

Profile

Issue 2
Fall 2010

OETR Offshore Energy
Technical
Research
Association

Play Fairway Analysis

A Study of Nova Scotia's
Offshore Basin

www.offshoreenergyresearch.ca

Special Project Insights: Importance of Biostratigraphy as part of the OETR Play Fairway Analysis

An essential area of research contributing to the OETR Association (OETR) Play Fairway Analysis (PFA) is the biostratigraphy project, which makes up one of the ten special projects the PFA encompasses. In this issue of 'Profile' we present a summary of the biostratigraphy work completed to-date, highlight several key researchers, as well as provide an update regarding next major steps in the final months of the PFA.

Under the direction of OETR, RPS Energy manages the biostratigraphy project, with the work being carried out by four subcontractors; Geological Survey of Canada - Atlantic, Saint Mary's University, Biostratigraphic Associates International and RPS Energy. Experts from each institution together make up a team that includes local and international specialists with extensive knowledge of the Nova Scotia Margin. The team includes industrial biostratigraphers with global expertise having more than 150 years of combined experience.

The next section will discuss the overall purpose of the project, the individual sub-project contributions, preliminary integration of these studies and how they fit within the larger PFA.

Why Perform Biostratigraphy?

Of prime importance to determining the petroleum potential of an area is an understanding of the depositional conditions of the sediments and how these have varied over time; where and when any sediments which provide a potential source for hydrocarbons may have been deposited, and where and when any potential reservoir sediments which can trap those hydrocarbons are located in relation to these sources. To determine the age and depositional conditions of the sediments, biostratigraphy is undertaken on samples from oil wells (cuttings, core or sidewall core samples).

Biostratigraphy within the petroleum industry is carried out using three different types of microfossils: micropalaeontological (sand grain sized calcareous and siliceous shells of a variety of organisms which live within the bottom sediments and in the water column – mainly foraminifera and ostracods), nannofossil (clay fraction sized microscopic calcareous plates of marine algae) and palynological (the

organic remains of algae, mainly marine but also living in non-marine lacustrine/fluvial environments, and of spores and pollen within the terrestrial setting). A combination of these three disciplines provides a very powerful tool for evaluating the age, depositional setting and source of the sediment deposited at any time.

Project Overview

Objectives:

- Age calibration of key wells across the margin;
- Determine palaeoenvironmental trends across the margin;
- Find and understand the nature of seismically mappable surfaces;
- Provide the age of the first marine sediments on the Nova Scotian offshore shelf;
- Understand timing of sediment loading leading to salt-withdrawal in the north of the Sable sub-basin;
- Integrate results with the PFA study.

This was undertaken by:

- Conducting new biostratigraphic analyses (nannofossil, micropalaeontology and palynology) on up to 950 samples;
- Reviewing pre-existing biostratigraphy well data;
- Integrating with seismic interpretation undertaken by BeicipFranlab;
- Establishing an integrated biostratigraphic framework (nannos, forams and palynology) for the 200-100 Ma interval: understanding paleoenvironmental evolution;
- Applying this and the existing younger framework to more wells; and
- Developing a regional tectonostratigraphic and sequence stratigraphic framework – integrating well and seismic data.

Biostratigraphy as an Ingredient to the PFA

The biostratigraphy project was undertaken in two phases. The aim of the first phase was to undertake new multi-disciplinary biostratigraphic analyses on a number of key wells (6) and integrate these with a review of pre-existing biostratigraphic data from other wells (14) in order to determine key stratigraphic surfaces for integration with the seismic mapping project. The wells were picked in a variety of structural settings and aimed to provide as good a geographic spread as possible across the margin. Results were periodically integrated with seismic mapping undertaken by BeicipFranlab personnel (PFA technical consultants), in that greater understanding of the recognized surfaces could be achieved (e.g. regional extent of unconformities). The data were then used to understand the depositional conditions at the well locations through time.

