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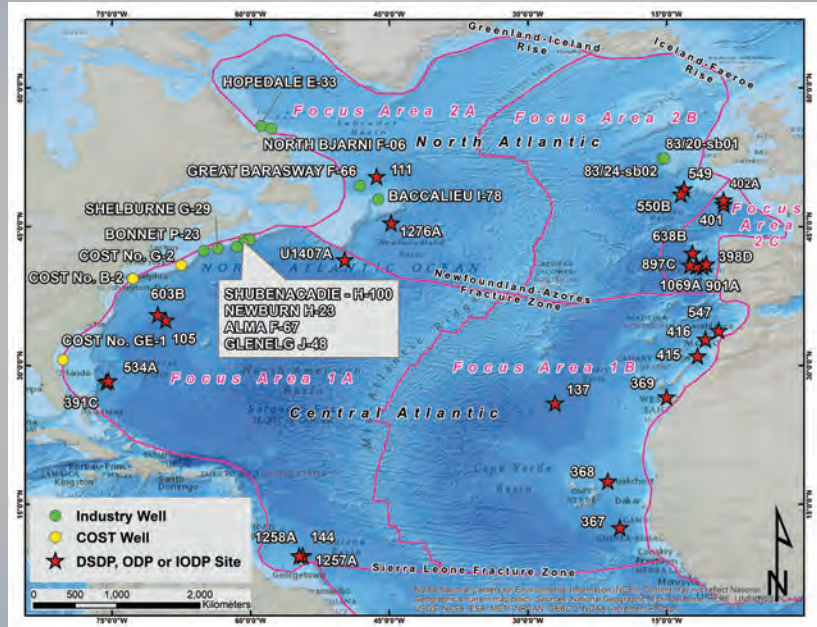
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EGI Oceans: Central & North Atlantic Evaluation of the Stratigraphy & Petroleum Systems



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EXECUTIVE SUMMARY

This study has devised and applied an integrative workflow involving chronostratigraphy, paleoenvironment, pyrolysis, palynofacies, and kinetics to qualify the source rock systems of the Central and North Atlantic conjugate margins (Figure 1). The project has established a unified high-resolution (± 0.5 Ma best resolution) Mesozoic and Cenozoic chronostratigraphy with the delineation of regional unconformities for the 41 stratigraphically deepest available DSDP-ODP-IODP sites, industry, and COST wells that display four stratigraphic intervals with source rock potential on a regional scale. These intervals have been characterized in considerable detail for source rock properties such as richness, quality, preservation, maturity and kinetic parameters (Figure 2). A new organic matter end-member classification is proposed for the Central and North Atlantic source rocks with two categories that have not been described previously from the studied areas. The Gas-Oil Ratio (GOR) and Source Potential Index (SPI) were calculated through mass balance equations considering the net thickness of each of the identified source rock intervals, and used as a ranking metric to high-grade the basins and focus areas evaluated herein.

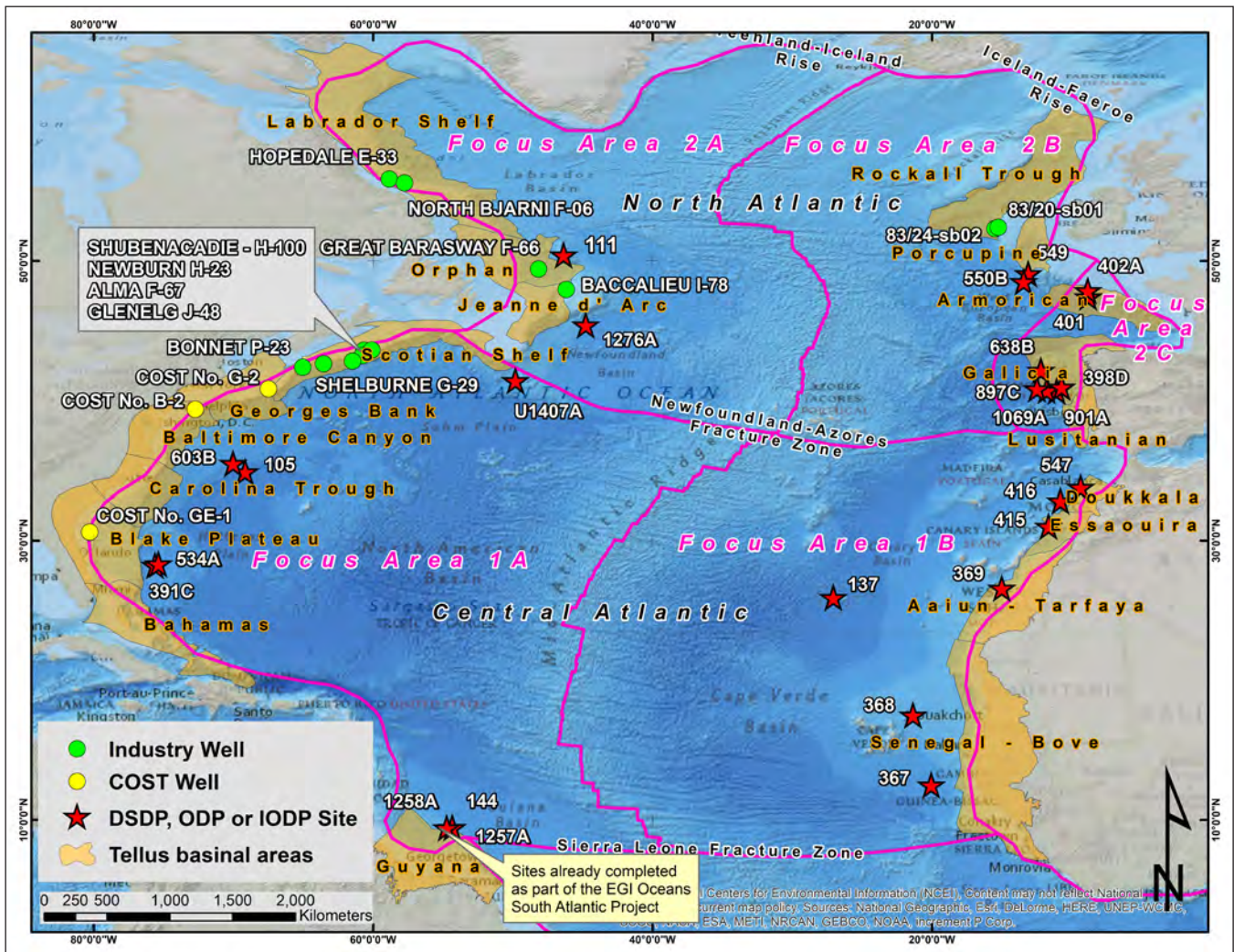


Figure 1: Map showing sectors and focus areas with the site/well locations chosen.

