Energy & Geoscience Institute
AT THE UNIVERSITY OF UTAH

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Principal Investigators:

Sudeep Kanungo, Ph.D.
Research Assistant Professor
Chronostratigraphy
Email: skanungo@egi.utah.edu

Eiichi Setoyama, Ph.D.
Research Instructor
Foraminiferal Biostratigraphy
Email: esetoyama@egi.utah.edu

Dhrupad Beti, M.S.
Petroleum Geochemistry Lab Manager
Email: dbeti@egi.utah.edu

Sylvain Garel, Ph.D.
Affiliate Scientist
Email: contact@egi.utah.edu

Sponsors Receive

- *Analytics-ready Data*
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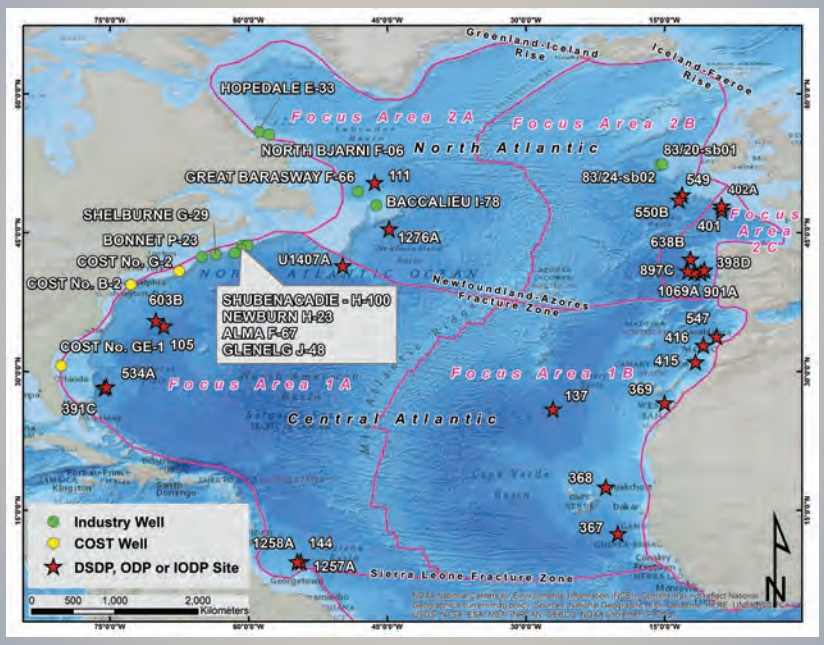
EGI Oceans: Central & North Atlantic

Evaluation of the Stratigraphy & Petroleum Systems



Sudeep Kanungo, PhD, Eiichi Setoyama, PhD
Sylvain Garel, PhD, & Dhrupad Beti, MS

I 01229

EGI Energy & Geoscience Institute

THE UNIVERSITY OF UTAH

Project I 01229

EMAIL:
ContactEGI@egi.utah.edu

PHONE: (801) 585-3826

July 7, 2021 2:48 PM

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.

