Project Portfolio

1. Source Rocks of the North & Central American Basins
2. Petroleum Systems Atlas of Mexico
3. Southern Caribbean Sediment Sources & Sinks
4. Petroleum Migration History – Colombian Foreland
5. South American Shales, Phase 2
6. EGI Oceans – S Atlantic Source Rock Reclassification
7. EGI Oceans – C & N Atlantic Petroleum Systems
8. Circum-Adriatic Petroleum Systems
9. Karoo Basin Reservoir Characterization
10. East African Basins & Petroleum Systems
11. Myanmar to Java – Basin Analysis & Petroleum Systems
12. South China Sea Petroleum Systems
13. Asia-Pacific Hybrid Unconventional Non-marine Plays
15. Sheared Margins of Western Australia, Supplement
15. Sheared Margins of Western Australia, Phase 2
16. Beyond Digital Rock Physics
17. Enhanced Oil Recovery in Shales
18. Heterogeneity of Fine-grained Reservoirs
19. Large-scale Geologic Controls on Hydraulic Stimulation

20. Production & Economic Analysis of Tight Reservoirs
21. Source Rocks of Gondwana Continents & Margins
22. Source Rocks in Space & through Time, Phase 2
23. “Strike-slip Terrains & Transform Margins”
24. Systematics of Foreland & Foredeep Basins
25. Thermal History of Transform Margins

Available to All EGI Members
A) Central Eurasia Shales
B) Central Utah-Nevada Deep Plays
C) China Shale, Phases 1 & 2
D) EGI Oceans – South Atlantic
E) Flow in Nanoporous Rocks
F) Improved Liquid Recovery in Shales
G) Liquids From Shales, Phases 1 & 2
H) More Efficient Hydraulic Fracturing Systems
I) Shale Gas Production Analysis, Phases 1 & 2
J) Sheared Margins of Western Australia, Phase 1
K) Source Rocks in Space & through Time, Phase 1
L) UK Shales

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EGI Project Portfolio Categories

In Development | For Sponsorship
Research topics in this stage range from concept to kick-off. As CA sponsors indicate interest and meet with the research team the critical goals and deliverables are developed along with the workflow and timeline. Most projects require a minimum number of sponsors and when the goal is met the research commences. New sponsors are welcome to join at any time and provide guidance for the project goals and objectives.

In Progress | Open for Sponsorship
The project is moving forward based on the input of the initial CA sponsors and research team. Regular meetings provide updates and reviews. In some cases information and interpretations are uploaded to dedicated, secure websites for easy access during the study. New sponsors may join during this research phase and help steer the project through completion.

Completed | Immediate Delivery to New Sponsors
The research study is complete and the report has been delivered to the initial sponsors. New sponsors may join and immediately receive the entire report and all connected documents. Additionally, the principal investigator will be available for an on site, full presentation, including work flow integration for the CA.

Recently Released | Available to all Members
These reports have recently been released from the two-year sponsorship period of confidentiality. All current EGI members may download these reports.

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1 Source Rocks of the North & Central American Basins

In Progress | Open for Sponsorship

Project Rationale & Significance:

North and Central Americas contain world-class petroleum provinces and have historically been prominent producers of oil and gas. USA alone is a pivotal market for oil and gas globally.

An appraisal of organic-rich and thermally mature sedimentary rocks lies at the base of the petroleum system analysis for both conventional (migrated) and unconventional (self-sourced) hydrocarbon plays. A quantitative knowledge of the distribution of source rocks in space and through time has important implications not only for the inventory of rich source-rock formations but also evaluating the geologic conditions favorable for source-rock sweet-spots and the generation of oil and gas in a basin.

The present study aims to assemble and digitize geospatial, geologic, and geochemical data on source-rock formations of various basins in North and Central Americas in a user-friendly and query searchable ArcGIS platform enhanced with geological, geophysical, and paleofacies maps.

EGI, with its 46 years of research work in various basins and regions around the world, holds an impressive archive of >850 reports plus thousands of non-EGI reports and papers. The main objective of this study is to assemble and standardize a source-rock database primarily from EGI sources supplemented by newer, public sources.

Value

- By better understanding the source rock characteristics of sedimentary basins in North & Central America based on a user-friendly database, explorationists can mitigate the risk of charge potential and hydrocarbon generation as part of the overall petroleum system.
- A quick assessment tool for conventional and unconventional play analysis based on source rocks and for assessing data-poor and/or by-passed plays based on basin-scale correlatable source rocks.

