</i>	D239	1690-1700m	113.0 x 15.0
J-102	<i>Stellatopollis largissimus</i>	D239	1690-1700m	103.0 x 13.0
J-103	<i>Florentinia ferox</i>	D239	1690-1700m	100.0 x 12.8

J-104	<i>Aequitriradites spinulosus</i>	D239	1690-1700m	107.5 x 11.5
J-105	<i>Florentinia</i> sp. #TA	D239	1690-1700m	103.6 x 10.0
J-106	<i>Odontochitina rhakodes</i>	D239	1690-1700m	113.0 x 9.8
J-107	<i>Oligosphaeridium</i> sp. #TA	D239	1690-1700m	113.8 x 9.2
J-108	<i>C. polypes</i>	D239	1690-1700m	18.8 x 8.0
J-109	<i>Oligosphaeridium irregulare</i>	D239	1690-1700m	108.2 x 5.0
J-110	<i>Aptea eisenackii</i>	D239	1720-1730m	116.0 x 15.0
J-111	<i>Appendicisporites tricornitus</i>	D239	1720-1730m	112.0 x 13.0
J-112	<i>Appendicisporites problematicus</i>	D239	1750-1760m	114.0 x 15.0
J-113	<i>Odontochitina Operculata</i>	D239	1750-1716m	110.0 x 14.0
J-114	<i>Apteodinium granulatum</i>	D239	1750-1760m	103.1 x 12.8
J-115	<i>Nyktericysta arachnion</i>	D239	1750-1760m	101.8 x 9.6
J-116	<i>Chichaouodinium vestitum</i>	D239	1750-1760m	101.0 x 8.8
J-117	<i>Odontochitina ancala</i>	D239	1750-1760m	106.0 x 4.0
J-118	<i>Micrhystridium recurvatum</i>	D239	1780-1790m	101.5 x 19.5
J-119	<i>Trilobosporites trioreticulosus</i>	D239	1780-1790m	97.8 x 16.5
J-120	<i>Lycopodiumsporites marginatus</i>	D239	1780-1790m	112.0 x 12.0
J-121	<i>Cyathidites minor</i>	D239	1780-1790m	100.2 x 12.0
J-122	<i>Ornamentifera echinata</i>	D239	1780-1790m	104.0 x 10.9
J-123	<i>Litosphaeridium siphonophorum</i>	D239	1810-1820m	117.0 x 12.0
J-124	<i>Chichaouodinium vestitum</i>	D239	1810-1820m	117.2 x 12.5

J-125	<i>Cymosphaeridium validum</i>	D239	1840-1850m	102.5 x 13.0
J-126	<i>Diconodinium</i> sp. #TA	D239	1840-1850m	105.0 x 13.1
J-127	<i>C. polypes</i>	D239	1840-1850m	10.0 x 6.0
J-128	<i>Concavissimisporites minor</i>	D239	1870-1880m	106.5 x 11.0
J-129	<i>Stereisporites antiquasporites</i>	D239	1870-1880m	105.0 x 9.5
J-130	<i>Tehamadinium sousensis</i>	D239	1900-1910m	114.4 x 13.0
J-131	<i>Callaiosphaeridium asymmetricum</i>	D239	1440-1450m	105.2 x 12.0
J-132	<i>Gleicheniidites</i> sp. #TA	D239	1930-1940m	100.4 x 5.4
J-133	<i>Fromea amphora</i>	D239	1960-1970m	108.0 x 20.0
J-134	<i>Cribroperidinium</i> cf <i>edwardsii</i>	D239	1960-1970m	113.0 x 20.2
J-135	<i>Kiokansium</i> sp. #TA	D239	1960-1970m	104.5 x 4.5
J-136	<i>Eucommiidites minor</i>	D239	1960-1970m	102.3 x 13.0
J-137	<i>Lophotriletes habsae</i>	D239	1990-2000m	109.2 x 12.5
J-138	<i>Cicatricosporites auritus</i>	D239	1990-2000m	115.2 x 10.2
J-139	<i>Foveotriletes subtriangularis</i>	D239	1990-2000m	107.8 x 7.5
J-140	<i>Todisporites minor</i>	D239	1990-2000m	100.0 x 4.0
J-141	<i>Fromea</i> sp. #TA	D239	2020-2030m	116.0 x 16.2
J-142	<i>Oligosphaeridium</i> sp. #TA	D239	2020-2030m	107.5 x 13.0
J-143	<i>Cyclonephelium hughesii</i>	D239	2050-2060m	116.0 x 13.5
J-144	<i>Cyclonephelium chabaca</i>	D239	2050-2060m	117.5 x 11.0
J-145	<i>Cicatricosisporites ornatus</i>	D239	2050-2060m	102.5 x 8.8