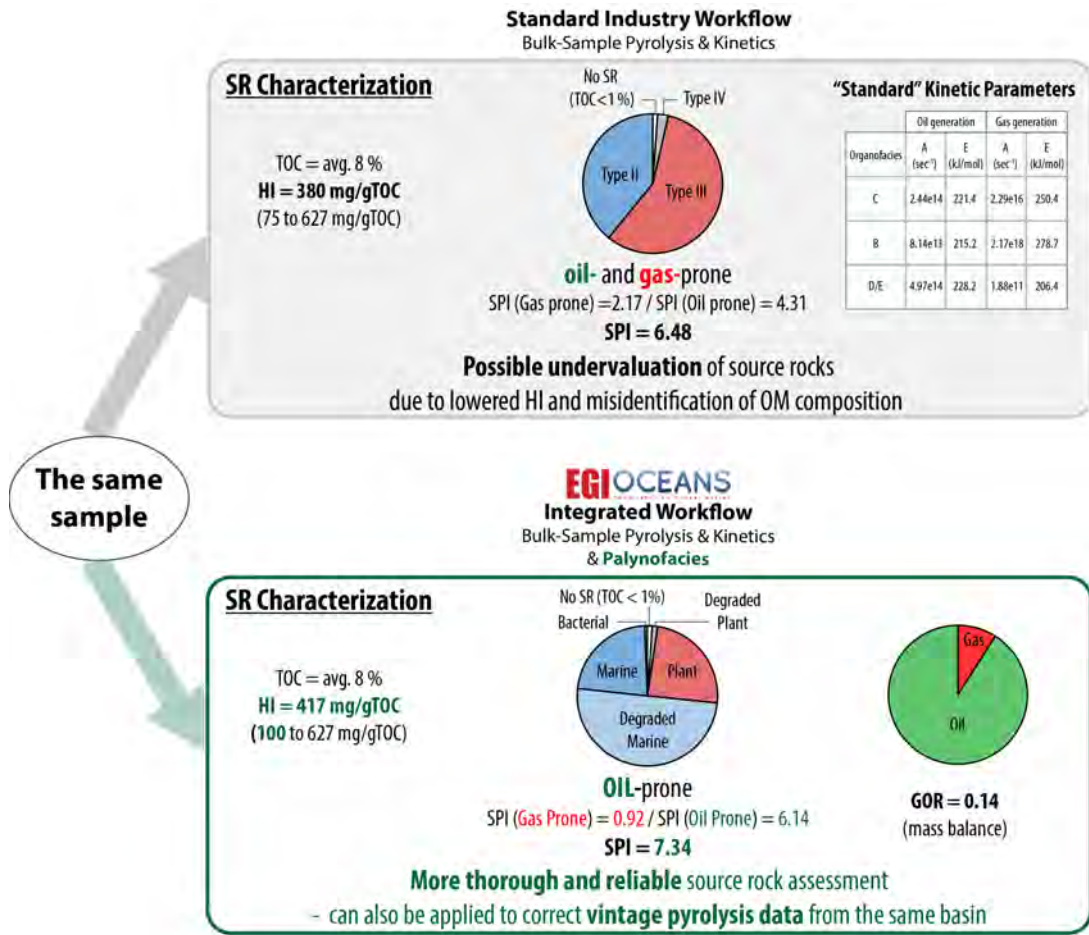


Figure 2: Palynofacies & Paleoenvironmental Flowchart

TABLE 1. SUMMARY OF THE DELIVERABLES

- 40 Graphic Correlation Charts Linked to Respective Well Locations
- 40 Integrated Geochemical Well Summaries Linked to Respective Well Locations
- 7 Chronostratigraphic Cross Sections Linked to Cross Section Locations
- 13,219 Organic Geochemistry Sample Data Results (All Geo-referenced):
 - 12,495 Organic Geochemistry Sample Data from Literature (Curated)
 - 722 New TOC Analyses (Analyses Commissioned by EGI Oceans)
 - 583 New Pyrolysis Analyses (Analyses Commissioned by EGI Oceans)
 - 72 Samples from 18 Sites/Wells with Palynofacies Results
- 569 Pyrograms Linked to Respective Organic Geochemistry Sample Locations
- 14 Samples from 6 Wells with New Vitrinite Reflectance Analyses
- VR Summary Sheets Linked to Respective Organic Geochemistry Sample Locations
- 22 Samples from 12 Wells with Bulk Kinetics Analysis Results (4 models per sample) Original Bulk Kinetics Data Results and Graphs Linked to Bulk Kinetics GIS Layer
- 3 Samples from 3 Wells with Compositional Kinetics Results (Geo-referenced)
- Source Rock Evaluation Interpretation for EGI Oceans Region 2 Wells GIS Layer

SPONSORS



COLLABORATION & PARTNERSHIPS FOR DATA AND SAMPLES

Relevant data, including samples, and completed reports have been integrated via the following collaborating eight data partners:



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Table of Contents

CHAPTER 1 INTRODUCTION	1
1.1 Background and Objectives	2
1.2 Geographic Limits of the Study Area	3
1.3 Study Sites and Wells.....	3
1.4 Deliverables	6
CHAPTER 2 DATA ACQUISITION, UPGRADING, AND METHODOLOGY	9
2.1 Types of Data.....	10
2.1.1 DSDP-ODP-IODP Legacy Data.....	10
2.1.2 DSDP-ODP-IODP Post-Cruise Data.....	11
2.1.3 Industry and COST Well Data	11
2.1.4 Micropaleontology Related Data.....	12
2.1.4.1 Biostratigraphic Data Acquisition.....	12
2.1.4.2 Reprocessing and Standardizing Legacy Data	12
2.1.4.3 Biostratigraphic Data Upgrade.....	12
2.1.5 Lithostratigraphy, Core Photos, and Geophysical (log) Data	13
2.1.6 Core Repository Visits Undertaken	14
2.2 Methods.....	14
2.2.1 Workflow	14
2.2.2 Chronostratigraphy Interpretation Methodology.....	15
2.2.2.1 Micropaleontological Sample Preparation.....	15
2.2.2.2 Composite Standard Database	16
2.2.2.3 Graphic Correlation	16
2.2.2.4 Advantages of Graphic Correlation Methodology.....	17
2.2.3 Paleoenvironment Interpretation	18
2.2.4 Wheeler Diagrams (Chronostratigraphic Cross-Sections)	18
2.2.5 Organic Geochemistry	19
2.2.5.1 Total Organic Carbon (TOC)	19
2.2.5.1.1 LECO Analytical Procedure.....	19
2.2.5.1.2 LECO Instrument Operation	20
2.2.5.1.3 LECO Quality Assurance.....	20
2.2.5.2 Anhydrous Pyrolysis (Rock-Eval 6 pyrolysis)	21
2.2.5.2.1 Rock-Eval 6 Analytical Procedure.....	21
2.2.5.2.2 Rock-Eval 6 Instrument Operation	21
2.2.5.2.3 Rock-Eval 6 Quality Assurance	22
2.2.5.2.4 Mineral Matrix Effect.....	22
2.2.5.3 Palynofacies.....	23

2.2.5.3.1 Introduction	23
2.2.5.3.2 Samples Selection and Preparation	24
2.2.5.3.3 Observation and Quantification.....	24
2.2.5.3.4 Organic Matter Sources and Preservation.....	29
2.2.5.3.4.1 OM Groups.....	29
2.2.5.3.4.2 End-Members.....	35
2.2.5.4 Source Rock Evaluation	36
2.2.5.4.1 Introduction	36
2.2.5.4.2 Maturity Diagnostic	37
2.2.5.4.3 TOC Distributions.....	37
2.2.5.4.4 MME correction	38
2.2.5.4.5 Organofacies Proportions	40
2.2.5.4.6 Gas-Oil Ratio (GOR).....	42
2.2.5.4.7 Source Potential Index (SPI).....	43
2.2.5.5 Kinetics.....	44
2.2.5.5.1 Bulk Kinetics	44
2.2.5.5.2 Compositional Kinetics.....	45
References.....	46
CHAPTER 3 RESULTS AND INTERPRETATIONS.....	49
FOCUS AREA 1A	51
DSDP Site 105 (Lower Continental Rise, Offshore Eastern USA).....	53
Site 105.1 Introduction	53
Site 105.2 Chronostratigraphy	54
Site 105.3 Paleoenvironment	56
Site 105.4 Source Rock Results	57
<i>Site 105.4.1 Maturity.....</i>	<i>57</i>
<i>Site 105.4.2 TOC Distributions.....</i>	<i>57</i>
<i>Site 105.4.3 Palynofacies Results</i>	<i>58</i>
<i>Site 105.4.4 End-member Proportions</i>	<i>59</i>
<i>Site 105.4.5 Source Rock Potential</i>	<i>60</i>
References.....	61
DSDP Site 144 (Demerara Rise).....	63
Site 144.1 Introduction	63
Site 144.2 Chronostratigraphy	64
Site 144.3 Paleoenvironment	67
Site 144.4. Source Rock Results	67
<i>Site 144.4.1 Maturity.....</i>	<i>67</i>

<i>Site 144.4.2 TOC Distributions</i>	68
<i>Site 144.4.3 Palynofacies Results</i>	68
<i>Site 144.4.4 End-member Proportions</i>	69
<i>Site 144.4.5 Source Rock Potential</i>	69
References	70
DSDP Site 391 (Blake-Bahama Basin, Offshore Eastern USA)	71
Site 391.1 Introduction	71
Site 391.2 Chronostratigraphy	72
Site 391.3 Paleoenvironment	75
Site 391.4 Source Rock Results	75
<i>Site 391.4.1 Maturity</i>	75
<i>Site 391.4.2 TOC Distributions</i>	75
<i>Site 391.4.3 Palynofacies Results</i>	76
<i>Site 391.4.4 End-member Proportions</i>	77
<i>Site 391.4.5 Source Rock Potential</i>	77
References	78
DSDP Site 534 (Blake-Bahama Basin, Offshore Eastern USA)	79
Site 534.1 Introduction	79
Site 534.2 Chronostratigraphy	80
Site 534.3 Paleoenvironment	81
Site 534.4 Source Rock Results	84
<i>Site 534.4.1 Maturity</i>	84
<i>Site 534.4.2 TOC Distributions</i>	84
<i>Site 534.4.3 Palynofacies Results</i>	85
<i>Site 534.4.4 End-member Proportions</i>	86
<i>Site 534.4.5 Source Rock Potential</i>	87
References	88
DSDP Site 603 (Hatteras Basin, Offshore Eastern USA)	91
Site 603.1 Introduction	91
Site 603.2 Chronostratigraphy	92
Site 603.3 Paleoenvironment	96
Site 603.4 Source Rock Results	97
<i>Site 603.4.1 Maturity</i>	97
<i>Site 603.4.2 TOC Distributions</i>	97
<i>Site 603.4.3 Palynofacies Results</i>	98
<i>Site 603.4.4 End-member Proportions</i>	98
<i>Site 603.4.5 Source Rock Potential</i>	100
References	101