Key Deliverables

- An ArcGIS database of source rocks of North & Central American basins (USA, Canada, Mexico and Cuba and certain relevant countries) including basinal, stratigraphic, sedimentological, and geochemical attributes (e.g. TOC, Ro, kerogen type, pyrolysis, HC type, etc.) compiled from EGI's proprietary data archive, DSDP-ODP sites as well as from other technical publications.
- ArcGIS maps highlighting distribution of source rocks in space and through geologic history.
2 Petroleum Systems Atlas of Mexico

Completed | Available for Immediate Delivery

Full Title: Petroleum Systems Atlas of Mexico | An ArcGIS Folio
Investment: $50k (USD) to Sponsor the completed project
Project Completed: Q4 2017

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Project Rationale & Significance:
The ArcGIS Petroleum Systems Atlas of Mexico was commissioned by 16 EGI corporate associate member companies. The rationale for the project was driven by the amendments to Mexico's constitution in 2013 that changed the structure of the petroleum industry in Mexico, setting the stage for significant opportunities in exploration, field development, EOR and the potential for unconventional E&P. Successful ventures in each of these categories are predicated on a fundamental understanding of the petroleum systems in each basin. The project delivered the initial ArcGIS Atlas product prior to bid round one in mid-2015 providing sponsors with a GIS framework for rapid evaluation of initial and future opportunities. The ArcGIS was upgraded three additional times from the preliminary delivery in 2015 to the end of 2017 and provides the framework for evaluation of conventional petroleum systems as well as unconventional petroleum opportunities.

The ArcGIS Petroleum Systems Atlas provides a further understanding of Mexico Petroleum Systems by assembling information and data from the literature, universities, and government sources into a coherent view of the proven and speculative petroleum systems. A key source of unique information was acquired from the work of Barreada and Associates that had compiled and produced extensive basin reports for all the major basin covered in this Atlas. The project scope covered five of Mexico's producing, onshore and shallow-water basins: Sabinas, Burgos, Tampico-Misantla, Veracruz, and Sureste.

Deliverables:
- ArcGIS product with an emphasis on describing petroleum system components and analog petroleum systems.
- Data include: 2,415 source rock geochemistry data points, 60 reservoir data points, 130 oil geochemistry data points, 340 gas sample data points, and 2,665 piston core gas geochemistry data points
- Integrated Stratigraphic Chart & Petroleum Systems Event Chart for each basin
- GIS map database that includes geographic information, topography, shaded relief, satellite image, basin outline, protected areas, surface geologic map, well locations, oil and gas fields, key information from data sources, data and sample locations as well as interpretations derived from the Atlas generation
- Preliminary assessment of risk for each petroleum system
3 Southern Caribbean Sediment Sources & Sinks

**Project Rationale & Significance:**
The strategy is to develop a new and better development history of the South Caribbean region and its controlling factors. Synthesizing the new set of available analytical data on onshore sediment provenances, including low-temperature thermochronology and detrital geochronology data, with a newly developed tectonic history model will allow one to understand the spatial and temporal history of uplifts.

Developing the new analytical data for offshore sediment sinks, including low-temperature thermochronology and detrital geochronology data, and synthesizing them with a newly developed tectonic history model will allow one to understand the spatial and temporal history of depocenters. Finally, the attempt will be made to combine the results to characterize the reservoir and source rock distributions, and to develop a catalog of hydrocarbon provinces together with their controlling factors and elements controlling each petroleum system.

**Value**
The best predictive approach is the source-to-sink (sediment provenance-depocenter) reconstruction with time as controlled by the determined tectonic development. Knowing the tectonic and depositional histories, this project aims to address exploration problems that include:

- Finding evidences of thermogenic hydrocarbons in individual South Caribbean provinces,
- Determining factors controlling the thermogenic hydrocarbon systems with focus on tectonic factors,
- Developing the catalog of the individual hydrocarbon provinces of the South Caribbean, and
- Developing the catalog of individual hydrocarbon kitchens and regional hydrocarbon migration destinations inside of these provinces with main focus on thermogenic hydrocarbons.

**Deliverables**
- Folio with integrated write-up, figures, tables, maps and cross sections, organized in chapters addressing individual points listed as anticipated results
- Arc GIS project
4 Petroleum Migration History – Colombian Foreland

In Development | For Sponsorship

**Full Title:** Petroleum Migration History Models for Foreland Basins | Colombian Foreland

**Investment & Timetable:** $57k (USD) per Sponsor
Duration: 12 months

**EGI Contacts:**
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**Project Rationale & Significance:**
Foreland strata accretion into the developing thrustbelt taper and accelerated sediment transport from the emergent portion of the orogen undergoing mountain building control a relatively rapid burial of the proximal portion of the foreland basin. They are the most prominent factors affecting the expulsion timing from the organic rich strata residing under and inside the foreland basin fill.