J-146	<i>Distaltriangulisporites</i> sp. #TA	D239	2050-2060m	117.5 x 2.0
J-147	<i>Isabelidinium</i> <i>belfastense</i>	D239	2080-2090m	108.5 x 12.0
J-148	<i>Pilosisorites</i> <i>trichopapillosus</i>	D239	2110-2120m	114.5 x 13.8
J-149	<i>Cribroperidinium</i> cf <i>exilicristatum</i>	D239	2110-2120m	104.8 x 10.0
J-150	<i>Trilobosporites</i> <i>marylandensis</i>	D239	2170-2180m	99.5 x 16.0
J-151	<i>Classopollis classoides</i>	D239	2170-2180m	115.5 x 13.5
J-152	<i>Hystrichosphaerina</i> <i>schindewolfii</i>	D239	2230-2240m	103.0 x 17.0
J-153	<i>Scriniodinium</i> cf <i>campanula</i>	D239	2230-2240m	102.0 x 7.0
J-154	<i>Vesperopsis</i> sp. #TB	D239	2230-2240m	107.5 x 5.2
J-155	<i>Palaeoperidinium</i> sp. #TB	D239	2230-2240m	102.2 x 10.2
J-156	<i>Canningia</i> sp. #TB	D239	2290-2300m	105.8 x 10.0
J-157	<i>Florentinia cooksonii</i>	D239	2290-2300m	107.0 x 5.0
J-158	<i>Trilobosporites</i> <i>marylandensis</i>	D239	2320-2330m	112.5 x 12.0
J-159	<i>Aptea polymorpha</i>	D239	2350-2360m	112.2 x 3.5
J-160	<i>Hystrichosphaeridium</i> <i>asterigerum</i>	D239	2380-2390m	104.0 x 13.8
J-161	<i>Antulsporites</i> <i>distaverrucosus</i>	D239	2380-2390m	110.0 x 13.0
J-162	<i>Distaltriangulisporites</i> <i>perplexus</i>	D239	2380-2390m	110.0 x 9.5
J-163	<i>Surculosphaeridium</i> sp. #TA	D239	2410-2420m	117.2 x 11.8
J-164	<i>Emmetrocyta</i> sp. #TA	D239	2410-2420m	112.0 x 5.8
J-165	<i>Veryhachium</i> sp.	D239	2440-2450m	110.0 x 16.5

J-166	<i>Subtilisphaera</i> <i>perlucida</i>	D239	2440-2450m	102.5 x 16.5
J-167	<i>Systematophora</i> sp. #TA	D239	2440-2450m	102.8 x 11.8
J-168	<i>Surculosphaeridium</i> sp. #TB	D239	2440-2450m	105.6 x 10.2
J-169	<i>Micrhystridium</i> sp. #TA	D239	2500-2510m	
J-170	<i>Pareodinia</i> <i>ceratophora</i>	D239	2565-2575m	109.0 x 6.8
J-171	<i>Scriniodinium</i> <i>galeritum</i>	D239	2565-2575m	99.2 x 3.0
J-172	<i>Sestrosporites</i> <i>pseudoalveolatus</i>	D239	2590-2600m	100.0 x 11.0
J-173	<i>Sentusidinium</i> sp. #TA	D239	2680-2690m	117.0 x 8.0
J-174	<i>Cerbia</i> <i>tabulata</i>	D239	2680-2690m	118.2 x 6.0
J-175	<i>Callaiosphaeridium</i> sp. #TA	D239	2680-2690m	111.2 x 5.0
J-176	<i>Vesperopsis</i> <i>mayi</i>	D239	2770-2780m	98.2 x 12.0
J-177	<i>Canningia</i> sp. #TC	D239	2770-2780m	101.0 x 12.0
J-178	<i>Surculoptera</i> <i>longifurcatum</i>	D299	2800-2810m	105.2 x 13.0
J-179	<i>Callialasporites</i> <i>trilobatus</i>	D239	2440-2950m	114.5 x 12.0
J-180	<i>Muderongia</i> <i>simplex</i>	D239	2940-2950m	108.2 x 8.0
J-181	<i>Subtilisphaera</i> <i>terrula</i>	D239	2970-2980m	103.5 x 9.5
J-182	<i>Cribrroperidinium</i> <i>auctificum</i>	D239	3000-3010m	108.5 x 15.0
J-183	<i>Polycingulatisporites</i> <i>clavus</i>	D239	3000-3010m	110.0 x 15.0
J-184	<i>Dingodini</i> <i>cerviculum</i>	D239	3000-3010m	110.8 x 4.2
J-186	<i>Oligosphaeridium</i> <i>poculum</i>	D239	3030-3040m	116.5 x 3.0
J-187	<i>Taleisphaera</i> <i>hydra</i>	D239	3240-3250m	116.0 x 13.5
J-188	<i>Muderongia</i> <i>tomaszowensis</i>	D239	3270-3280m	101.5 x 9.5