A second supplementary project was later initiated, targeted at a better understanding of the older (Jurassic) sediments in two key areas. The first was to determine the age of the oldest marine strata on the offshore shelf. New multi-disciplinary biostratigraphic analyses were undertaken on samples from Mohican I-100, plus pre-existing data from another well, Moheida P-15, were reviewed. Mohican I-100 was important, as it has five cored intervals through the Middle and Early Jurassic (from the Scatarie Member of the Abenaki Formation to the Eurydice Formation), plus cuttings samples at 10ft intervals and sidewall core samples which provided excellent material for new analyses. The samples chosen from cores were selected by Dr. Andrew MacRae (Saint Mary's University), targeting the optimum lithologies for biostratigraphic recovery – a critical reason for the success of recovery within these generally poorly fossiliferous sections.

The second aim of the supplementary

study was to address the timing of the extensive sediment loading that has led to salt withdrawal within the northern part of the Sable sub-basin. There are major changes in sediment thickness from the margin of the Sable sub-basin in the north to immensely thickened strata to the south in Arcadia J-16, South Desbarres O-76, Mic Mac H-86 and Uniacke G-72. New multi-disciplinary analyses were undertaken on the South Desbarres O-76 well, and a review of pre-existing biostratigraphic data was undertaken from the Uniacke G-72 well. Once again, sidewall core and core data collected by Dr. Andrew MacRae proved critical to the understanding of these difficult sections.

Sub-project Contributions

RPS Energy

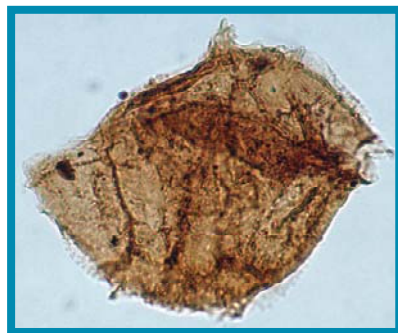
Work undertaken by RPS Energy has included the washing and splitting of well samples from eight wells on the Scotian Shelf; Cohasset L-97, Glooscap C-63, South Griffin J-13, Bonnet P-23, Chebukto K-90, Glenelg J-48, Mohican I-100 and South Desbarres O-76. (See Figure 1 for sample dinocysts from the Glooscap C-63 well.) These wells were chosen for the biostratigraphy project due to their good spatial coverage and stratigraphic penetration,

as well as correlation with the seismic grid. The samples from these wells come from the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) Geoscience Research Centre in Dartmouth. The RPS Energy team has also performed nannofossil processing and analysis on Jurassic and Cretaceous-aged samples in Woking, UK. A Nannofossil Range Chart for each well has been produced digitally in StrataBugs format to be used for stratigraphic and well-log stratigraphic interpretation. The team has also produced summary stratigraphic charts for each of the well sections in ODM3 format, which includes all of the stratigraphic and palaeoenvironmental interpretations, together with the key stratigraphic markers. Abundance and diversity histograms produced from the quantitative biostratigraphic data produced by RPS Energy and Biostratigraphic Associates have been included on the summary logs for each well. These are crucial for the identification of maximum flooding events.

As a part of the multinational biostratigraphy team, RPS Energy personnel have reviewed pre-existing biostratigraphic data from 16 other wells to define the main sequence stratigraphic surfaces within these sections. The team has also produced summary stratigraphic charts, similar to those for the 8 wells, with new biostratigraphic



Adnatosphaeridium caulleryi



Korystocysta gochtii



Gonyaulacysta jurassica

Figure 1
A selection of dinoflagellate cysts from the Glooscap C-63 well. These are all marine indicators and are typical of the Middle Jurassic of the Scotian Shelf.

analyses for these well sections. RPS Energy and Biostratigraphic Associates International are in the process of collaboratively developing a summary report to describe the depositional environments, definition of sequences, and their interpretation.



Dr. Janice Weston
Project Manager, RPS Energy

Dr. Weston graduated from Exeter University, UK in 1979 with a B.Sc. in Geology (First Class Hons.) and then completed her Ph.D. in Geology in 1982, also from Exeter University. She has since worked as a consultant biostratigrapher for the petroleum industry, initially as a micropalaeontologist, then focusing on integrating the different biostratigraphic disciplines with other geological data to help integration with seismic data in exploration well studies. The consultancy company she works for has changed its name through the years (Stratigraphic Services International, then TimeTrax and now RPS Energy), but the core team she's worked with has remained stable. Her main areas of expertise are Africa and Eastern Europe – the PFA has been her first project on the Canadian margin. As project manager of this study, she scoped out the biostratigraphy project and led the integration of both the biostratigraphy data at meetings in Halifax and the seismic data with BeicipFranlab in Paris. She presented a paper on the preliminary results from this study at the

American Association of Petroleum Geologists International Conference and Exhibition in Calgary in September 2010. She feels privileged to have worked with such a first class group of Canadian and UK biostratigraphers.