If the contraction driving the thrustbelt and foreland basin development is orthogonal to thrustbelt and basin axes, hydrocarbon expulsion from source rocks of the same stratigraphic age is more-or-less synchronous along strike. However, the timing can quickly gain more complex character if the contraction is either oblique to the axis of linear thrustbelt-foreland basin system or fanning inside of salients and reentrants of the curved thrustbelt-foreland basin system.

**Value**
Determination of
- flexural forebulge location of the Llanos foreland basin in time.
- flexure-driven normal fault patterns of the Llanos foreland basin in time and space.
- major mountain building events of the Eastern Cordillera in time and space.
- major advance events of the Eastern Cordillera in time and space.
- expulsion timing in the hydrocarbon kitchens of all recognized oil families.
- spatial distribution of results of each individual migration pulse.
- lateral and vertical migration segments of each migration pulse.

**Key Deliverables**
- Arc GIS project including all data, profiles and maps addressing problems to be solved
- Written report with accompanying graphic documentation on the results
5 South American Shales, Phase 2

**Completed | Available for Immediate Delivery**

**Full Title:** South America Shale Gas and Shale Oil Plays | Phase 2: Data Analysis & ArcGIS Folio

**Investment:** $156k (USD) to Sponsor the completed project

**Project Completed:** Q2 2018

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**Project Rationale & Significance:**

The Phase 2 study of shale systems spans six countries, evaluates 15 additional basins, and 47 shale systems beyond the Phase 1 project EGI. This Final Report, along with the previously delivered (November 2017) ArcGIS product, represents the most comprehensive data analysis for shales in South America and provides a digital platform for all new data and analyses.

The availability of core and well data for the formations of interest generated significant in-roads for creating a statistically significant dataset to analyze South American shales in relation to their North American counterparts. The data and analyses presented in this report are derived from:

- 27,821 TOC Measurements
- 16,011 Tmax Maturity Measurements
- 2,435 XRD Measurements
- 84 1-D models

**Deliverables**

The GIS map database contains geographic information, topography, shaded relief, satellite image, basin outlines, protected areas, surface geologic map, well locations, oil and gas fields, petroleum infrastructure, key data, sample locations, interpretations and location points derived from this study.

- 100,000+ Well Locations
- 363 3-D Seismic Survey Locations
- 2,947 XRD Rock Sample Analyses
- 8 Seep Samples with Analyses
- 372 Depth vs Pyrolysis Well Profiles
- 89 Ternary Diagrams
- 40 Geochemistry Charts from Literature
- 108 Stratigraphic Charts (25 created by EGI)
- 51 Geohistory Models (32 Updated by EGI)
- 310 Georeferenced Maps
- 59,000+ 2-D Seismic Line Locations
- 3,491 Rock Samples with TOC/Pyrolysis
- 64 Oil Samples with Analyses
- 6,855 Geochemistry Data Points from Literature
- 89 XRD vs Geochemistry Crossplots
- 81 QEMSCAN® Rock Sample Images
- 68 Geochemistry Summary Parameters GIS layers
- 211 Transects (19 created by EGI)
- 29 Petroleum System Event Charts (9 updated by EGI)
6 EGI Oceans – South Atlantic Source Rock Reclassification

In Development | For Sponsorship

Full Title: 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

Investment & Timetable: $80k (USD) Pending number of samples obtained for analysis and number of sponsors

Duration: 12 months

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Project Rationale & Significance:
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-endmember-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.

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.

Deliverables

- Source rock characterization for richness, maturity, organofacies type and kinetics
- Multi-disciplinary paleoenvironmental interpretation (foraminifera, nannofossils, organic-walled microfossils and siliceous microfossils)
- Integrated paleoenvironmental and organofacies maps for identified source rock intervals
- Gas-Oil Ratio (GOR) and Source Potential Index (SPI) ranking maps
7 EGI Oceans – C & N Atlantic Petroleum Systems

Completed | Available for Immediate Delivery

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

Investment: $180k (USD) to Sponsor the completed project

Project Completed: Q3 2019

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Project Rationale & Significance:
The region has significant license rounds within the forthcoming 1–6 years. This research project is a timely opportunity to leverage critical well data and analysis in advance of evaluating new acreage in the region.