J-188	Taleisphaera hydra	D239	3240-3250m	106.0 x 1.0
J-189	Muderongia tomaszowensis	D239	3270-3280m	101.5 x 9.5
J-190	Occisusysta ? balios	D239	3270-3280m	108.0 x 10.0
J-191	Muderongia tomaszowensis	D239	3270-3280m	105.0 x 10.0
J-192	Oligosphaeridium poriforatum	D239	3300-3310m	99.5 x 5.0
J-193	Gonyaulacysta kostromiensis	D239	3270-3280m	106.5 x 15.0
J-194	Pyxidiniopsis sp. #TA	D239	3360-3370m	99.2 x 12.5
J-195	^O Bati ol ladinium jaegeri	D239	3360-3370m	109.0 x 4.0
J-196	Batioladinium longicornutum	D239	3360-3370m	104.4 x 3.8
J-197	Stiphrosphaeridium arbustum	D239	3420-3430m	100.9 x 16.6
J-198	Cribroperidinium exilicristatum	D239	3450-3460m	109.2 x 14.0
J-199	Spiniferites lenzii	D239	3450-3460m	119.5 x 11.1
J-200	Scriniodinium sp. #TA	D239	3450-3460m	108.8 x 2.8

J-201	Ph ilosporites cf grandis	D239	3480-3490m	113.0 x	10.2
J-202	Klukisporites scaberis	D239	3480-3490m	109.5 x	9.0
J-203	Florentinia sp. #TA	D239	3510-3520m	111.0 x	16.8
J-204	Phoberocysta neocomica	D239	3510-3550m	99.5 x	3.8
J-205	Achomosphaera verdieri	D239	3510-3520m	110.2 x	3.0
J-206	Pareodinia sp. #TA	D239	3540-3550m	110.2 x	17.2
J-208	Hystrichosphaerina sp. #TA	D239	3540-3550m	105.5 x	5.5
J-209	Cicatricosisporites #TA	D239	3570-3580m	106.0 x	15.0
J-210	Cyclonephelim sp. #TA	D239	3570-3580m	102.0 x	14.0
J-211	Sentusidinium sp. #TB	D239	3570-3580m	111.0 x	7.5
J-212	Sentusidinium sp. #TB	D239	3570-3580m	115.0 x	5.0
J-213	Stiphrosphaeridium dictyophorum	D239 D239	3570-3580m 3630-3640m	115.0 x 106.8 x	5.0 17.5
J-214	Striphrosphaeridium dictyophorum	D239	3630-3640m	106.8 x	17.5
J-215	Apteodinium sp. #TA	D239	3630-3640m	114.0 x	5.0
J-216	Cribroperidinium cf confossum	D239	3660-3670m	107.2 x	18.0
J-217	Meiourogonyaaulax sp. #TA	D239	3690-3700m	102.2 x	7.0
J-218	Phoberocysta sp. #TA	D239	3690-3700m	113.0 x	4.9
J-219	Pyxidopsis sp. #TA	D239	3360-3370m	99.2 x	12.5
J-220	Batioladinium micropodium	D239	3900-3910m	111.3 x	16.5
J-221	Sentusidinium rioultii	D239	3900-3910m	103.8 x	7.9
J-222	Cribroperidinium sp. #TA	D239	3990-4000m	107.2 x	6.0