IODP Site U1407 (Newfoundland Ridge, Offshore Canada)	103
Site U1407.1 Introduction	103
Site U1407.2 Chronostratigraphy	104
Site U1407.3 Paleoenvironment.....	105
Site U1407.4 Source Rock Results.....	107
<i>Site U1407.4.1 Maturity</i>	107
<i>Site U1407.4.2 TOC Distributions</i>	108
<i>Site U1407.4.3 End-member Proportions</i>	108
<i>Site U1407.4.4 Source Rock Potential</i>	109
References	109
ODP Site 1257 (Demerara Rise)	111
Site 1257.1 Introduction	111
Site 1257.2 Chronostratigraphy	112
Site 1257.3 Paleoenvironment.....	114
Site 1257.4 Source Rock Results.....	114
<i>Site 1257.4.1 Maturity</i>	114
<i>Site 1257.4.2 TOC Distributions</i>	115
<i>Site 1257.4.3 Palynofacies Results</i>	116
<i>Site 1257.4.4 End-member Proportions</i>	117
<i>Site 1257.4.5 Source Rock Potential</i>	118
References	119
ODP Site 1258 (Demerara Rise)	121
Site 1258.1 Introduction	121
Site 1258.2 Chronostratigraphy	122
Site 1258.3 Paleoenvironment.....	125
Site 1258.4 Source Rock Results.....	126
<i>Site 1258.4.1 Maturity</i>	126
<i>Site 1258.4.2 TOC Distributions</i>	126
<i>Site 1258.4.3 Palynofacies Results</i>	127
<i>Site 1258.4.3 End-member Proportions</i>	128
<i>Site 1258.4.4 Source Rock Potential</i>	129
References	130
Introduction To The Scotian Margin Industry Wells, Offshore Eastern Canada	133
References	133
Alma F-67 Well, Scotian Margin, Offshore Eastern Canada	135
Alma F-67.1 Introduction.....	135
Alma F-67.2 Chronostratigraphy.....	136

Alma F-67.3 Paleoenvironment.....	136
Alma F-67.4 Source Rock Results	139
<i>Alma F-67.4.1 Maturity</i>	139
References.....	139
Bonnet P-23 Well, Scotian Margin, Offshore Eastern Canada	141
Bonnet P-23.1 Introduction	141
Bonnet P-23.2 Chronostratigraphy	142
Bonnet P-23.3 Paleoenvironment.....	142
Bonnet P-23.4 Source Rock Results.....	145
<i>Bonnet P-23.4.1 Maturity</i>	145
<i>Bonnet P-23.4.2 TOC Distributions</i>	145
<i>Bonnet P-23.4.3 End-member Proportions</i>	146
<i>Bonnet P-23.4.4 Source Rock Potential</i>	146
References.....	147
Glenelg J-48 Well, Scotian Margin, Offshore Eastern Canada	149
Glenelg J-48.1 Introduction	149
Glenelg J-48.2 Chronostratigraphy	150
Glenelg J-48.3 Paleoenvironment	150
Glenelg J-48.4 Source Rock Results.....	153
References.....	153
Newburn H-23 Well, Scotian Margin, Offshore Eastern Canada	155
Newburn H-23.1 Introduction	155
Newburn H-23.2 Chronostratigraphy	156
Newburn H-23.3 Paleoenvironment.....	158
Newburn H-23.4 Source Rock Results.....	158
<i>Newburn H-23.4.1 Maturity</i>	158
References.....	158
Shelburne G-29 Well, Scotian Margin, Offshore Eastern Canada	159
Shelburne G-29.1 Introduction.....	159
Shelburne G-29.2 Chronostratigraphy.....	160
Shelburne G-29.3 Paleoenvironment	160
Shelburne G-29.4 Source Rock Results	162
<i>Shelburne G-29.4.1 Maturity</i>	162
<i>Shelburne G-29.4.2 TOC Distributions</i>	162
<i>Shelburne G-29.4.3 End-member Proportions</i>	162
<i>Shelburne G-29.4.4 Source Rock Potential</i>	163
References.....	164

Shubenacadie H-100 Well, Scotian Margin, Offshore Eastern Canada.....	165
Shubenacadie H-100.1 Introduction	165
Shubenacadie H-100.2 Chronostratigraphy	166
Shubenacadie H-100.3 Paleoenvironment	166
Shubenacadie H-100.4 Source Rock Results.....	167
References.....	167
Cost Well G-2, Offshore Eastern USA (Outer Continental Shelf)	169
COST G-2.1 Introduction	169
COST G-2.2 Chronostratigraphy	170
COST G-2.3 Paleoenvironment	172
COST G-2.4 Source Rock Results	173
<i>COST G-2.4.1 Maturity.....</i>	<i>173</i>
<i>COST G-2.4.2 TOC Distributions.....</i>	<i>174</i>
<i>COST G-2.4.3 End-member Proportions</i>	<i>174</i>
References.....	175
COST Well B-2, Offshore Eastern USA (Outer Continental Shelf).....	177
COST B-2.1 Introduction	177
COST B-2.2 Chronostratigraphy	178
COST B-2.3 Paleoenvironment.....	181
COST B-2.4 Source Rock Results.....	181
<i>COST B-2.4.1 Maturity.....</i>	<i>181</i>
<i>COST B-2.4.2 TOC Distributions</i>	<i>181</i>
<i>COST B-2.4.3 End-member Proportions.....</i>	<i>182</i>
<i>COST B-2.4.4 Source Rock Potential.....</i>	<i>183</i>
References.....	183
Cost Well GE-1, Offshore Eastern USA (Outer Continental Shelf).....	185
COST GE-1.1 Introduction.....	185
COST GE-1.2 Chronostratigraphy.....	186
COST GE-1.3 Paleoenvironment.....	189
COST GE-1.4 Source Rock Results	189
<i>COST GE-1.4.1 Maturity</i>	<i>189</i>
<i>COST GE-1.4.2 TOC Distributions.....</i>	<i>189</i>
<i>COST GE-1.4.3 End-member Proportions</i>	<i>190</i>
References.....	190
FOCUS AREA 1B.....	193
DSDP Site 137 (Offshore NW Africa, West of Cap Blanc)	194
Site 137.1 Introduction	194
Site 137.2 Chronostratigraphy	195
Site 137.3 Paleoenvironment	197
Site 137.4 Source Rock Results	197
<i>Site 137.4.1 Maturity.....</i>	<i>197</i>

<i>Site 137.4.2 TOC Distributions</i>	198
<i>Site 137.4.3 Palynofacies Results</i>	198
<i>Site 137.4.4 End-member Proportions</i>	198
<i>Site 137.4.5 Source Rock Potential</i>	199
References	200
DSDP Site 367 (Cape Verde Basin, NW Africa)	201
Site 367.1 Introduction	201
Site 367.2 Chronostratigraphy	202
Site 367.3 Paleoenvironment	203
Site 367.4 Source Rock Results	206
<i>Site 367.4.1 Maturity</i>	206
<i>Site 367.4.2 TOC Distributions</i>	206
<i>Site 367.4.3 Palynofacies Results</i>	207
<i>Site 367.4.4 End-member Proportions</i>	207
<i>Site 367.4.5 Source Rock Potential</i>	208
References	209
DSDP Site 368 (Cape Verde Rise, NW Africa)	211
Site 368.1 Introduction	211
Site 368.2 Chronostratigraphy	212
Site 368.3 Paleoenvironment	214
Site 368.4 Source Rock Results	215
<i>Site 368.4.1 Maturity</i>	215
<i>Site 368.4.2 TOC Distributions</i>	215
<i>Site 368.4.3 Palynofacies Results</i>	216
<i>Site 368.4.4 End-member Proportions</i>	217
<i>Site 368.4.5 Source Rock Potential</i>	218
References	218
DSDP Site 369 (Off Cape Bojador, Spanish Sahara, Moroccan Basin, NW Africa)	221
Site 369.1 Introduction	221
Site 369.2 Chronostratigraphy	222
Site 369.3 Paleoenvironment	223
Site 369.4 Source Rock Results	224
<i>Site 369.4.1 Maturity</i>	224
<i>Site 369.4.2 TOC Distributions</i>	224
<i>Site 369.4.3 Palynofacies Results</i>	225
<i>Site 369.4.4 End-member Proportions</i>	225
<i>Site 369.4.5 Source Rock Potential</i>	226
References	227
DSDP Site 415 (Agadir Canyon, NW Africa)	229
Site 415.1 Introduction	229
Site 415.2 Chronostratigraphy	230