- Refined source rock evaluation workflow facilitated by hydrogen index correction for the mineral matrix effect and the visual identification of organic matter by palynofaices analysis.
- A new organic matter end-member classification for the studied basins
- Recalibrating the stratigraphy and evaluating source rock systems of the Central & North Atlantic Ocean conjugate margin.
- A carefully selected array of 41 wells (COST – Continental Offshore Stratigraphic Test plus commercial wells) and DSDP-ODP-IODP sites, recommended by EGI corporate members.
- Both in-house and affiliate scientist expertise and partnerships with 8 international institutes and governmental agencies in the evaluation of the Atlantic margins.
- COST well data already acquired by EGI through collaboration and agreement.
- Unique world class capability in high resolution chronostratigraphy via composite standards calibrated to the 2012 geologic time scale, and novel analytical techniques in petroleum geochemistry

Deliverables:
- Multi-disciplinary age and paleoenvironmental interpretation: Annotated graphic correlation charts and age-top depth relationship tables for each study well.
- Wheeler diagrams (chronostratigraphic cross-sections) illustrating the regional chronostratigraphy and distribution of biofacies.
- Source rock characterization for richness, maturity, kerogen type, and kinetics
- Source (kerogen) type integrated with depositional environment
- Anhydrous pyrolysis kinetic values for elected source intervals
- Paleoenvironment summary maps with total organic carbon, organofacies, oil-gas ratio, and source potential index for key time horizons relevant to major source rock intervals.
- ArcGIS delivery platform for results.
8 Circum-Adriatic Petroleum Systems

In Development | For Sponsorship

Full Title: Circum-Adriatic | Petroleum System Evaluation of Dinarides, Albanides, Hellenides, and Apennines

Estimated Investment & Timetable: $50k (USD) per Sponsor
Duration: 12 months

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Project Rationale & Significance:
Depending on their occurrence in respective orogens, the sediments accreted in thrustbelts of the Dinarides, Albanides, Hellenides, and Apennines reflect a complex history of evolution from the late Triassic-Early Cretaceous rifting, Middle Jurassic-Eocene failed rift or passive margin development, and Early Cretaceous-present-day passive margin and subsequent thrustbelt development, and syn-orogenic deposition in associated foredeep/foreland basin system (e.g., Dercourt et al., 2000; Roure et al., 2004; Kapnistos et al., 2007; Fantoni and Francoisi, 2010; Massini et al., 2013; Doglioni, 2015; Wrigley et al., 2015). In detail, these processes occurred during different time intervals in each thrustbelt, although the western and eastern groups of thrustbelts have somewhat similar tectonic event timing. Their development histories are reasonably known, which allows us to compare their similarities and differences, understanding their development engines and controlling factors. The next step further from this comparison is to develop predictive tools allowing one to understand the distribution of source rocks, reservoir rocks, seals, trap timing, expulsion timing, and pooled hydrocarbon preservation trends.

Value
- Determination of crustal types, architecture and plate configuration for robust thrustbelt/basin models
- Development of stratigraphic relationships for key areas for basin modeling
- Characterization of all major source rocks, reservoir rocks, seals and trap retention
- Inventory of oils, gases, and potential source rocks from the region from all available sources

Deliverables:
- Arc GIS project including all data, profiles and maps addressing problems to be solved.
- Brief explanatory text with accompanying graphic documentation on the results of the tasks focused on individual open problems.
9 Karoo Basin Reservoir Characterization

*In Development | For Sponsorship*

**Full Title:** Reservoir Characterization of the Karoo Basin, South Africa | Regional Geological & Unconventional Reservoir Evaluation

**Estimated Investment & Timetable:** $80k (USD) per Sponsor

**Duration:** 24 months

**EGI Contacts:**
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**Project Rationale & Significance:**
Recent estimates of unconventional resources in the Karoo Basin, suggest widely variable recoverable shale gas in-place from ~30 Tcf to ~500 Tcf (i.e. Decker and Marot, 2012). Potentially large gas reserves; coupled with the present energy shortfall in South Africa, has led to shale gas becoming an attractive new energy prospect, with much of the renewed exploration focus falling on the Karoo Basin shales.

**Value**
- The integration of three key technical areas to establish an unparalleled understanding of shale resources in South Africa's Karoo Basin.
- Geophysical & Petrophysical Data: integrated within the gross tectonic structural framework, taking into account the correlation of available gravity and magnetic data within the fundamental sequence stratigraphic framework of the basin.
- Organic Petrology: Evaluation of key samples using rock-Eval, TOC, and biomarkers with the integration of inorganic (petrological) analyses and regional (geophysical/petrophysical) data.