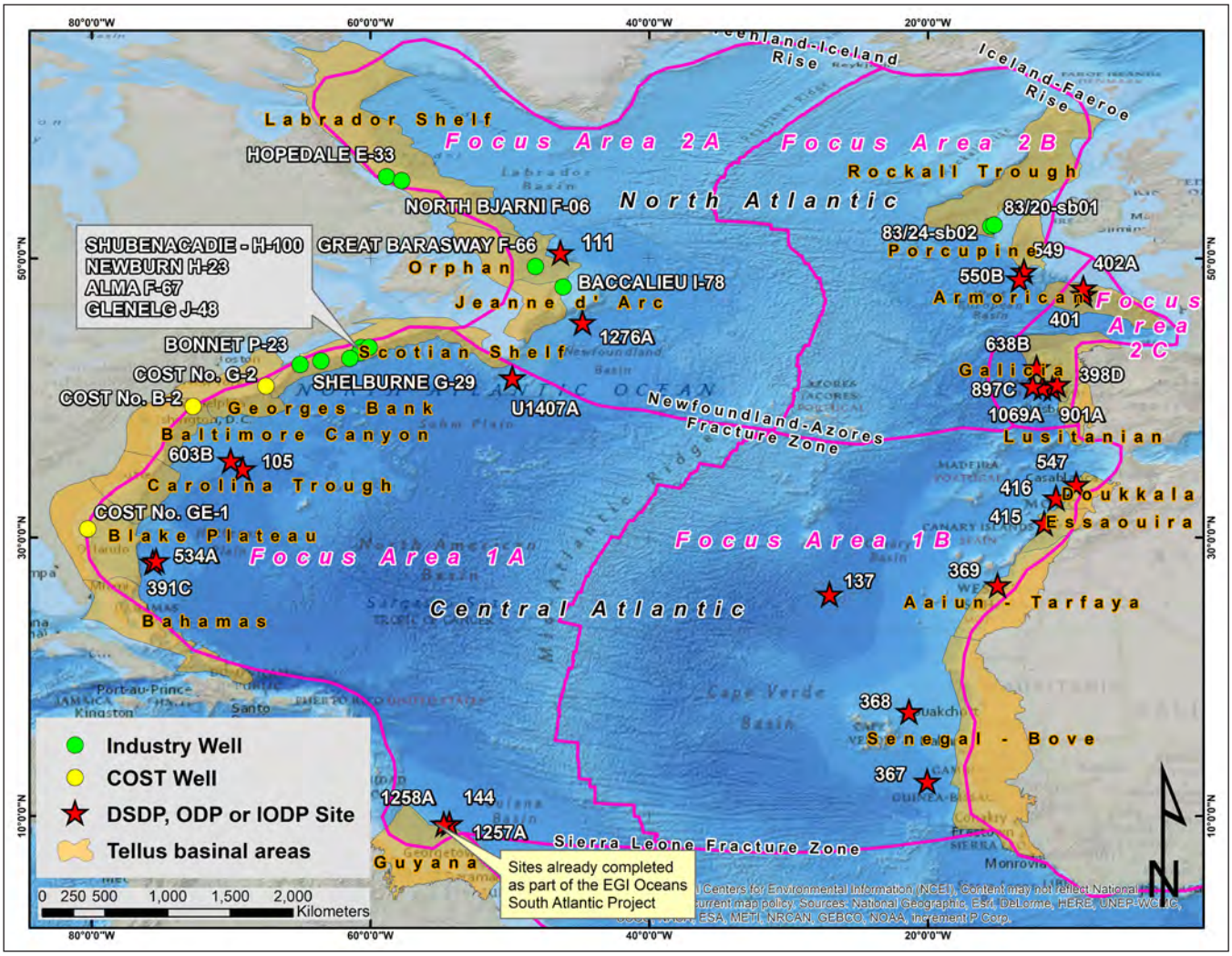


Figure 1: Map showing sectors and focus areas with the site/well locations chosen.