Dr. Kevin Cooper
Nannofossil Specialist, RPS Energy

Dr. Kevin Cooper graduated from the University College of Wales, Swansea in 1980 with a B.Sc. in Geology (Upper Second Class. Hons.) and then completed his Ph. D. in Geology at University College London in 1987. From 1983, he has worked as a consultant biostratigrapher for the petroleum industry as a nannofossil specialist. Academically, he is one of few nannofossil workers who have specialized in Jurassic nannofossil biostratigraphy. Kevin is co-author of the main published nannofossil zonation scheme for the Jurassic (Bown & Cooper 1998). He has also published on nannofossils stratigraphy from the Jurassic/Cretaceous boundary, the Early Cretaceous and the Cenomanian/Turonian boundary. Within the industrial sector, Dr. Cooper's main areas of expertise include Africa and Eastern Europe and, having been the principal nannofossil worker for the RPS Energy team for more than 25 years, he has built up an extensive knowledge of Neogene, Palaeogene and Late Cretaceous nannofossil biostratigraphy. Dr. Cooper brings this knowledge to all of the major projects he works on, including this project on the Canadian margin.

Biostratigraphic Associates International Ltd.

Researchers from the Biostratigraphic Associates team have contributed to this special project by performing palynological and micropalaeontological analyses on the eight wells selected for new analyses. The Palynology Analytical Program provided quantitative analysis of each sample, with counts of up to 200 taxa (where the palynomorph recovery is sufficient). All palynomorph types were examined and recorded, including marine indicators such as dinocysts, microforam test linings and marine algae, and terrestrially derived spores, pollen, algae and fungal bodies. The Micropaleontology Data Gathering Program's objective was to compile quantitative counts of all micropaleontological elements free of matrix, or estimates if matrix bound. The microfaunal elements included foraminifera, ostracods, macrofaunal elements, algae and other miscellanea.

The research team prepared a Palynology Range Chart and a Micropaleontology Range Chart in StrataBugs format for each of the wells analyzed. They display the species that are found in each of the samples from each of the well sections. The data were provided digitally to RPS Energy who then prepared Abundance and Diversity histograms for each well, to be included on the Stratigraphic Summary Logs. The analytical data derived from the analyses has been used to determine age, zonation and environment. The integration with the new nannofossil data and wireline logs has enabled the stratigraphic calibration of the well sections and recognition of key sequence stratigraphic surfaces. As mentioned earlier, Biostratigraphic Associates International is working with RPS Energy to prepare a summary report that will review these integrated results.



David Shaw
*Director and Palynologist,
Biostratigraphic Associates International*

David Shaw received his B.Sc. in Geology (1981) and M.Sc. in Palynology (1982) from Sheffield University. He is currently registered with Southampton University for a part time external Ph.D., working on the palynology of the Late Neogene sediments of Lake Albert in Uganda. Mr. Shaw has worked continuously as a palynologist for almost 30 years, first in Aberdeen and Watford (UK), then overseas in Cairo for about four years, and then moving to Venezuela for about five years. For the past ten years Mr. Shaw has worked as an independent consultant based in the UK. Mr. Shaw gained initial experience working in the North Sea, but later specialized in international work, particularly Africa and South America. He is experienced in the Jurassic, Cretaceous and Tertiary, tropical non-marine Tertiary, and the North African Palaeozoic. Mr. Shaw has worked on all the palynology groups (dinocysts, acritarchs, spores, pollen, fungi and algae) and is experienced in the applications of palynology to sequence stratigraphy, palaeoenvironmental, vegetation and climatic interpretation. In conjunction with previous work on the Scotian Shelf, all of this experience proved extremely useful in the Scotian Shelf study. David Shaw has been an integral part of the biostratigraphy team and has reviewed and interpreted the biostratigraphic data in Halifax.

