

IN PROGRESS

Principal Investigators:

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

Sudeep Kanungo, Ph.D.
Research Associate
Adjunct Associate Professor
Email: skanungo@egi.utah.edu

Sylvain Garel, Ph.D.
EGI Affiliate Scientist
Email: sylvain.garel.laurin@gmail.com

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

Tony Doré, Ph.D., D.Sc., OBE
Global Chief Scientist
Senior Advisor to the Director
Email: tdore@egi.utah.edu

Investment per Sponsor
\$80k (USD)
(pending number of samples
obtained for analysis and
number of sponsors)

Duration
12 months

EGI Ref# I 01350

EMAIL:
ContactEGI@egi.utah.edu

PHONE: (801) 585-3826

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EGI Oceans - South Atlantic

Reclassification of organofacies and re-evaluation of source rock systems of selected DSDP-ODP sites using organic geochemistry and palynofacies analyses

VALUE

Determination of

- Source rock potential and their associated OM end-member distribution
- Richness and quality for each chronostratigraphically delineated South Atlantic source rock interval
- Paleoenvironmental conditions controlling the deposition of source rocks
- Spatial distribution of anoxic/dysoxic conditions and organofacies type for identified source rock intervals

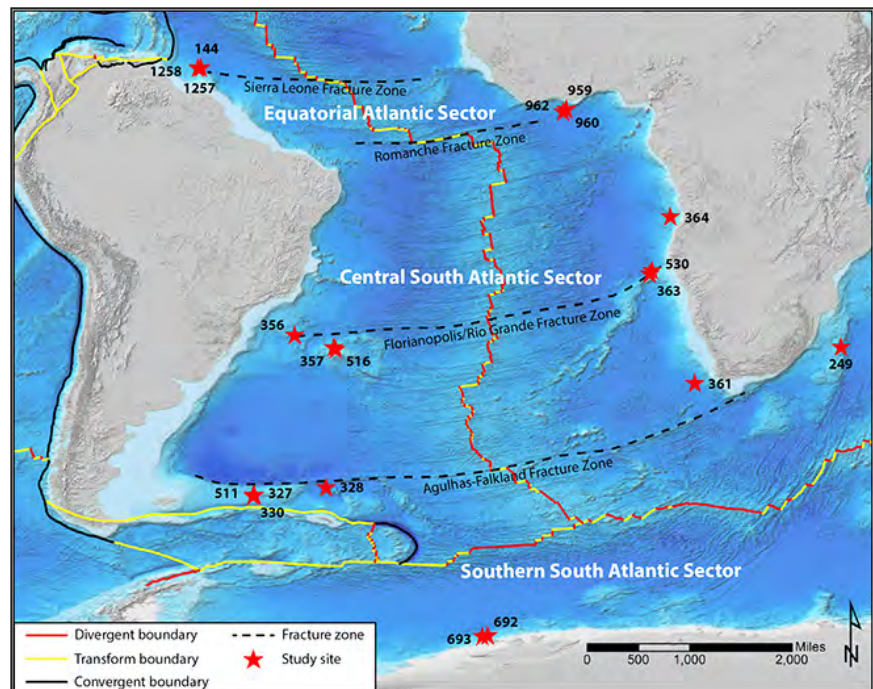


Figure 1. DSDP-ODP study sites from the EGI Oceans South Atlantic Project (2017) will be used for this project.

KEY DELIVERABLES

1. Source rock characterization for richness, maturity, organofacies type and kinetics
2. Multi-disciplinary paleoenvironmental interpretation (foraminifera, nannofossils, organic-walled microfossils and siliceous microfossils)
3. Integrated paleoenvironmental and organofacies maps for identified source rock intervals
4. Gas-Oil Ratio (GOR) and Source Potential Index (SPI) ranking maps