**Deliverables:**
Project deliverables are proposed to focus on the critical assessment of potential shales in key areas of the basin, using available literature, geological modeling and new analyses of samples, including:
- Comprehensive petrological analyses using the Core through Pore™ integrated analytical approach using optical microscopy, XRD, XRF, QEMSCAN®, SEM, FIB-SEM and TEM/STEM.
- Geochemical and petrological databases and charts (Excel).
- Integrated assessment of analysis with available well log and magnetic data.
- Delivered on ArcGIS platform with GIS catalog delivered in Excel format.
- Analog table containing key shale parameters and potential analogous North American reservoirs (Excel).
- Documentation from interim and final project presentations
10 East African Basins & Petroleum Systems

In Development | For Sponsorship

Full Title: East African Basins & Petroleum Systems
Investment & Timetable: $55k (USD) per Sponsor
Duration: 14 months
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Project Rationale & Significance:
The East African region from Sudan as far south as Mozambique encompasses a sedimentary record from the Late Carboniferous to Recent times. The relative distribution and preservation of these sediments were largely controlled by tectonic events as the region evolved from an inter-cratonic basin at the heart of Gondwana in the late Paleozoic through the rift-drift fragmentation of Gondwana during the Jurassic-Cretaceous to its present settings as an onshore continental rift and offshore passive margin. This project constructs a regional framework for the paleogeographic, structural and petroleum-system evolution of East Africa (onshore to deepwater).

Value:
The project results will integrate the onshore and offshore basins of East Africa, will compare and contrast the East African margin with its corresponding Gondwana margins (including India and Madagascar) in terms of petroleum systems, and will analyze the superimposition of the Cenozoic rift basins on the underlying Cretaceous sediments and the effects of East African rift tectonics on the overall sedimentary and structural evolution of the East African margin. The work will be conducted in collaboration with institutions in selected East African countries.

Deliverables:
The ArcGIS deliverables will include detailed integrated stratigraphic charts, structural cross-sections, well-controlled paleogeographic facies reconstructions (Carboniferous-Recent), play fairway maps, basin modeling, and geochemistry of oil samples.
11 Myanmar to Java – Basin Analysis & Petroleum Systems

In Development | For Sponsorship

Full Title: Basin Analysis & Petroleum Systems of Western SE Asia – Myanmar to Java

Estimated Investment & Timetable: $76.5k (USD) per Sponsor
Duration: 12 months

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Project Rationale & Significance:
The expertise and knowledge of EGI’s researchers and reports from previous studies in SE Asia and basins with similar geology, interpretation, and integrated analysis from new data combined with previous data will make this high quality research project feasible. Sponsors will benefit from a prioritized list of potential exploration targets in both unexplored/underexplored basins and basins considered mature from an exploration standpoint. For companies that are not active in SE Asia, our systematic and comparative study will help help them use the knowledge learned from SE Asia as analogs for basin evolution and petroleum systems in other basins with similar tectonic settings.

Value:
- Summary for the regional tectonics and basin evolution in western SE Asia, running North – South, from Myanmar to Java Island region.
- Comparison of the geology and petroleum systems of back-arc, fore-arc and fore-deep basins on a regional basis.
- Recommended play exploration opportunities in both frontier basins and exploration mature basins.
- Compendium with predictive models addressing the similarities and dissimilarities of petroleum systems in back-arc, fore-arc and fore-deep basins in different tectonic settings prioritized for exploration strategy or as analogs for exploration in other similar basins in the world.

Deliverables:
- ArcGIS based database including regional tectonic and depositional maps, stratigraphic charts and stratigraphic cross sections for each basin and/or sub-basins, maps of Petroleum system elements and chart, modeled burial and thermal history and hydrocarbon migration and accumulation results, play maps, potential plays, examples and models for basins in trench-slope fore-deep, fore-arc and back-arc settings.
- Interim data uploads (2 to 3) during the course of the research.
- Meeting presentations and project report (both digital and hardcopy).
- Reliable bibliographic database
Project Rationale & Significance:

Recent discoveries in Yinggehai Basin and Pearl River Mouth Basin located in the northern continental margin, Cuu Long in western SCS, and Reed Bank in southeastern SCS have spurred exploration efforts in the region. The current exploration status differs from basin to basin due to the variety of geologic settings, and a lack of regional studies to characterize the differences in those basins. The study objectives are to understand the regional tectonic and depositional evolution and petroleum systems in SCS, and predict the future exploration opportunities based on integrated study and play fairway analysis.