Saint Mary's University



Dr. Andrew MacRae
Assistant Professor, Saint Mary's University

Dr. Andrew MacRae, Assistant Professor in the Department of Geology at Saint Mary's University, has contributed to the biostratigraphy project by providing peer review and expert stratigraphic advice for the study of the Jurassic and Cretaceous wells from the Scotian Shelf. Dr. MacRae is a graduate of the University of Calgary and received his Ph.D in 1998. Dr. MacRae brings a valuable range of experience to the PFA project. He has been a leading contributor throughout the program and has played an important role in the integration process in Halifax and Paris. Dr. MacRae has provided collaboration on the biostratigraphy and lithostratigraphy of the eight wells being

analyzed by RPS Energy and Biostratigraphic Associates, as well as the 14 other wells offering pre-existing data also being reviewed by these contractors. Dr. MacRae has produced digital lithological data for the 20 wells

in the initial study (six definite study wells and 14 review wells) with accompanying interpretation through logs and summary plots. Dr. MacRae presented the team's work on the project in Lisbon at the Conjugate Margin Conference at the end of September 2010.

Geological Survey of Canada - Atlantic

The Geological Survey of Canada – Atlantic (GSC – Atlantic) team has lent their expert taxonomic and stratigraphic advice to the biostratigraphy study and is providing peer review. Dr. Graham Williams and Dr. Rob Fensome have offered collaboration on taxonomy and biostratigraphy to the palynological consultant from Biostratigraphic Associates, David Shaw. Dr. Piero Ascoli has provided collaboration on taxonomy and biostratigraphy to the micropalaeontological consultants from Biostratigraphic Associates. The GSC – Atlantic research team has provided both personal data and input to the interpretation of both the pre-existing biostratigraphic data of 16 well sections and the 8 wells analysed by Biostratigraphic Associates and RPS Energy. They are also contributing to the development of a regional stratigraphic framework and have been involved with the workshops on biostratigraphy and integration with seismic contractors.

Dr. Rob Fensome Research Scientist, Geological Survey of Canada – Atlantic

After attaining degrees at Nottingham University in England and the University of Saskatchewan, Dr. Fensome spent time as a post-doc at the University of Toronto before coming to GSC – Atlantic in 1984. His research interests lie mainly in the application of Mesozoic and Cenozoic fossil dinoflagellates, spores and pollen to biostratigraphy, in which areas he has substantive publications, but he has also written widely on dinoflagellate systematics and



The biostratigraphy team pulling together data to provide accurate age and paleoenvironmental control for the Scotian Margin. From left to right are Kevin Cooper, Andrew MacRae, Janice Weston, Piero Ascoli and Dave Shaw; missing are Rob Fensome and Graham Williams (both GSC Atlantic).

evolution. He is also very active in outreach, most notably as a co-editor with Dr. Graham Williams and co-author of the best-selling AGS book *The Last Billion Years*. Dr. Fensome is currently embarking on a research project with Dr. Andrew MacRae and others to consolidate the biostratigraphic framework of the Triassic to early Cretaceous succession of the Scotian Margin.

Dr. Piero Ascoli
Emeritus Research Scientist, Geological Survey of Canada – Atlantic

Dr. Piero Ascoli attained his degrees in Italy and first worked as a micropaleontologist with AGIP, the Italian state oil company in 1955. Through the late 1950s and the 1960s, Dr. Ascoli shared time between AGIP and Louisiana State University, honing his skills especially as a Mesozoic and Tertiary ostracod specialist. In 1971 he joined the Dartmouth office of the Geological Survey of Canada to establish a foraminiferal-ostracod biostratigraphic framework for offshore eastern Canada. Since 1971, he has examined almost 100 offshore exploration wells biostratigraphically. Dr. Ascoli retired in the mid 1990s, but has continued to work on the micropaleontology of the offshore wells and participate in current projects such as the PFA.