Site 415.3 Paleoenvironment	230
Site 415.3 Source Rock Results	233
<i>Site 415.4.1 Maturity</i>	233
<i>Site 415.4.2 TOC Distributions</i>	234
<i>Site 415.4.3 End-member Proportions</i>	234
<i>Site 415.4.4 Source Rock Potential</i>	235
References	235
DSDP Site 416 (Moroccan Basin, NW Africa)	237
Site 416.1 Introduction	237
Site 416.2 Chronostratigraphy	238
Site 416.3 Paleoenvironment	240
Site 416.4 Source Rock Results	242
<i>Site 416.4.1 Maturity</i>	242
<i>Site 416.4.2 TOC Distributions</i>	242
<i>Site 416.4.3 End-member Proportions</i>	242
<i>Site 416.4.4 Source Rock Potential</i>	243
References	243
DSDP Site 547 (Mazagan Escarpment, NW Africa)	245
Site 547.1 Introduction	245
Site 547.2 Chronostratigraphy	246
Site 547.3 Paleoenvironment	247
Site 547.4 Source Rock Results	250
<i>Site 547.4.1 Maturity</i>	250
<i>Site 547.4.2 TOC Distributions</i>	250
<i>Site 547.4.3 Palynofacies Results</i>	251
<i>Site 547.4.4 End-member Proportions</i>	251
<i>Site 547.4.5 Source Rock Potential</i>	253
References	254
FOCUS AREA 2A	255
DSDP Site 111 (Orphan Knoll, Newfoundland Margin)	257
Site 111.1 Introduction	257
Site 111.2 Chronostratigraphy	258
Site 111.3 Paleoenvironment	259
Site 111.4 Source Rock Results	261
<i>Site 111.4.1 Maturity</i>	261
References	262
ODP Site 1276 (Newfoundland Basin, Offshore Canada).....	263
Site 1276.1 Introduction	263
Site 1276.2 Chronostratigraphy	264
Site 1276.3 Paleoenvironment.....	265
Site 1276.4 Source Rock results	268

<i>Site 1276.4.1 Maturity</i>	268
<i>Site 1276.4.2 TOC Distributions</i>	268
<i>Site 1276.4.3 Palynofacies Results</i>	268
<i>Site 1276.4.4 End-member Proportions</i>	269
<i>Site 1276.4.5 Source Rock Potential</i>	270
References	271
Baccalieu I-78 (Newfoundland – Labrador Industry Wells, Offshore Canada)	273
Baccalieu I-78.1 Introduction	273
Baccalieu I-78.2 Chronostratigraphy	274
Baccalieu I-78.3 Paleoenvironment	275
Baccalieu I-78.4 Source Rock Results	276
<i>Baccalieu I-78.4.1 Maturity</i>	276
<i>Baccalieu I-78.4.2 TOC Distributions</i>	277
<i>Baccalieu I-78.4.3 End-member Proportions</i>	277
<i>Baccalieu I-78.4.4 Source Rock Potential</i>	278
References	279
Great Barasway F-66 (Newfoundland – Labrador Industry Wells, Offshore Canada)	281
Great Barasway F-66.1 Introduction	281
Great Barasway F-66.2 Chronostratigraphy	282
Great Barasway F-66.3 Paleoenvironment.....	284
Great Barasway F-66.4 Source Rock Results.....	284
References	284
North Bjarni F-06 (Newfoundland – Labrador Industry Wells, Offshore Canada)	287
North Bjarni F-06.1 Introduction.....	287
North Bjarni F-06.2 Chronostratigraphy.....	288
North Bjarni F-06.3 Paleoenvironment.....	290
North Bjarni F-06.4 Source Rock Results	290
<i>North Bjarni F-06.4.1 Maturity</i>	290
<i>North Bjarni F-06.4.2 TOC Distributions</i>	290
<i>North Bjarni F-06.4.3 End-member Proportions</i>	291
<i>North Bjarni F-06.4.4 Source Rock Potential</i>	291
Reference	291
Hopedale E-33 (Newfoundland – Labrador Industry Wells, Offshore Canada)	293
Hopedale E-33.1 Introduction	293
Hopedale E-33.2 Chronostratigraphy	294
Hopedale E-33.3 Paleoenvironment.....	295
Hopedale E-33.4 Source Rock Results	296
<i>Hopedale E-33.4.1 Maturity</i>	296
<i>Hopedale E-33.4.2 TOC Distributions</i>	296
<i>Hopedale E-33.4.3 End-member Proportions</i>	296

<i>Hopedale E-33.4.4 Source Rock Potential</i>	297
References	297
FOCUS AREA 2B	299
DSDP Site 549 (Porcupine Basin, Offshore Ireland)	301
Site 549.1 Introduction	301
Site 549.2 Chronostratigraphy	302
Site 549.3 Paleoenvironment	305
Site 549.4 Source Rock Results	306
<i>Site 549.4.1 Maturity</i>	306
<i>Site 549.4.2 TOC Distributions</i>	307
<i>Site 549.4.3 Palynofacies Results</i>	307
<i>Site 549.4.4 End-member Proportions</i>	308
<i>Site 549.4.5 Source Rock Potential</i>	309
References	310
DSDP Site 550 (Porcupine Abyssal Basin, Offshore Ireland)	311
Site 550.1 Introduction	311
Site 550.2 Chronostratigraphy	312
Site 550.3 Paleoenvironment	314
Site 550.4 Source Rock Results	315
<i>Site 550.4.1 Maturity</i>	315
<i>Site 550.4.2 TOC Distributions</i>	315
<i>Site 550.4.3 End-member Proportions</i>	315
<i>Site 550.4.4 Source Rock Potential</i>	316
References	317
Borehole 83/20-sb01 (Rockall Trough, Offshore Western Ireland)	319
83/20-sb01.1 Introduction	319
83/20-sb01.2 Chronostratigraphy	320
83/20-sb01.3 Paleoenvironment.....	322
83/20-sb01.4 Source Rock Results.....	322
<i>83/20-sb01.4.1 Maturity</i>	322
<i>83/20-sb01.4.2 TOC Distributions</i>	323
<i>83/20-sb01.4.3 End-member Proportions</i>	323
<i>83/20-sb01.4.4 Source Rock Potential</i>	324
References	324
Borehole 83/24-sb02 (Rockall Trough, Offshore Western Ireland)	325
83/24-sb02.1 Introduction	325
83/24-sb02.2 Chronostratigraphy	326
83/24-sb02.3 Paleoenvironment.....	327
83/24-sb02.4 Source Rock Results.....	330
<i>83/24-sb02.4.1 Maturity</i>	330
<i>83/24-sb02.4.2 TOC Distributions</i>	330

References.....	330
FOCUS AREA 2C.....	331
DSDP Site 398 (Vigo Seamount, Galicia Margin)	333
Site 398.1 Introduction	333
Site 398.2 Chronostratigraphy	334
Site 398.3 Paleoenvironment	338
Site 398.4 Source Rock Results	338
<i>Site 398.4.1 Maturity.....</i>	<i>338</i>
<i>Site 398.4.2 TOC Distributions.....</i>	<i>339</i>
<i>Site 398.4.3 Palynofacies Results</i>	<i>339</i>
<i>Site 398.4.4 End-member Proportions</i>	<i>340</i>
<i>Site 398.4.5 Source Rock Potential</i>	<i>341</i>
References.....	341
DSDP Site 401 (Northern Bay OF Biscay).....	343
Site 401.1 Introduction	343
Site 401.2 Chronostratigraphy	344
Site 401.3 Paleoenvironment	346
Site 401.4 Source Rock Results	347
<i>Site 401.4.1 Maturity.....</i>	<i>347</i>
<i>Site 401.4.2 TOC Distributions.....</i>	<i>347</i>
References.....	348
DSDP Site 402 (Northern Bay of Biscay)	349
Site 402.1 Introduction	349
Site 402.2 Chronostratigraphy	350
Site 402.3 Paleoenvironment	353
Site 402.4 Source Rock Results	353
<i>Site 402.3.1 Maturity.....</i>	<i>353</i>
<i>Site 402.3.2 TOC Distributions.....</i>	<i>353</i>
<i>Site 402.3.3 Palynofacies Results</i>	<i>353</i>
<i>Site 402.3.4 End-member Proportions</i>	<i>354</i>
<i>Site 402.3.5 Source Rock Potential</i>	<i>354</i>
References.....	355
ODP Site 638 (West Galicia Margin)	357
Site 638.1 Introduction	357
Site 638.2 Chronostratigraphy	358
Site 638.3 Paleoenvironment	360
Site 638.4 Source Rock Results	360
<i>Site 638.4.1 Maturity.....</i>	<i>361</i>
<i>Site 638.4.2 TOC Distributions.....</i>	<i>361</i>
<i>Site 638.4.3 Palynofacies Results</i>	<i>361</i>
<i>Site 638.4.4 End-member Proportions</i>	<i>362</i>