BACKGROUND

A focused and tested workflow from EGI's Central & North Atlantic research program supported by 10 major international oil companies, combining bulk geochemical data, new palynofacies observations, and bulk kinetic analyses, will be employed for a quantitative appraisal of the potential and quality of Mesozoic source rock systems delineated by the EGI Oceans South Atlantic Project (2017). Palynofacies observation enables unambiguous visual identification of organic matter (OM) type and composition, and the correction for the mineral matrix effect. Synthesizing the interpreted organic geochemistry and bio-chronostratigraphic data from the above mentioned Oceans project with new palynofacies analytical data will provide improved, higher-resolution constraining of the spatial and temporal evolution of potential source rocks along the South Atlantic conjugate margin than understood before (Figure 1). The OM-end-member-specific kinetics will provide reliable kinetic parameters, critical for quantitative modeling of hydrocarbon generation, for each potential source rock system, and thus refine the assessment of YTF resources in the South Atlantic (Figure 2).

Palynofacies observations allow us to visually identify the main organofacies of the potential source rocks, and resolve whether Type II/Type III samples determined by pyrolysis are actually characterized by a mixture of marine and terrestrial OM (mediocre quality, oil and gas prone) or by degraded marine OM (good quality, mostly oil prone). This detailed classification and quantification of OM end-members and the correction for the mineral matrix effect will significantly improve the source rock quality evaluation. Palynofacies observations will also help reconstruct paleoenvironment including redox conditions and detrital inputs. An effort to combine the new results using paleogeographical maps to depict the distribution of potential source rocks will facilitate understanding of its evolution through time. Proven metrics such as Gas-Oil Ratio (GOR) and Source Potential Index (SPI) will be employed to rank the basins for their source rock potential.

Efforts are underway to include a few pre-salt samples for source rock evaluation from the Brazil and Gabon conjugate margins. Pertinent authorities in both countries have been approached and negotiations are in progress.