J-223	<i>Muderongia testudinaria</i>	D239	4020-4030m	107.0 x (CAVED)	7.0
J-224	<i>Systematophora</i> sp. #TA	D239	4110-4120m	109.0 x (CAVED)	6.1
J-225	<i>Dinogymnium acuminatum</i>	D239	840-850m	110.0 x	17.0
J-226	<i>Pentadinium taeniagerum</i>	D239	840-850m	102.8 x	11.5
J-228	<i>Tricolporopollenites</i> sp. #TA	D239	840-850m	112.0 x	5.8
J-229	<i>Phelodinium</i> sp. #TA	D239	870-880m	103.5 x	4.8
J-230	<i>Achomosphaera vamulifera</i>	D239	900-910m	109.9 x	11.0
J-231	<i>Palambages</i> sp.	D239	900-910m	88.9 x	3.2
J-232	<i>Cordosphaeridium cantharellum</i>	D239	930-940m	102.5 x	3.2
J-233	<i>Phelodinium magnificum</i>	D239	930-940m	103.0 x	3.2
J-234	<i>Stiphrosphaeridium</i> sp. #TA	D239	2740-2750m	113.1 x	11.0
J-235	<i>Coronifera alberti</i>	D239	3360-3370m	106.2 x	14.8

Appendix B

LOCATION OF FORAMINIFERA AND OSTRACOD SPECIES

0840-0850: Middle Eocene.

Guembelitria columbiana (840-50, sq. 6)
Globorotalia sp. #CA (840-50, sq. 7)
Siphonina claibornensis (840-50, sq. 18)
Siphoninella claibornensis (840-50, sq. 19)
Hanzawaia sp. #CA
Heterolepa sp. #CA
Quinqueloculina sp. #CA (840-50, sq. 16)
Nonionella sp. #CA
Lenticulina alato-limbatus (840-50, sq. 14)
Marginulina sp. #CA (840-50, sq. 8)

0870-1060m: Maastrichtian

FORAMINIFERA:

Planularia dissona (870-80, sq. 18),
Rosita fornicata (870-80, sq. 5),
Gyroidinoides imitata (870-80, sq. 7)
Globigerinelloides multispina (900-10, sq. 6)
Heterohelix striata (900-10, sq. 7)
Hedbergella sp. #CA (900-10, sq. 18)
Praebulimina carseyae (900-10, sq. 19)
Gaudryina rudita (900-10, sq. 20)
Pullenia cretacea (900-10, sq. 21)
Guttulina sp. #CA
Hoeglundina supracretacea (900-10, sq. 33)
Gavelinella sp. #CA
Globotruncana arca (900-10, sq. 43)
Praeglobobulimina aspera (930-40, sq. 7)
Heterohelix glabrans (930-40, sq. 6)
Guembelitria cretacea (930-40, sq. 8)
Gavelinella correcta (960-70, sq. 6)
Gavelinella pseudopapillosa (960-70, sq. 7)
Globotruncana orientalis (960-70, sq. 42)
Lenticulina navarroensis (960-70, sq. 18)
Dorothia sp. #CA (960-70 sq. 19 & 20)
Dentalina cf. *basiplanata* (960-70, sq. 8)
Vaginulina cretacea (960-70, sq. 5)
Dorothia cf. *conula* (990-1000, sq. 6)
Rosita contusa (990-1000, sq. 31)
Pseudotextularia sp. #CA (990-1000, sq. 8)

Bolivina incrassata (990-1000, sq. 7)
Pulsiphonina prima (990-1000, sq. 20)
Archaeoglobigerina blowi (990-1000, sq. 19)
Praeglobobulimina kickapooensis (1020-30, sq. 8)
Dorothia bulletta (1020-30, sq. 9)
Globotruncanita cf. angulata (1020-30, sq. 10)
Globotruncana rosetta (1020-30, sq. 22)
Rugoglobigerina cf. rotundata (1020-30, sq. 21)
Spiroplectammina semicomplanata (1050-60, sq. 18)
Pseudouvigerina triangularis (1050-60, sq. 30)
Marginulina curvatura (1050-60, sq. 6)
Archaeoglobigerina cretacea (1050-60, sq. 11)
Rugoglobigerina rugosa (1050-60, sq. 22)
Globotruncanella petaloidea (1050-60, sq. 23)
Pseudoguembelina costulata (1050-60, sq. 21)
Pseudotextularia deformis (1050-60, sq. 45)
Pseudotextularia elegans (1050-60, sq. 33)
Racemiguembelina powelli (1050-60, sq. 9)
Gansserina gansseri (1050-60, sq. 34)
Globotruncana aegyptiaca (1050-60, sq. 19)
Globotruncana insignis (1050-60, sq. 8)
Rosita plicata (1050-60, sq. 35)
Globotruncana ventricosa (1050-60, sq. 32)
Globotruncanita stuarti (1050-60, sq. 31)
Bolivina incrassata gigantea (1230-40, sq. 33)