<i>Site 638.4.5 Source Rock Potential</i>	363
References	363
ODP Site 897 (Iberia Abyssal Plain)	365
Site 897.1 Introduction	365
Site 897.2 Chronostratigraphy	366
Site 897.3 Paleoenvironment	367
Site 897.4 Source Rock Results	367
<i>Site 897.4.1 Maturity</i>	367
<i>Site 897.4.2 TOC Distributions</i>	368
<i>Site 897.4.3 End-member Proportions</i>	368
<i>Site 897.4.4 Source Rock Potential</i>	368
References	369
ODP Site 901 (Iberia Abyssal Plain)	371
Site 901.1 Introduction	371
Site 901.2 Chronostratigraphy	372
Site 901.3 Paleoenvironment	374
Site 901.4 Source Rock Results	374
References	375
ODP Site 1069 (Iberia Abyssal Plain)	377
Site 1069.1 Introduction	377
Site 1069.2 Chronostratigraphy	378
Site 1069.3 Paleoenvironment.....	381
Site 1069.4 Source Rock Results.....	381
<i>Site 1069.4.1 Maturity</i>	381
<i>Site 1069.4.2 TOC Distributions</i>	381
References	381
CHAPTER 4 REGIONAL SYNTHESIS OF THE CENTRAL AND NORTH ATLANTIC	383
4.1. Chronostratigraphy	384
4.1.1 <i>Brief Overview of Conjugate Margins Tectonics</i>	384
4.1.2 <i>Chronostratigraphy of the Central Atlantic (Focus Areas 1A–1B)</i>	384
4.1.2.1 <i>Revisions to Chronostratigraphy of Individual Study Localities</i>	385
4.1.2.2 <i>Regional Unconformities</i>	389
4.1.3 <i>Chronostratigraphy of the North Atlantic (Focus Areas 2A–2B–2C)</i>	389
4.1.3.1 <i>Revisions to Chronostratigraphy of Individual Study Localities</i>	389
4.1.3.2 <i>Regional Unconformities</i>	390
4.2. Paleoenvironment.....	390
4.2.1 <i>Late Jurassic (Oxfordian–Tithonian)</i>	390
4.2.2 <i>Aptian–Albian</i>	391
4.2.3 <i>Cenomanian–Turonian</i>	392
4.2.4 <i>Santonian–Campanian</i>	393
4.3. Source Rock Geochemistry: High Grading Areas.....	396

4.3.1 Focus Area 1A.....	397
Demerara Rise.....	397
Mid-Atlantic Outer Continental Shelf (Baltimore Canyon)	397
4.3.2 Focus Area 1B.....	402
Cape Verde Basin.....	402
Deep Moroccan Basin	402
4.3.3 Focus Area 2A.....	402
Flemish Pass Basin	402
Newfoundland Basin.....	402
4.3.4 Focus Area 2B.....	402
4.3.5 Focus Area 2C.....	403
Galicia Margin	403
References.....	403
CHAPTER 5 BULK KINETICS RESULTS	405
Bulk Kinetics Summary.....	409
References	409
CHAPTER 6 CONCLUSIONS	411
Chronostratigraphy	413
Paleoenvironment.....	414
Source Rock Geochemistry	415
References.....	417

List of Tables

Table 1.1. Basic information for the sites/wells in the Focus Areas 1A and 1B.....	5
Table 1.2. Basic information for the sites/wells in the Focus Areas 2A–2C.....	6
Table 1.3. Project deliverables.....	7
Table 2.1. Archiving of core data in different databases.	10
Table 2.2. Frequently used websites for access to legacy data and publications.	11
Table 2.3. Microfossil disciplines available for the study sites.	12
Table 2.4. List of end-members with their corresponding HI values and palynofacies.	36
Table 2.5. TOC scales to quantify a source rock richness.....	37
Table 2.6. List of end-members with their corresponding HI values and palynofacies.	41
Table 2.7. The average SPI of basins around the world	44
Site 105 Table 1. Site summary.....	54
Site 105 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.....	58
Site 105 Table 3. Main palynofacies results.	59
Site 105 Table 4. End-members proportions for every immature SR interval.....	60
Site 105 Table 5. GOR and SPI values for every SR interval.....	60
Site 144 Table 1. Site summary.....	64
Site 144 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.....	68

Site 144 Table 3. Main palynofacies results.....	69
Site 144 Table 4. End-members proportions for every immature SR interval.	69
Site 144 Table 5. GOR and SPI values for every SR interval.....	70
Site 391 Table 1. Site summary.	72
Site 391 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.	76
Site 391 Table 3. Main palynofacies results.	76
Site 391 Table 4. End-members proportions for every immature SR interval.	77
Site 391 Table 5. GOR and SPI values for every SR interval.....	78
Site 534 Table 1. Site summary.	80
Site 534 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.	85
Site 534 Table 3. Main palynofacies results.....	86
Site 534 Table 4. End-members proportions for every immature SR interval.	87
Site 534 Table 5. GOR and SPI values for every SR interval.....	88
Site 603 Table 1. Site summary.	92
Site 603 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.	97
Site 603 Table 3. Main palynofacies results.	98
Site 603 Table 4. End-members proportions for every immature SR formation.....	99
Site 603 Table 5. GOR and SPI values for every SR interval.....	100
Site U1407 Table 1. Site summary.....	104
Site U1407 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.....	108
Site U1407 Table 3. End-members proportions for the only immature SR interval.	108
Site U1407 Table 4. GOR and SPI values for every SR interval.	109
Site 1257 Table 1. Site summary.....	112
Site 1257 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit of Hole 1257A.	115
Site 1257 Table 3. TOC distributions for every Mesozoic chronostratigraphic unit of Hole 1257B.....	115
Site 1257 Table 4. TOC distributions for every Mesozoic chronostratigraphic unit of Hole 1257C.....	116
Site 1257 Table 5. Main palynofacies results.	116
Site 1257 Table 6. End-members proportions for every immature SR interval of Hole 1257A.	117
Site 1257 Table 7. End-members proportions for every immature SR interval of Holes 1257B and 1257C.	118
Site 1257 Table 8. GOR and SPI values for every SR interval.	118
Site 1258 Table 1. Site summary.....	122
Site 1258 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit of Hole 1258A.	126
Site 1258 Table 3. TOC distributions for every Mesozoic chronostratigraphic unit of Hole 1258B.....	127
Site 1258 Table 4. TOC distributions for every Mesozoic chronostratigraphic unit of Hole 1258C.....	127
Site 1258 Table 5. Main palynofacies results.....	128
Site 1258 Table 6. End-members proportions for every immature SR interval of Hole 1257A.	128
Site 1258 Table 7. End-members proportions for every immature SR interval of Holes 1257B and 1257C.	129
Site 1258 Table 8. GOR and SPI values for every SR interval.	129
Alma F-67 Table 1. Site summary.....	136
Bonnet P-23 Table 1. Site summary.....	142
Bonnet P-23 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.	145

Bonnet P-23 Table 3. End-members proportions for every SR interval.	146
Bonnet P-23 Table 4. GOR and SPI values for every SR interval.	146
Glenelg J-48 Table 1. Site summary.	150
Newburn H-23 Table 1. Site summary.	156
Shelburne G-29 Table 1. Site summary.	159
Shelburne G-29 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.	162
Shelburne G-29 Table 3. End-members proportions for every SR interval.	163
Shelburne G-29 Table 4. GOR and SPI values for every SR interval.	163
Shubenacadie H-100 Table 1. Site summary.	166
COST G-2 Table 1. Site summary.	170
COST G-2 Table 2. TOC distributions for every immature Mesozoic chronostratigraphic unit.	174
COST G-2 Table 3. End-members proportions for SR intervals with Rock Eval 6 data.	175
COST B-2 Table 1. Site summary.	178
COST B-2 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.	182
COST B-2 Table 3. End-members proportions for SR intervals with Rock Eval 6 data.	183
COST B-2 Table 4. GOR and SPI values for the two SR intervals.	183
COST GE-1 Table 1. Site summary.	186
COST GE-1 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.	190
Site 137 Table 1. Site summary.	195
Site 137 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.	198
Site 137 Table 3. Main palynofacies results.	198
Site 137 Table 4. End-members proportions for every immature SR interval.	199
Site 137 Table 5. GOR and SPI values for every SR interval.	199
Site 367 Table 1. Site summary.	202
Site 367 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.	206
Site 367 Table 3. Main palynofacies results.	207
Site 367 Table 4. End-members proportions for every immature SR interval.	208
Site 367 Table 5. GOR and SPI values for every SR interval.	209
Site 368 Table 1. Site summary.	212
Site 368 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.	216
Site 368 Table 3. Main palynofacies results.	217
Site 368 Table 4. End-members proportions for every immature SR interval.	217
Site 368 Table 5. GOR and SPI values for every SR interval.	218
Site 369 Table 1. Site summary.	222
Site 369 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.	225
Site 369 Table 3. Main palynofacies results.	225
Site 369 Table 4. End-members proportions for every immature SR interval.	226
Site 369 Table 5. GOR and SPI values for every SR interval.	226
Site 415 Table 1. Site summary.	230
Site 415 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.	234
Site 415 Table 3. End-members proportions for every immature SR interval.	234