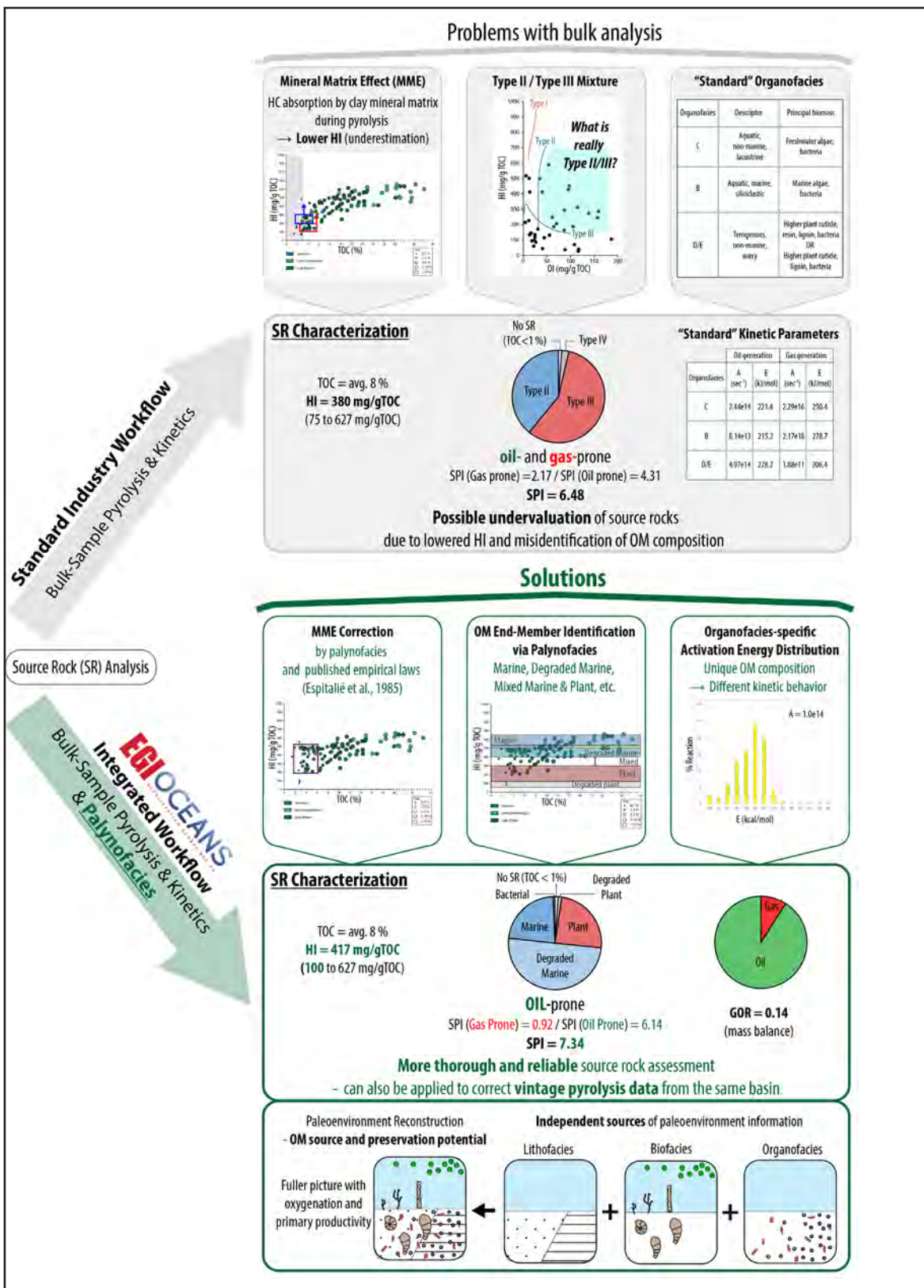


Figure 2. The comparison of source rock evaluation results from a standard industry workflow and the EGI Oceans' integrated workflow with palynofacies.

RESEARCH TEAM

| | | |
|----------------------------|---|---|
| Dr. Eiichi Setoyama | EGI Research Instructor | Paleoenvironment, Chronostratigraphy |
| Dr. Sudeep Kanungo | EGI Research Associate & Assistant Adjunct Professor | Chronostratigraphy |
| Dr. Sylvain Garel | EGI Affiliate Scientist | Organic Geochemistry, Palynofacies |
| Dhrupad R. Beti | EGI Petroleum Geochemistry Lab Manager | Organic Geochemistry, Kinetics |
| Dr. Tony Doré | Global Chief Scientists Senior Advisor to the Director | Project Advisor |

Additional EGI staff and expertise will be added as necessary.

SPONSORS



EGI TECHNICAL CONTACTS

Eiichi Setoyama, Ph.D., Research Instructor
Tel. (801) 585-9768 | Fax: (801) 585-3540 | Email: esetoyama@egi.utah.edu

Sylvain Garel, Ph.D., EGI Affiliate Scientist
Email: sylvain.garel.laurin@gmail.com

Sudeep Kanungo, Ph.D., Research Assistant Professor
Tel. (801) 585-7852 | Fax: (801) 585-3540 | Email: skanungo@egi.utah.edu

Dhrupad R. Beti, M.S., Petroleum Geochemistry Lab Manager
Tel. (404) 952-3821 | Fax: (801) 585-3540 | Email: dbeti@egi.utah.edu

Tony Doré, Ph.D., D.Sc., OBE, Chief Global Scientist, Senior Advisor to the Director
Tel. +44 (0) 777 191 8072 (London) | Email: tdore@egi.utah.edu

Raymond Levey, Ph.D., EGI Director & Research Professor – College of Engineering
Tel. (801) 585-3826 | Fax (801) 585-3540 | Email: EGIDirector@egi.utah.edu



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

esetoyama@egi.utah.edu

Phone

801-585-9768

Research Interests

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

EMAIL:

ContactEGI@egi.utah.edu

PHONE: (801) 585-3826



Sudeep Kanungo, PhD, MBA

RESEARCH ASSOCIATE & ADJUNCT ASSOCIATE PROFESSOR

Sudeep Kanungo is a nanofossil 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 Mesozoic (Cretaceous) nanofossils, and integrating them with foraminifera and palynofossils. Sudeep is the principal investigator for the EGI Oceans Research Program and received the Best Science Poster Award for the EGI Oceans South Atlantic Project at the 15th Annual Houston Geological Society Africa Conference in September 2016.