OSTRACODES:

Rehacythereis communis (840-50, sq. 20)
Cytherella (870-80, sq. 6)
Loxoconcha levinsoni (900-10, sq. 9)
Monoceratina cf. nitida (900-10, sq. 10)
Cytheropteron sp. #CA (900-10, sq. 32)
Loxoconcha sp. #CA (900-10, sq. 34)
Loxoconcha sp. #CB (900-10, sq. 36)
Cuneoceratina pedata (900-10, sq. 22)
Loxoconcha cf. fletcheri (930-40, sq. 18)
Brachycythere rhomboidalis (960-70, sq. 21)
Nigeria arachoides (960-70, sq. 9)
Haplocytheridea plummeri (1050-60, sq. 7)

1080-1240m: Campanian

Foraminifera:

Valvulineria allomorphinoides (1080-90, sq. 10)
Arenobulimina cf. americana (1080-90, sq. 11)
Gyroidinoides girardana (1080-90, sq. 23)
Allomorphina navarroana (1980-90, sq. 22)

Praebulimina reussi (1110-20, sq. 7)
Rugoglobigerina hexacamerata (1110-20, sq. 6)
Pseudoguembelina excolata (1110-20, sq. 18)
Gaudryina laevigata (1110-20, sq. 31)
Osangularia navarroana (1110-20, sq. 31)
Pseudouvierina seligi (1110-20, sq. 8)
Lagena cf. hexagona (1110-20, sq. 20)
Arenobulimina americana (1140-50, sq. 6)
Rosita patelliformis (1140-50, sq. 19)
Pseudoguembelina palpebra (1140-50, sq. 18)
Bolivinos draco miliaris (1140-50, sq. 7)
Ammobaculites stephensoni (1170-80, sq. 9)
Anomalinos cf. henbesti (1170-80, sq. 20)
Pullenia americana (1200-10, sq. 21)
Gavelinella spissocostata (1200-10, sq. 8)
Tritaxia capitosa (1200-10, sq. 7)
Globorotalites micheliniana (1200-10, sq. 20)
Globotruncanites elevata (1230-40, sq. 21)
Globotruncana bulloides (1230-40, sq. 20)
Planoglobulina glabrata (1230-40, sq. 34)
Pseudonodosaria manifesta (1230-40, sq. 10)
Dorothia cf. retusa (1230-40, sq. 7)
Stensolina pommerana (1230-40, sq. 10)

OSTRACODES:

Brachycythere ovata (1080-90, sq. 9)
Cytheropteron sp. #CB (1080-90, sq. 33),
Hermanites cf. #CA (1080-90, sq. 21),
Brachycythere rhomboidalis (1170-80, sq. 8),
Brachycythere sp. #CA (1170-80, sq. 7),
Loxoconcha cretacea (1170-80, sq. 19),
Loxoconcha sp. #CB (1170-80, sq. 31),
Xestoleberis opina (1200-10, sq. 19),
Fissocarinocythere pidgeoni (1200-10, sq. 9),
Phacorbaculites pokornyi (1230-40, sq. 9),

1260 to 1330m: Santonian

FORAMINIFERA:

Globorotalites multiseptus (1260-70), sq. 9),
Reussella szajnochae (1260-70, sq. 20),
Anomalinos cf. henbesti (1260-70, sq. 10),
Ammodiscus cretaceus (1260-70, sq. 22),
Lenticulina munsteri (1320-30, sq. 8),
Marginotruncana coronata (1320-30, sq. 19),
Fronidicularia lanceola bidentata (1120-30, sq. 22),

Dicarinella asymetrica (1320-30, sq. 30),
Marginotruncana marginata (1320-30, sq. 18),
Whiteinella baltica (1320-30, sq. 11),
Marginotruncana pseudolinneiana (1320-30, sq. 7),
Whiteinella paradubia (1320-30, sq. 32),
Globorotalites multiseptus (1320-30, sq. 33),
Stensoina esculpta esculpta (1320-30, sq. 20),
Arenobulimina sp. #CA (1320-30, sq. 9),
Gaudryina austinana (1320-30, sq. 21),
Marssonella trochus (1320-30, sq. 34)