Integrating the Results

What makes the PFA biostratigraphy project unique is the integrative nature of this multi-well (24) study. The integration is both between the biostratigraphic disciplines within this study, as well as the integration of biostratigraphic, lithofacies, well log and seismic data. This has enabled improved, robust stratigraphic resolution which allows for both the discrimination of reworked elements and recognition of downhole contamination. It has also enabled geophysicists to undertake seismic sequence stratigraphic interpretation with

greater confidence in the surfaces interpreted. This creates a better understanding of the timing of major regional events such as major flooding surfaces and unconformities. The biostratigraphically calibrated seismic surfaces the team has recognized between wells are detailed below.

Unconformities:

- Intra-Oligocene
- Intra-Ypresian
- Late Campanian
- Turonian/Cenomanian boundary (base Petrel Mbr)
- Late Albian
- Middle Albian
- Aptian (base Naskapi Mbr)
- Intra-Base Cretaceous

Flooding Surfaces:

- Santonian/Coniacian Chalk
- Albian/Aptian boundary
- Intra-Aptian (Naskapi)
- Intra-Hauterivian (related in part to the 'O' Marker)
- Tithonian
- Top Callovian

As part of the PFA, this work should help generate new momentum in the search for hydrocarbons on the Scotian Margin, much of which has not been explored, especially in the deeper water.

Next Steps

As the PFA Program wraps up in March 2011, there are several approaching milestones over the next few months. A major integration meeting in Paris has taken place December 13 and 14, 2010 bringing together the academic community, the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB), the Nova Scotia Department of Energy, BeicipFranlab, Saint Mary's University and RPS Energy. That meeting covered the following major topics:

PFA Partners



- 1) Bible line interpretation
- 2) Seismic mapping
- 3) Progress on Dionisos modelling
- 4) Geochemistry
- 5) Petroleum systems modelling
- 6) Biostratigraphy update (Jurassic)
- 7) Lower Cretaceous sedimentology
- 8) Planning for External Peer Review

27/28th January 2011

Also in Paris, a Gross Depositional Environment Workshop is scheduled for January 19 and 20, 2011. That workshop will present the results of the Dionisos modelling. Dionisos is a quantitative tool for assessing the complex interaction between accommodation space, sediment supply and transport through a coupled simulation of sedimentary processes. It delivers a history of sedimentary basin development featuring sedimentary architecture, lithological facies and paleo-bathymetry through space and time. The sedimentary stratigraphic setting is a key feature controlling hydrocarbon occurrence and behavior. The "stratigraphic model" generated using Dioniso includes lithological facies, potential source rock, reservoir and seal distributions and thicknesses. It also incorporates paleo-environment ensuring consistency between paleo-topography, sediment architecture and facies.

Following this workshop the project team will prepare for External Peer Review meetings. At these meetings the results of the PFA work to date will be presented to technical representatives from oil and gas companies to assess the preliminary findings of the PFA.

In early February, there will be a workshop on the CRS (Common Risk Segment) mapping, followed by the Yet-to-Find and derisking of identified plays in early March. A final presentation in Halifax will be held at the end of March 2011.

A key aspect to the future of the PFA project is tied to a Request for Proposals that was

issued by the Government of Nova Scotia on December 6, 2010. The RFP titled *Consulting Services for the Marketing of New Offshore Nova Scotia Petroleum Investment Opportunities* has the goal of developing a marketing and communications plan that will communicate the PFA findings to the international offshore exploration industry.

There has been discussion regarding a possible PFA Phase II that would extend beyond the original March 31, 2011 completion date. This notion has arisen due to the need for more work on the carbonates project, maintenance of the PFA Atlas, as well as potentially more required work on the Laurentian Sub-basin. As more integration meetings occur, it will become clearer whether a potential PFA Phase II is necessary, whether funds exist to perform the suggested activities and what the detailed work plans would consist of. OETR will continue to update stakeholders on new developments regarding PFA deliverables and further discussions of a potential second phase of the program.



For more information about the Play Fairway Analysis Program contact:

Jennifer Matthews

j.matthews@offshoreenergyresearch.ca
5151 George Street, Suite 400, PO Box 2664
Halifax, Nova Scotia B3J 3P7 Canada
P: (902) 424-2493 • F: (902) 428-2200

OETR is a not-for-profit corporation dedicated to fostering geoscience research that will enhance Nova Scotia's offshore petroleum exploration and development. OETR's members include the Nova Scotia Department of Energy, Dalhousie University and Saint Mary's University.