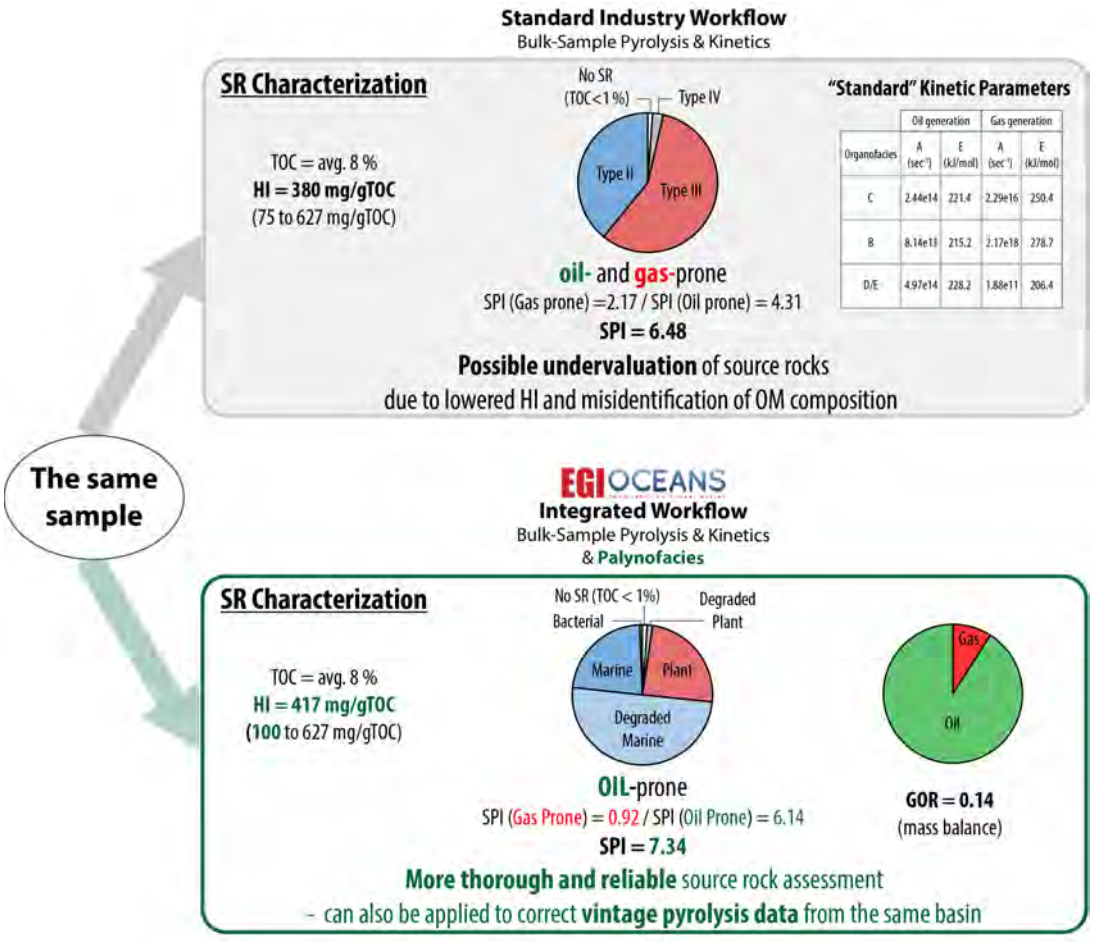


Figure 2: Palynofacies & Paleoenvironmental Flowchart

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:

Research Team

Staff	Expertise/Affiliation
Sudeep Kanungo, Ph.D.	Chronostratigraphy, Research Assistant Professor; EGI, University of Utah
Eiichi Setoyama, Ph.D.	Paleoenvironments, Research Instructor EGI, University of Utah
Sylvain Garel, Ph.D.	Palynofacies and Organic Geochemistry; EGI Affiliate Scientist, Paris, France
Dhrupad Beti, M.S.	Petroleum Geochemistry; Petroleum Geochemistry Lab Manager
Júlia Kotulová, Ph.D.	Petroleum Geochemistry, Research Scientist EGI, University of Utah
Alastair Fraser, Ph.D.	Project Advisor & EGI Chair in Petroleum Geoscience, Imperial College, London
Jonathan Bujak, Ph.D.	Bujak Research International
Supporting Research Staff (3)	ArcGIS | Research Assistant | Database Management
Graduate Students & Post Doc Staff	2

Table of Contents

List of Tables

List of Figures

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Email
skanungo@egi.utah.edu

Phone
801-585-7852

Expertise

- Integrated microfossil chronostratigraphy
- Nannofossil biostratigraphy

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.

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.

EMAIL:
ContactEGI@egi.utah.edu

PHONE: (801) 585-3826

Email
esetoyama@egi.utah.edu

Phone
801-585-9768

Research Interests

- Application of foraminifera for paleoenvironmental and paleobathymetric estimation
- High-resolution biostratigraphy

Eiichi Setoyama, PhD

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
- Integrated, multi-disciplinary biostratigraphy

Email
dbeti@egi.utah.edu

Phone
801-581-5126

Research Interests

- Petroleum Geochemistry
- Petroleum Systems Analysis
- Source Rock Pyrolysis
- Interpretation

Dhrupad Raghuveer Beti, MSc (PhD Candidate)

Petroleum Geochemistry Lab Manager

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

EMAIL:
ContactEGI@egi.utah.edu

PHONE: (801) 585-3826

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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).

Research Interests

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

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.

EMAIL:
ContactEGI@egi.utah.edu

PHONE: (801) 585-3826