Value:

- An expanded understanding for the regional geology and petroleum systems including yet to find resources of the South China Sea.
- Catalog the parameters of producing reservoirs including porosity, permeability, net/gross, reservoir type, depositional facies, hydrocarbon type, trap type, and size.
- Quantify key parameters for discovered fields and a re-examination of previously failed exploration areas.
- Develop the petroleum system models across parts of SCS using Chinese and English literature, theses, dissertations, research of multi-national institutes, and our original studies.
- Assess potential and predict future hydrocarbon resources based on an integrated study including a comprehensive play fairway analysis.

Deliverables:

- Catalog of the parameters of producing reservoirs including porosity, permeability, net/gross, reservoir type, depositional facies, hydrocarbon type, trap type, and size
- Petroleum system models across different regions of the South China Sea Stratigraphic charts, structural and depositional evolution maps
- Atlas of oil/gas fields
- Potential prospects in time and space
- Petroleum system elements and play fairway maps (e.g., source rock, reservoir, caprock)
- Digital and ArcGIS based reports and PDF files.
13 Asia-Pacific Hybrid Unconventional Non-marine Plays

In Development | For Sponsorship

**Full Title:** Hybrid Unconventional Non-marine Plays in Asia-Pacific | Geology, Play Identification & Hydrocarbon Systems in China, Indonesia & Australia

**Investment & Timetable:** $175k (USD) per Sponsor for two-year project
- $89k (USD) – Due upon signing
- $86k (USD) – Start of year 2

Duration: 24 months

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**Project Rationale & Significance:**
The Asia-Pacific region ranks No. 1 in terms of remaining, technically recoverable, unconventional gas plays (shale gas, CBM, tight gas). The most prospective tight sands, coal beds and organic-rich shales were deposited in non-marine settings and are stratigraphically associated. Huge unconventional resource potentials, proven producing basins, primary unconventional production, high demand, existing infrastructure, favorable policies and high domestic gas price high-grade China, Indonesia and Australia as three countries on which to focus our research. Recent production from Jurassic lacustrine shale and associated tight carbonate reservoirs in the Sichuan Basin (southwest China) and preliminary production from Permian lacustrine shale in Cooper Basin imply the huge, untapped potential of coexisting hybrid unconventional plays in lacustrine basins.

**Value:**
- An integrated study providing an expanded understanding for basin-specific geologic, geochemical and mineralogical knowledge of non-marine strata in major producing Asia-Pacific onshore basins with producing or potential unconventional plays.
- Define basin evolution and the development of non-marine petroleum system elements including prioritized geological controls related to unconventional accumulation and production.
- Generate predictive non-marine models for play habitat of stratigraphically associated hybrid unconventional tight sand/carbonate, shale and CBM hydrocarbon systems.
- Characterization of unconventional plays via data integration, interpretation, analysis of sample tests and comparisons U.S. analog unconventional plays.
- An evaluation of unconventional non-marine play opportunities.

**Deliverables:**
- ArcGIS based database including map layers and excel spreadsheet.
- Project report with text, figures, and meeting presentations.
- Stratigraphic charts, structural and depositional evolution maps.
- Petroleum system components.
- Play fairways maps for hybrid unconventional plays.
- Reservoir characterization of representative hybrid unconventional non-marine plays.
Project Rationale & Significance:

This study is a geochemical report. It forms the initial phase of a comprehensive study of source rocks and oil fluid samples in the foreland and Papuan fold belt.

EGI had access to available open file rock samples (core, side wall core, drill cuttings) gas and oil seep samples, geophysical and geological logs, data and reports. Using these resources and published data, a comprehensive data base was created. Analytical work has been conducted at EGI's organic geochemistry lab which houses a state of the art HAWK™ pyrolysis instrument. The HAWK™ instrument offers greater precision in free hydrocarbon measurement and better repeatability than previous generation instruments and the complementary suite of instruments provides full quantification of the petroleum system elements.

Sixty (60) wells were sampled in the foreland basin and parts of the fold belt and they form the essential data base for this report, along with 28 analyses of oils and seeps

Deliverables

- Digital & Printed Report
- 1900 HAWK Analyses
- Pyrolysis & Pyrograms from 60 wells
- Analyses & interpretation from 28 oil samples
- Maps, Cross sections & Selected Well Montages
Project Rationale & Significance:
Outer frontier margins of Western Australia are characterized by stranded continental blocks and marginal plateaus. Sedimentary section is prospective in Permian, Triassic, Jurassic and Cretaceous marine sequences with potential oil source rocks and siliciclastic reservoirs. Potential traps extend over 2500 km of under-explored Western Australian margin. This study will open minds to new plays over a vast region of Australian waters.