Site 415 Table 4. GOR and SPI values for every SR interval.....	235
Site 416 Table 1. Site summary.	238
Site 416 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.	242
Site 416 Table 3. End-members proportions for every immature SR interval.	243
Site 416 Table 4. GOR and SPI values for every Mesozoic SR interval.....	243
Site 547 Table 1. Site summary.	246
Site 547 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit of Hole 547A.	250
Site 547 Table 3. TOC distributions for every Mesozoic unit of Hole 547B.....	251
Site 547 Table 4. Main palynofacies results for the 2 samples from Hole 547B.	251
Site 547 Table 5. End-members proportions for every immature SR formation of Hole 547A.....	252
Site 547 Table 6. End-members proportions for every immature SR formation of Hole 547B.....	253
Site 547 Table 7. GOR and SPI values for every SR interval.....	253
Site 111 Table 1. Site summary.	258
Site 111 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.	262
Site 1276 Table 1. Site summary.....	264
Site 1276 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.....	268
Site 1276 Table 3. Main palynofacies results.	269
Site 1276 Table 4. End-members proportions for every immature SR interval.....	270
Site 1276 Table 5. GOR and SPI values for every SR interval.	270
Baccalieu I-78 Table 1. Site summary.....	274
Baccalieu I-78 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.....	277
Baccalieu I-78 Table 3. End-members proportions for every SR interval.....	278
Baccalieu I-78 Table 4. GOR and SPI values for every SR interval.	278
Great Barasway F-66 Table 1. Site summary.....	282
North Bjarni F-06 Table 1. Site summary.....	288
North Bjarni F-06 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.	290
North Bjarni F-06 Table 3. End-members proportions for every SR interval.....	291
North Bjarni F-06 Table 4. GOR and SPI values for every SR interval.....	291
Hopedale E-33 Table 1. Site summary.....	293
Hopedale E-33 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.....	296
Hopedale E-33 Table 3. End-members proportions for every SR interval.....	296
Hopedale E-33 Table 4. GOR and SPI values for every SR interval.	297
Site 549 Table 1. Site summary.	302
Site 549 Table 2. TOC distributions for every Paleozoic–Mesozoic chronostratigraphic unit.....	307
Site 549 Table 3. Main palynofacies results.	308
Site 549 Table 4. End-members proportions for every immature SR interval.	309
Site 549 Table 5. GOR and SPI values for every SR interval.....	310
Site 550 Table 1. Site summary.	312
Site 550 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.	315
Site 550 Table 3. End-members proportions for every immature SR interval.	316
Site 550 Table 4. GOR and SPI values for every SR interval.....	316

83/20-sb01 Table 1. Site summary.....	320
83/20-sb01 Table 2. TOC distributions for every chronostratigraphic unit.	323
83/20-sb01 Table 3. End-members proportions for every SR interval.	323
83/20-sb01 Table 4. GOR and SPI values for every SR interval.	324
83/24-sb02 Table 1. Site summary.....	326
83/24-sb02 Table 2. TOC distributions for every chronostratigraphic unit.	330
Site 398 Table 1. Site summary.	334
Site 398 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.	339
Site 398 Table 3. Main palynofacies results.	340
Site 398 Table 4. End-members proportions for every immature SR interval.	340
Site 398 Table 5. GOR and SPI values for every SR interval.....	341
Site 401 Table 1. Site summary.	344
Site 401 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.	348
Site 402 Table 1. Site summary.	350
Site 402 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.	353
Site 402 Table 3. Main palynofacies results.	354
Site 402 Table 4. End-members proportions for every immature SR interval.	354
Site 402 Table 5. GOR and SPI values for every SR interval.....	355
Site 638 Table 1. Site summary.	358
Site 638 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.	361
Site 638 Table 3. Main palynofacies results.....	362
Site 638 Table 4. End-members proportions for every immature SR interval.	362
Site 638 Table 5. GOR and SPI values for every SR interval.....	363
Site 897 Table 1. Site summary.	366
Site 897 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.	368
Site 897 Table 3. End-members proportions for every immature SR interval.	368
Site 897 Table 4. GOR and SPI values for every SR interval.....	369
Site 901 Table 1. Site summary.	372
Site 1069 Table 1. Site summary.....	378
Site 1069 Table 2. TOC distributions for every Mesozoic chronostratigraphic unit.....	381
Table 4.1 Revisions to Chronostratigraphy	386

List of Figures

Figure 1. EGI Oceans’ novel integrative source rock evaluation compared with the standard industry workflow.....	iii
Figure 1.1. EGI Oceans research methodology.....	2
Figure 1.2. Location of the Central and North Atlantic sites/wells selected for this study and Focus Areas 1A–2C.....	4
Figure 2.1. Data harvesting and depth standardization.	13
Figure 2.2. EGI Oceans workflow for the Central and North Atlantic project.	15
Figure 2.3. Graphic correlation method.	17
Figure 2.4. Paleoenvironment reconstruction.	18
Figure 2.5. Wheeler diagram workflow.	19

Figure 2.6. A schematic showing the sample preparation procedure for TOC-LECO analysis.....	20
Figure 2.7. A schematic showing the pyrolysis method used to perform the experiments in this study.....	22
Figure 2.8. Palynofacies AOM classes observed	26
Figure 2.9. palynofacies phytoclasts and palynomorphs observed	28
Figure 2.10. HI values compared to fAOM proportions for samples with TOC above 4%.....	29
Figure 2.11. Typical grumeleuse amorphous organic matter with numerous round brown lumps in a diffuse matrix. Red bar = 20 μ m.	31
Figure 2.12. HI values compared to grAOM (green) and dAOM (blue) proportions for samples with TOC >4 %.....	32
Figure 2.13. Comparison of fluorescence intensity, color and homogeneity of fAOM, grAOM and dAOM.	33
Figure 2.14. Ranges of HI values (with and without MME) for each type of dominant organic matter.	35
Figure 2.15. HI vs. TOC diagram for samples dominated by altered marine OM.	39
Figure 2.16. HI vs. TOC diagram for samples dominated by altered marine OM.	40
Figure 2.17. A schematic of the calculations performed to attain the GOR values presented in this study.	42
Site 105 Figure 1. Map showing the location of Site 105.	53
Site 105 Figure 2. Comparison of age interpretation by Shipboard Scientific Party (1972) and this study.....	55
Site 105 Figure 3. Mesozoic paleoenvironment summary with organofacies.	56
Site 144 Figure 1. Map showing the location of Site 144.	63
Site 144 Figure 2. Comparison of age interpretation by Shipboard Scientific Party (1972) and this study.....	66
Site 144 Figure 3. Mesozoic paleoenvironment summary with organofacies.	67
Site 391 Figure 1. Map showing the location of Site 391.	71
Site 391 Figure 2. Comparison of age interpretation by Shipboard Scientific Party (1978) and this study.....	73
Site 391 Figure 3. Mesozoic paleoenvironment summary with organofacies.	74
Site 534 Figure 1. Map showing the location of Site 534.....	79
Site 534 Figure 2. Comparison of age interpretation by Shipboard Scientific Party (1983) and this study.....	82
Site 534 Figure 3. Mesozoic paleoenvironment summary with organofacies.	83
Site 603 Figure 1. Map showing the location of Site 603.	91
Site 603 Figure 2. Comparison of age interpretation by Shipboard Scientific Party (1987) and this study.....	94
Site 603 Figure 3. Mesozoic paleoenvironment summary with organofacies.	95
Site U1407 Figure 1. Map showing the location of Site U1407.	103
Site U1407 Figure 2. Comparison of age interpretation by Norris et al. (2014) and this study.....	106
Site U1407 Figure 3. Mesozoic paleoenvironment summary with organofacies.	107
Site 1257 Figure 1. Map showing the location of Site 1257.	111
Site 1257 Figure 2. Comparison of age interpretation by Erbacher et al. (2004) and this study.....	113
Site 1257 Figure 3. Mesozoic paleoenvironment summary with organofacies.	114
Site 1258 Figure 1. Map showing the location of Site 1258.	121
Site 1258 Figure 2. Comparison of age interpretation by Erbacher et al. (2004b) and this study.....	124
Site 1258 Figure 3. Mesozoic paleoenvironment summary with organofacies.	125
Alma F-67 Figure 1. Map showing the location of the Alma F-67 well.	135
Alma F-67 Figure 2. Comparison of age interpretation by Weston et al. (2012) and this study with Mesozoic paleoenvironment summary.....	138
Bonnet P-23 Figure 1. Map showing the location of the Bonnet P-23 well.	141