OSTRACODES:

Krithe swaini (1260-70, sq. 8),
Cuneoceratina pedata (1320-30, sq. 10)

1350-1390m: Coniacian

FORAMINIFERA:

Dicarinella primitiva (1320-30, sq. 6),
Marginotruncana schneegansi (1320-30, sq. 31),
Saracenaria triangularis (1350-60, sq. 18),
Glomospira corona (1350-60, sq. 8),
Hedbergella delroiensis (1350-60, sq. 33),
Dicarinella imbricata (1350-60, sq. 21)

OSTRACODES:

Brachycythere sp. #CA (1350-60, sq. 9),
Morrowina sp. #CA (1350-60, sq. 6),
Amphicytherura sp. #CA (1350-60, sq. 19),
Cythereis dallasensis rhachis (1380-90, sq. 22)

1410-1420m: Turonian

FORAMINIFERA:

Epistomina sp. #CA (1410-20, sq. 3),
Gavelinella tourainensis (1410-20, sq. 20),
Dorothia af. *filaformis* (1410-20, sq. 19),
Dicarinella algeriana (1410-20, sq. 21),
Lingulogavelinella turonica (1440-50, sq. 7)
Helvetoglobotruncana helvetica

OSTRACODES:

Cythereis af. *sagena* (1410-20, sq. 4)

1440-1940m: Cenomanian

FORAMINIFERA:

Ammobaculites comprimatus (1440-50, sq. 9),
Marssonella cf. *trochus* (1440-50, sq. 8),
Rotalipora cf. *deecke*i (1440-50, sq. 19),
Hedbergella delroiensis
Gavelinella cenomanica (1480-90, sq. 20),
Epistomina cf. *charlottae* (1480-90, sq. 7),
Lenticulina cf. *gaultina* (1660-70, sq. 14),
Trochammina sp. #CA (1750-60, sq. 7),
Recurvoides sp. #CA (1810-20, sq. 17)

OSTRACODES:

Eocytheropteron sp. #CA (1480-90, sq. 9),
Cythereis eaglefordensis (1510-20, sq. 19),
Neocythere sp. #CA (1510-20, sq. 31),
Protocythere cf. *speetonensis* (1510-20, sq. 7),
Eocytheropteron sp. #CB (1510-20, sq. 32),
Rehacythereis sp. #CA (1570-80, sq. 15),
Hutsonia sp. #CA (1660-70, sq. 14),
Cythereis ornatissima (1720-30, sq. 4),
Schuleridea jonesiana (1870-80, sq. 6),
Rehacythereis reticulata (1870-80, sq. 18),
Planileberis sp. #CA (1870-80, sq. 19),
Eocytheropteron cf. *semiconstrictum* (1900-10, sq. 5),
Rehacythereis sp. #CB (1900-10, sq. 6)

1960-2210m: Albian

FORAMINIFERA:

Trochammina sp. #CC,
Haplophragmoides sp. #CC,
Epistomina f. *chapmani* (2080-90, sq. 7),
Tritaxia singularis (2170-80, sq. 5),
Gavelinella sp. #CB (2170-80, sq. 6),
Verneuilinoides sp. #CA

OSTRACODES:

Cytheropteron sp. #CC (2020-30, sq. 4),
Protocythere speetonensi (2080-90, sq. 6)

2230-2390m: Aptian

FORAMINIFERA:

Gavelinella cf. *barremiana* (2330-40, sq. 4),
Reophax sp. #CA (2230-40, sq. 15),
Epistomina spinulifera (2230-40, sq. 16),
Tritaxia pyramidata (2320-30, sq. 7),
Tritaxia singularis (2320-30, sq. 21),
Gavelinella cf. *brielensis* (2320-30, sq. 9),
Lentiuculina nodosa (2320-30, sq. 8),
Epistomina cretosa (2350-60, sq. 17)

2410-2510m: Undiagnostic

No diagnostic in situ microfauna.