Value
Studying the spatial and temporal distribution of fault activity, burial minima, erosional unconformities and missing strata allows one to interpret:

- which eroding structures were footwall edges and which were horsts;
- which structures did not have a top seal and for which time span;
- which positive topographic features must have been hydrocarbon migration destinations and for which time span;
- where were the main sediment entry points into the deeper basins (i.e., the main input of the reservoir-rock prone sediment);
- where were the main sediment distribution pathways in the deeper basins (i.e., the main zones of the reservoir-prone sediment); and which sediment catchment areas were separated by positive topographic features from any potential reservoir-prone sediment input (i.e., areas prone to seal and source rock deposition)

Deliverables
Arc GIS project (Arc Map v. 10.3), which contains:

- 10 horizon depth maps
- 8 sedimentary (resp. rock) thickness maps
- fault activity timing map
- 4 maps of unconformable and conformable portions of key horizons
- 6 maps of color-coded missing age span associated with erosional unconformities determined in wells
15_3 Sheared Margins of Western Australia, Phase 2

Project Rationale & Significance:
To understand thermal regimes associated with transform margins and develop large-scale thermal history models for the main West Australian transform margins in 3D and time. The understanding will be based on three-dimensional finite-element modeling done in time by a thermomechanical coupled simulation. The new thermal models will replace the existing thermal models that were developed by tools originally designed for rifted margins. Thus, the new modeling will replace the simple thermal models, which are characterized by rift and break-up related thermal peak and subsequent cooling, with realistic models that contain the effect of thermal transients developed along the transform fault systems during their oceanic/continental stage.

Value
- The identification of pull-apart regions whose source rocks reached an oil window without adequate burial, but with the help of thermal transients controlled by transform fault-associated factors,
- New thermal models to replace existing thermal models that were developed by tools originally designed for rifted margins,
- Identify the regions where the source rock kitchens may have reached the hydrocarbon expulsion stage under the burial that would not be sufficient in the case of rifted margins.

Deliverables
- ArcGIS formatted databases and full documentation,
- Map of continental crust thickness distribution, set of maps on stratigraphic gaps associated with erosional unconformities spanning from the mid-Jurassic to Turonian unconformities,
- Set of maps on fault activity timing and type distribution; maps on magmatic rock lithology and emplacement timing distribution; map of pull-apart basin distribution,
- Two 3D finite-element models of thermal history in time for the Zeewyk-Houtman and Joey Wombat transform margins, and
- 1D source rock maturation models made for several clusters of pseudo-wells targeting distinct pull-apart areas located in the regions of calculated 3D models.
16 Beyond Digital Rock Physics

In Development | For Sponsorship

Full Title: Beyond Digital Rock Physics | Printing your Rock Type (Rock on Chip) to Conduct Improved Stimulation (Lab on Chip) for Increased Hydrocarbon Recovery

Estimated Investment:
- Module 1 $60k (USD) per Sponsor
- Module 2 $45k (USD) per Sponsor

Duration: 9 months

EGI Contacts:
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- Dr. Manas Pathak | Co-Principal Investigator & EGI Affiliate Scientist

Project Rationale & Significance:

Rock on Chip (ROC) is a new technology to perform experiments to test and refine properties, new materials, and methods for enhanced recovery in conventional and unconventional reservoirs. The Rock on Chip technology goes a step beyond traditional digital rock physics. The Rock on Chip technology uses the pore or fracture geometry derived from digital rock model and fabricates it onto a custom-coated silicon chip. Testing and refining new materials and processes at the field scale are expensive, time-consuming and often in-conclusive. The Rock on Chip technology provides a rapid, small scale, conclusive method to test and refine materials and processes to experimentally and effectively stimulate reservoir for enhanced recovery through use of new surfactant, new proppants or fracturing fluid, CO2/N2 for huff & puff.

The flow through experiments are performed in the Lab on Chip (LOC) that consists of a high resolution imaging system, a highly sensitive flow controller and flow sensing system with femtoliter resolution in order to measure key properties related to transport of fluids at nano-scale. The conventional simulators that use physics based on Darcy’s law for permeability and conventional EOS for PVT properties, fail to add the complexity of pore-wall–fluids interaction in calculating transport and thermodynamic properties of hydrocarbon fluids in shales. The customized Rock on Chip that replicates the actual geology of the relevant formation provides useful insights into transport and thermodynamic properties in nanoporous rocks.