Bonnet P-23 Figure 2. Comparison of age interpretation by Weston et al. (2012) and this study with Mesozoic paleoenvironment summary.	144
Glenelg J-48 Figure 1. Map showing the location of the Glenelg J-48 well.	149
Glenelg J-48 Figure 2. Comparison of age and paleoenvironmental interpretation by Weston et al. (2012) and this study with organofacies.	152
Newburn H-23 Figure 1. Map showing the location of the Newburn H-23 well.	155
Newburn H-23 Figure 2. Comparison of age interpretation by Weston et al. (2012) and this study with Mesozoic–Cenozoic paleobathymetry.	157
Shelburne G-29 Figure 1. Map showing the location of the Shelburne G-29 well.	159
Shelburne G-29 Figure 2. Comparison of age and paleoenvironmental interpretation by Weston et al. (2012) and this study with organofacies.	161
Shubenacadie H-100 Figure 2. Comparison of age interpretation by Weston et al. (2012) and this study with Mesozoic paleoenvironment summary.	167
COST G-2 Figure 1. Map showing the location of the COST G-2 well.	169
COST G-2 Figure 2. Comparison of age interpretation by U.S. Department of the Interior (1980) and this study....	171
COST G-2 Figure 3. Mesozoic paleoenvironment summary with organofacies.	172
COST B-2 Figure 1. Map showing the location of the COST B-2 well.	177
COST B-2 Figure 2. Comparison of age interpretation by Bujak (1978) with Williams (1978) and this study.....	179
COST B-2 Figure 3. Mesozoic paleoenvironment summary with organofacies.....	180
COST GE-1 Figure 1. Map showing the location of the COST GE-1 well.	185
COST GE-1 Figure 2. Comparison of age interpretation by Poag and Hall (1979) and this study.	187
COST GE-1 Figure 3. Mesozoic paleoenvironment summary with organofacies.....	188
Site 137 Figure 1. Map showing the location of Site 137.	194
Site 137 Figure 2. Comparison of age interpretation by Shipboard Scientific Party (1972) and this study.....	196
Site 137 Figure 3. Mesozoic paleoenvironment summary with organofacies.	197
Site 367 Figure 1. Map showing the location of Site 367.	201
Site 367 Figure 2. Comparison of age interpretation by Shipboard Scientific Party and Bukry (1978) and this study.	204
Site 367 Figure 3. Mesozoic paleoenvironment summary with organofacies.	205
Site 368 Figure 1. Map showing the location of Site 368.	211
Site 368 Figure 2. Comparison of age interpretation by Shipboard Scientific Party (Krasheninnikov and Pflaumann, 1978; Pflaumann and Krasheninnikov, 1978) and this study.	213
Site 368 Figure 3. Mesozoic paleoenvironment summary with organofacies.	214
Site 368 Figure 4. Tmax, Ro on all vitrinites and HI values for Site 368 between 900 and 1000 mbsf.	215
Site 369 Figure 1. Map showing the location of Site 369.	222
Site 369 Figure 2. Comparison of age interpretation by Shipboard Scientific Party (1978) and this study.....	223
Site 369 Figure 3. Mesozoic paleoenvironment summary with organofacies.	224
Site 415 Figure 1. Map showing the location of Site 415.	229
Site 415 Figure 2. Comparison of age interpretation by Shipboard Scientific Party (1980) and this study.....	232
Site 415 Figure 3. Mesozoic paleoenvironment summary with organofacies.	233
Site 416 Figure 1. Map showing the location of Site 416.	237
Site 416 Figure 2. Comparison of age interpretation by Shipboard Scientific Party (1980) and this study.....	239

Site 416 Figure 3. Mesozoic paleoenvironment summary with organofacies.	241
Site 547 Figure 1. Map showing the location of Site 547.	245
Site 547 Figure 2. Comparison of age interpretation by Shipboard Scientific Party (1984) and this study.	248
Site 547 Figure 3. Mesozoic paleoenvironment summary with organofacies.	249
Site 111 Figure 1. Map showing the location of Site 111.	257
Site 111 Figure 2. Comparison of age interpretation by Shipboard Scientific Party et al. (1972) and this study.	260
Site 111 Figure 3. Mesozoic paleoenvironment summary with organofacies.	261
Site 1276 Figure 1. Map showing the location of Site 1276.	263
Site 1276 Figure 2. Comparison of age interpretation by Shipboard Scientific Party (2004) and this study.	266
Site 1276 Figure 3. Mesozoic paleoenvironment summary with organofacies.	267
Baccalieu I-78 Figure 1. Map showing the location of the Baccalieu I-78 well.	273
Baccalieu I-78 Figure 2. Comparison of age interpretation by Bujak Davis Group (1987) and this study with paleobathymetric interpretation by Robertson Research International Ltd. (2004) and organofacies. ..	276
Great Barasway F-66 Figure 1. Map showing the location of the Great Barasway F-66 well.	281
Great Barasway F-66 Figure 2. Comparison of age interpretation by Ainsworth et al. (2008) and this study with Mesozoic paleoenvironment summary.	283
North Bjarni F-06 Figure 1. Map showing the location of the North Bjarni F-06 well.	287
North Bjarni F-06 Figure 2. Comparison of age interpretation by Bujak Davies Group (1987) and this study with Mesozoic–Cenozoic paleobathymetry interpretations by Bujak Davies Group (1987) and Miller and d’Eon (1987).	289
Hopedale E-33 Figure 1. Map showing the location of the Hopedale E-33 well.	293
Hopedale E-33 Figure 2. Comparison of age interpretation by Bujak Davies Group (1987) and this study with Mesozoic–Cenozoic paleobathymetry interpretations by Bujak Davies Group (1987) and Miller and d’Eon (1987).	295
Site 549 Figure 1. Map showing the location of Site 549.	301
Site 549 Figure 2. Comparison of age interpretation by Shipboard Scientific Party (1985) and this study.....	304
Site 549 Figure 3. Mesozoic paleoenvironment summary with organofacies.	306
83/20-sb01 Figure 1. Map showing the location of 83/20-sb01.	319
83/20-sb01 Figure 2. Comparison of age interpretation by Harington et al. (2000) and this study.....	321
83/20-sb01 Figure 3. Mesozoic paleoenvironment summary with organofacies.	322
83/24-sb02 Figure 1. Map showing the location of 83/24-sb02.	325
83/24-sb02 Figure 2. Comparison of age interpretation by Harington et al. (2000) and this study.....	327
83/24-sb02 Figure 3. Mesozoic paleoenvironment summary with organofacies.	329
Site 398 Figure 1. Map showing the location of Site 398.	333
Site 398 Figure 2. Comparison of age interpretation by Shipboard Scientific Party (1979) supplemented by Sigal (1979) and this study.	336
Site 398 Figure 3. Mesozoic paleoenvironment summary with organofacies.	337
Site 401 Figure 1. Map showing the location of Site 401.	343
Site 401 Figure 2. Comparison of age interpretation by Shipboard Scientific Party (1979) and this study.....	345
Site 401 Figure 3. Mesozoic paleoenvironment summary with organofacies.	347
Site 402 Figure 1. Map showing the location of Site 402.	349
Site 402 Figure 2. Comparison of age interpretation by Shipboard Scientific party (1979) and this study.....	351

Site 402 Figure 3. Mesozoic paleoenvironment summary with organofacies.	352
Site 638 Figure 1. Map showing the location of Site 638.	357
Site 638 Figure 2. Comparison of age interpretation by Shipboard Scientific Party (1987) and this study.....	359
Site 638 Figure 3. Mesozoic paleoenvironment summary with organofacies.	360
Site 897 Figure 1. Map showing the location of Site 897.	365
Site 897 Figure 2. Mesozoic paleoenvironment summary with organofacies.	367
Site 901 Figure 1. Map showing the location of Site 901.	371
Site 901 Figure 2. Comparison of age interpretation by Shipboard Scientific Party (1994) and this study.....	373
Site 901 Figure 3. Tithonian paleoenvironment summary.	374
Site 1069 Figure 1. Map showing the location of Site 1069.	377
Site 1069 Figure 2. Comparison of age interpretation by Shipboard Scientific Party (1998) and this study.	379
Site 1069 Figure 3. Mesozoic and Cenozoic paleoenvironment summary with organofacies.	380
Figure 4.1. Kimmeridgian–Tithonian paleoenvironment reconstruction.	391
Figure 4.2. Aptian–Albian paleoenvironment reconstruction.	392
Figure 4.3. Cenomanian–Turonian paleoenvironment reconstruction.	393
Figure 4.4. Santonian–Campanian paleoenvironment reconstruction.	394
Figure 4.5. Stratigraphic summary of paleoenvironment, TOC and organofacies for the Central Atlantic (Focus Areas 1A and 1B).	395
Figure 4.6. Stratigraphic summary of paleoenvironment, TOC and organofacies for the North Atlantic (Focus Areas 2A, 2B and 2C).	396
Figure 4.7. Tithonian SPI oil and SPI gas.	398
Figure 4.8. Aptian–Albian SPI oil and SPI gas.	399
Figure 4.9. Cenomanian–Turonian SPI oil and SPI gas.	400
Figure 4.10. Santonian SPI oil and SPI gas.	401
Kinetics Figure 1. Activation energy (E_i) distributions for different kerogen types, generated through pure kerogen models (Image modified from Burnham, 2017).	406
Kinetics Figure 2. Activation energy (E_i) distribution of samples dominated by well-preserved marine OM (around 90%).	407
Kinetics Figure 3. Activation energy (E_i) distribution of samples dominated by degraded marine OM 407	407
Kinetics Figure 4. Activation energy (E_i) distribution of samples dominated by Plant-Bactria OM.	408
Kinetics Figure 5. Activation energy (E_i) distribution of samples dominated by a mixture of terrestrial (around 80%) and preserved marine OM.	408
Kinetics Figure 6. Activation energy (E_i) distribution of samples dominated by a mixture of terrestrial and altered marine OM.....	409



Sudeep Kanungo, PhD, MBA

RESEARCH ASSISTANT PROFESSOR

Sudeep Kanungo is a nannofossil biostratigrapher recognized for his work in applied chronostratigraphy through the graphic correlation methodology and composite standard database technology. The foundation of this method is the former Amoco Composite Standard. Sudeep leads his team in integrative, multi-disciplinary chronostratigraphy projects to identify periods of rock accumulation, unconformities and depositional environments in absolute time (mega-annum age). This aids in creating data for improved spatial and temporal calibration of source rock events. Sudeep specializes in Cretaceous nannofossils, and integrating them with planktonic foraminifera and palynomorphs through the graphic correlation methodology. Sudeep recently received the Best Scientific Poster Award at the 15th Annual Houston Geological Society Africa Conference in September 2016.