3535-2840m: Barremian

FORAMINIFERA:

Gaudryinella tealbyensis (2535-45, sq. 7),
Marginulinopsis sp. #CA (2565-75, sq. 5),
Gyroidinoides sp. #CB (2565-75, sq. 4),
Epistomina cretosa (2565-75, sq. 6),
Epistomina hechti (2565-75, sq. 16),
Marssonella kummi (2565-75, sq. 17),
Verneulinoides neocomiensis (2565-75, sq. 18),
Conorboides sp. #CA (2565-75, sq. 30),
Lenticulina cf. *ouachitaensis* (2565-75, sq. 28),
Lenticulina heirermanni (2590-2600, sq. 6),
Lenticulina praegaultina (2590-2600, sq. 7),
Epistomina ornata (2680-90, sq. 17),
Epistomina cf. *carcolla* (2710-20, sq. 20),
Caucasella hoterivica (2710-20, sq. 19),
Saracenaria sp. #CA (2740-50, sq. 16),
Glomospira sp. #CA,
Marginulinopsis humilus (2770-80, sq. 8),
Pseudonodosaria humilus (2770-80, sq. 9),
Lenticulina cf. *kugleri* (2770-80, sq. 20),
Lenticulina ouachensis (2830-40, sq. 6)

OSTRACODES:

Protocythere sp. #CA (2680-90, sq. 18),
Alatocythere sp. #CA (2740-50, sq. 17)

2880-3250m: Undiagnostic

No diagnostic *in situ* microfauna.

3270-3520m: Hauterivian

FORAMINIFERA:

Gaudryinella tealbyensis,
Marssonella kummi,
Lenticulina nodosa,
Epistomina hechti,
Epistomina cretosa,
Epistomina ornata,
Lenticulina praegaultina,
Caucasella hoterivica,
Epistomina caracolla (3300-10, sq. 8),
Certobulimina sp. #CA (3300-10, sq. 9),
Trocholina af. *infragranulata*,
Marginulinopsis humilus,
Gaudryina sp. #CA (3360-70, sq. 19),
Epistomina sp. #CC (3360-70, sq. 20),
Pseudonubeculina nodulosa (3420-30, sq. 19),
Marginulinopsis humilus,
Vaginulina sp. #CA,
Planularia crepidularis,
Lenticulina saxonica saxonica (3510-20, sq. 32),
Lenticulina kugleri (3510-20, sq. 31),
Lenticulina heiermanni,
Vaginulina recta (3510-20, sq. 20),
Marginulinopsis sigali (3510-20, sq. 19),
Marssonella cf. *oxycona* (3510-20, sq. 33)

3540-4000m: Valanginian to Berriasian

FORAMINIFERA:

Epistomina cf. *caracolla*,
Lenticulina nodosa,
Marssonella cf. *oxycona*,

Planularia crepidularis,
Lenticulina guttata,
Marginulinopsis sigali,
Lenticulina saxonica saxonica (3540-50, sq. 20),
Lenticulina cf. saxonica bifurcilla 3540-50, sq. 21),
Conorotalites cf. bartensteini (3540-50, sq. 22),
Eoponidella sp. #CA 3540-50, sq. 34),
Ceratobulimina sp. #CA,
Tristix insigne (3570-80, sq. 19),
Caucasella hoterivica (3570-80, sq. 20),
Marginulina sp. #CC,
Lingulina nodosaria (3630-40, sq. 19),
Pseudotextulariella sp. #CA (3630-40, sq. 31),
Patellina sp. #CA (3660-70, sq. 21),
Conorboides hofkeri (3660-70, sq. 20),
Textularia sp. #CA,
Vaginulinopsis reticulosa (3690-3700, sq. 20),
Trocholina sp. #CA,
Marssonella hauteriviana (3780-90, sq. 19),
Pseudocyclammina sp. #CA,
Ammodiscus cretaceous (3930-40, sq. 17)

4020-4180m: Tithonian

FORAMINIFERA:

Epistomina uhligi (4050-60, sq. 9),
Epistomina stellicostata (4050-60, sq. 21),
Ammodiscus cretaceous,
Gaudryina sp. #CB

OSTRACODES:

Hutsonia sp. #CA

4200-5052m TD: Tithonian to Kimmeridgian

FORAMINIFERA:

Epistomina uhligi,
Epistomina stellicostata,
Gaudryina sp. #CC,
Quinqueloculina sp. #CC,
Lenticulina sp. #CA,
Lenticulina sp. #CB,

Saracenaria sp. #CC,
Saracenaria sp. #CD,
Pseudonodosaria sp. #CA,
Gyroidinides sp. #CA,
Pseudonodosaria sp. #CB,
Gaudryinella sp. #CA

OSTRACODES:

Paracypris sp. #CC,
Schuleridea sp. #CA,
Schuleridea sp. #CB,
Polycope sp. #CA,
Macrodentina sp. #CA

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