Regional Experience:

- Central and North Atlantic: Conjugate Margin
- South Atlantic: Conjugate Margin
- Equatorial Transform Margin: Côte d'Ivoire – Ghana Transform 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 nanofossils, 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 (Nanofossils). 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
skanungo@egi.utah.edu

Phone
801-585-7852

Expertise

- Integrated microfossil chronostratigraphy
- Nanofossil biostratigraphy
- Integrative source rock studies

EMAIL:
ContactEGI@egi.utah.edu

PHONE: (801) 585-3826



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

EMAIL:

ContactEGI@egi.utah.edu

PHONE: (801) 585-3826



Email
dbeti@egi.utah.edu

Phone
801-581-5126

Research Interests

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

EMAIL:
ContactEGI@egi.utah.edu

PHONE: (801) 585-3826

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



Tony Doré, OBE, DSc, PhD

GLOBAL CHIEF SCIENTIST

Senior Advisor to the Director

Recently retired from Equinor (formerly Statoil), Tony Doré obtained his PhD from University College London and joined the petroleum industry in 1977. He has held senior technical and leadership positions with Equinor (Statoil) for 20 years, including VP Exploration Americas (2002–2008) and VP North America (2008–2011), and is currently based in London.

He has worked petroleum provinces all over the world, with emphasis on NW Europe, the Arctic and the Americas. His achievements include major oil and gas discoveries in Norway, Brazil, Gulf of Mexico and Canada.

Tony has published on stratigraphy, NE Atlantic–Arctic evolution, basement reactivation, basin modelling, passive margin structure, transform margins, hyperextension, exhumed petroleum systems, and exploration risk analysis. He has edited books on basin modelling, resource quantification and passive margins.

He was Editor-in-Chief of the Journal of Petroleum Geoscience between 2006 and 2009, and chairman of the Geological Society Petroleum Group 2001–2003; chaired the 2003 Petroleum Geology of NW Europe conference and edited the subsequent proceedings (2005).

Tony serves on the advisory boards of several universities and currently holds an Honorary Professorship at Durham University.

His awards include the Petroleum Group Medal (2006), Order of the British Empire (OBE) in 2010 for services to geology, the AAPG Special Award, (2011), the William Smith Medal of the Geological Society (2015), Doctor of Science honoris causa Durham University (2016) and Lifetime Achievement Award from the Petroleum Group of the Geological Society, 2017.

Recent Publications

Doré, A.G., Lundin, E.R., Gibbons, A., Sømme, T. O & Tørudbakken, B.O. 2015. Transform margins of the Arctic: a synthesis and re-evaluation. In: Nemčok, M., Rybár, S., Sinha, S., Hermeston, S.A. & Ledvényiová, L. (eds.) *Transform Margins: Development, Controls, and Petroleum Systems*. Geological Society Special Publication. 431, 32 pp.

Lundin, E.R. & **Doré, A.G.** 2017. The Gulf of Mexico and Canada Basin: Genetic siblings on either side of North America. *GSA Today*, 27, 1, 4–11. Geological Society of America.

Lundin, E.R. & **Doré, A.G.** 2018. Non-Wilsonian break-up, pre-disposed by transforms: examples from the North Atlantic and Arctic. In: Wilson, R. W., Houseman, G. A., McCaffrey, K. J. W., Doré, A.G. & Buiter, S. J. H. (eds) *Fifty Years of the Wilson Cycle Concept in Plate Tectonics*. Geological Society, London, Special Publications, 470. Online First, 18 pp.

Sømme, T.O., **Doré, A.G.**, Lundin, E.R. & Tørudbakken, B.O. 2018. Triassic-Paleogene paleogeography of the Arctic: implications for sediment routing and basin fill. *American Association of Petroleum Geologists Bulletin* 102 (12), 2481–2517.

Email
 tdore@egi.utah.edu

Phone
 +44 (0) 777 191 8072 (London)

Research Interests

- Petroleum geology
- Regional geology, particularly of passive margins
- Hyperextended margins
- Basement reactivation
- Cratonic basins
- Petroleum systems of exhumed basins

Business Interests

- Prospect and play generation
- Commercial negotiation in the exploration domain
- Economics
- Future energy supply

EMAIL:
ContactEGI@egi.utah.edu

PHONE: (801) 585-3826