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Expertise

- Integrated microfossil chronostratigraphy
- Nannofossil biostratigraphy

Regional Experience:

- South Atlantic: Conjugate Margin
- Equatorial Transform Margin: Côte d'Ivoire – Ghana Transform Margin
- Central and North Atlantic: Conjugate Margin
- East and West India Passive Margin: 16 onshore to offshore basins
- East Africa: Somalia to Mozambique basins (onshore to offshore)

Recent Publications:

- Kanungo, S., Bown, P. R., Young, J. R., and Gale, A. S.: A brief warming event in the late Albian: evidence from calcareous nannofossils, macrofossils, and isotope geochemistry of the Gault Clay Formation, Folkestone, southeastern England, *J. Micropalaeontol.*, 37, 231-247, <https://doi.org/10.5194/jm-37-231-2018>, 2018.
- Ahmed, W., Bhat, G.M., Mc Lennan, J., Sinha, H.N., Kanungo, S., Pandita, S.K., Singh, Y., Hakhoo, N., Hafiz, M., Thusu, B. & Choudhary, N.H.: Kerogen typing using palynofacies analysis in Permian Barren Measures Formation in Raniganj sub-basin, East India. *The Palaeobotanist* 67(2): 113–122, 2018.
- Kanungo S., Young J., Skowron, G.: Microfossils: Calcareous Nannoplankton (Nannofossils). In: Sorkhabi R. (eds.) *Encyclopedia of Petroleum Geoscience, Encyclopedia of Earth Sciences Series*, Springer, Cham, https://doi.org/10.1007/978-3-319-02330-4_4-2, 2017.

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FORAMINIFERAL BIOSTRATIGRAPHER

Dr. Eiichi Setoyama's expertise is in benthic foraminifera, a microfossil group that is critical in the industry and academia for paleoenvironmental reconstructions to underpin the understanding of the distribution of source and reservoir sediments and margin paleogeography. Dr. Setoyama joined EGI in 2014 as a paleoenvironment and biostratigraphy expert with the Chronostratigraphy Team.

Dr. Setoyama earned his Ph.D. from the Institute of Geological Sciences, Polish Academy of Sciences, in 2012, followed by a post-doctoral research position at the King Fahd University of Petroleum and Minerals in Dhahran, Saudi Arabia where he focused on the project "Pliocene to Pleistocene benthic foraminifera from IODP Expedition 323 Cores in the Bering Sea: The role of sea-level change, oxygenation, productivity, and volcanism."

He also received his MS in Paleobiology from University College London, UK. In addition to authoring multiple peer-reviewed publications, he is the proud recipient of several academic awards and grants related to ocean research drilling, and notably the Alan Higgins Award for Applied Micropalaeontology from The Micropalaeontological Society. Dr. Setoyama is bilingual in Japanese and English.

Dr. Setoyama has been involved in EGI Oceans South Atlantic (I 01350), Central & North Atlantic (I 01229), and iCORDS. His role includes conducting paleoenvironmental evaluation and high resolution chronostratigraphy of Mesozoic and Cenozoic sections of the DSDP/ODP/IODP sites.

His research focus areas include:

- Source rock depositional environment
- Paleobathymetric modeling
- Biofacies modeling
- The use of foraminiferal assemblages for analysis of displaced sediments
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- Source Rock Pyrolysis
- Interpretation

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EGI Petroleum Geochemistry Lab Manager DhruPAD RaghuvEer Beti came to EGI from KDMIPE (Keshava Deva Malaviya Institute of Petroleum Exploration) in ONGC (Oil and Natural Gas Corporation) Dehradun, India where he first received his training in Petroleum Geochemistry. His research work at EGI is focused on Petroleum Geochemistry, Petroleum Systems Analysis, Source Rock Pyrolysis and Interpretation, QC/QA for HAWK™ data (Hydrocarbon Analysis with Kinetics), HAWK™ data processing for removal of bitumen or drilling fluid contamination, and accurate estimation of source rock maturity.

DhruPAD earned a Bachelor of Technology (B.Tech) in Chemical Engineering from Jawaharlal Nehru Technological University (India) and a Masters in Petroleum Engineering from the University of Utah. He is currently pursuing his Ph.D. in Chemical Engineering at the University of Utah. He is an active member of the Society of Petroleum Engineers.

In addition to English, DhruPAD speaks Hindi, Urdu, and Telugu.

Professional Expertise

R & D | Petroleum Engineering & Petroleum Geochemistry – Research involves developing a suite of analytically methods and techniques to understand the API gravity, PVT properties, water saturation, hydrocarbon saturation, and porosity of the rocks while drilling the well; reduce risk by avoiding drilling in predicted unproven wells and increase the efficiency of drilling operations; and predicting the Bubble point in the reservoir. Developing a preliminary reservoir simulation software, by measuring the PVT properties and characterizing the reservoir at early drilling operations stage.

Instrumentation | Certified in experimentation, maintenance, and analysis of source rock pyrolysis using HAWK™ (Hydrocarbon Analysis with Kinetics) instruments, Rock-Eval®, and SRA™.

Regional & Basin Experience

Papua New Guinea

Argentina and Colombia

West Australia

India

US shale plays



Sylvain Garel-Laurin, PhD

AFFILIATE SCIENTIST

Dr. Sylvain Garel is an organic geochemist and sedimentologist with experience in conventional and unconventional petroleum exploration. After completing a Ph.D. on 'Environmental Consequences of the Paleocene-Eocene Thermal Maximum' at Paris Université Pierre et Marie Curie in 2013, Sylvain worked within the exploration department of Total as a postdoctoral researcher before working as an independent consultant.

During his Ph.D., Sylvain used several organic geochemistry proxies along with sedimentology and palynofacies observations to produce an integrated schema of paleoenvironmental changes at the Paleocene-Eocene boundary for Northwest Europe. As a petroleum geochemist, Sylvain focused on source-rock evaluation of Central and South Atlantic Basins and the relationship between paleoenvironmental settings and source-rock properties. He also worked on oil-SR correlation using biomarkers for European and African basins. The last couple of year, Sylvain helped to develop a specific workflow combining palynofacies, Rock-Eval, kinetic and biomarker data that allows a precise assessment of source-rock potential.

As an independent consultant, Sylvain is involved in several academic and industrial projects including a review of Central & North Atlantic Source-Rocks with EGI and a paleoenvironmental and characterization of the Autun Basin (France) and its unconventional system with the Sorbonne Université. Sylvain is a board member of the French Researcher on Organic Geochemistry association (FROG) since 2016. He is a member of the European Association of Organic Geochemists (EAOG).

Selected Publications:

Behar, F., Delhaye-Prat, V., Chaboureau, A.-C., **Garel, S.**, 2018. Detritic input quantification in lacustrine petroleum systems: example of the pre-salt source rocks from the Lower Congo Basin (Congo). AAPG International Conference & Exhibition 2018, Cape Town. Abstract.

Chaboureau, A.-C., **Garel, S.**, Mourlot, Y., Behar, F., 2018. New insights of the Cretaceous source rock potential in the Central Atlantic Ocean based on palynofacies analyses and Rock Eval data. AAPG Annual Conference, Salt Lake City 2018. Abstract.

Garel, S., Behar, F., Schnyder, J., Baudin, F., 2017. Control of paleoenvironmental settings on primary fluids characteristics of lacustrine source rocks in the Autun Permian Basin (France). In Baudin, F., & Wendebourg, J. (Eds.), Petroleum Source Rocks. Bull. Soc. Géol. Fr., 188, 29.

Garel, S., Quesnel, F., Jacob, J., Roche, E., Le Milbeau, C., Dupuis, C., Boussafir, M., Baudin, F., Schnyder, J., 2014. High frequency floral changes at the Paleocene-Eocene Boundary revealed by comparative biomarkers and palynological studies. Org. Geoch. 77, 43 – 58.

Garel, S., Schnyder, J., Jacob, J., Dupuis, C., Boussafir, M., Le Milbeau, C., Storme, J.-Y., Iakovleva, A. I., Yans, J., Baudin, F., Fléhoc, C., Quesnel, F., 2013. Paleohydrological and paleoenvironmental changes recorded in terrestrial sediments of the Paleocene–Eocene boundary (Normandy, France). Palaeogeogr. Palaeoclimatol. Palaeoecol. 373, 184 – 199.

Research Interests

- Source-Rock geochemistry
- Palynofacies
- Organic geochemistry
- Biomarkers
- Study of Anoxic Ocean Events and associated black shales
- Paleoenvironmental and paleoclimatic reconstructions

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