Value
- Developing new constitutive transport laws for shales by performing flow through experiments on Rock on Chip at nano-scale
- Understanding the effect of wettability by tailoring the wettability of Rock on Chip
- Understanding the effect of channel shape and dimensions on relative permeability
- Understanding the effect of confinement on PVT properties of hydrocarbon fluids

Key Deliverables (for conventional & unconventional liquid and/or gas rich reservoir rocks)
- Report on ranges of organic and inorganic porosity from digital rock model and 3D visualization of organic and inorganic facies
- Experimental measurements of relative permeabilities for multi-phase fluids in rocks of in-situ wettability
- Evaluation of recovery factor after secondary and tertiary recovery treatment of choice
- Selection of most effective fracturing fluid and proppant for a particular reservoir
- Report on bubble points of nano-confined oil
**In Development | For Sponsorship**

**Full Title:** Enhanced Oil Recovery in Shales

**Investment & Timetable:** $75k (USD) per Sponsor

Duration: 12 months

**EGI Contacts:**
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- Dr. Palash Panja | Co-Principal Investigator | Post Doctoral Research Associate Tel. (801) 585-9829 | Email: ppanja@egi.utah.edu

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**Project Rationale & Significance:**

It is recognized that oil recoveries in plays producing liquids are low (5-10%), and that new technologies are necessary to unlock the enormous amount of stranded oil. Secondary recovery in the form of waterflooding is common in conventional reservoirs. Gas injection is used to enhance recoveries in a number of cases, with carbon dioxide (CO2) being the most common injectant. Keys to the success of any injection strategy to enhance recoveries are the compositions and properties of the phases formed (phase behavior) and flow capacities (relative permeabilities) of the phases.

Previous research conducted at the Energy & Geoscience Institute has revealed interesting permeability characteristics for organic and aqueous phases. Once the suitability of injection fluid is established based on phase behavior and flow considerations, an appropriate injection-production program must be designed to understand, how, where and when to inject and produce fluids. Experimental investigation of phase behavior and flow for various injectants and computer simulations of injection/production strategies will be undertaken in this project.

**Value**

- Provide sound injection strategies for enhanced oil recovery in shales based on phase behavior and flow capacities.
- Provide optimized injection – production well configurations for field application.

**Deliverables**

- Report on suitability of using water, CO2, natural gas, ethane or propane for enhancing recovery from shales based on core flood recoveries.
- Evaluation of the effect of rock type on the choice of the injection fluid.
- Measurements of permeabilities of liquids and gases by performing flow-through experiments and relative permeabilities of selected pairs of fluids (water-oil; oil-CO2; oil-gas).
- Guidelines based on computer simulations for injection and production configurations – well locations, spacing, fracture spacing, etc.
18 Heterogeneity of Fine-grained Reservoirs

**In Development | For Sponsorship**

**Full Title:** Heterogeneity of Fine-grained Unconventional Reservoirs

**Estimated Investment & Timetable:** $68k (USD) per Sponsor

**Duration:** 24 months

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**Project Rationale & Significance:**

A new robust and practical quantitative method for heterogeneity characterization will be employed to reveal the variations of fine-grained unconventional reservoir properties in different depositional and tectonic settings using representative type plays. Lateral and vertical effects on the reservoir quality, hydrocarbon accumulation, and production will be evaluated.

This project aims to provide summative, qualitative, and quantitative models of heterogeneity for key fine-grained unconventional reservoirs and their applications to exploration and production with a multi-scale, multi-disciplinary, and integrated approach to examine the detailed sedimentological, structure, mineralogical, geochemical, petrophysical, petrological, and reservoir pressure. Large-scale and micro-scale, e.g., nano-scale characterization of reservoir properties, will be bridged systematically to summarize the unique characteristics of each facies in specific settings. Sponsors will be able to apply the concepts and methods to develop a more refined predictive capability in petroleum exploration and development of similar type of rocks in their own plays or look for new ventures of similar and different geologic settings.

**Value**

- Multi-scale conceptual models
- Thorough understanding of the relationship between geologic variables and their heterogeneity, reservoir quality, hydrocarbon accumulation and production of unconventional plays;
- Predictable models of heterogeneity for marine, transitional, and lacustrine settings in different tectonic settings in the U.S., Canada, Argentina, and China at multiple scales;
- An atlas of typical fine-grained reservoirs and interdisciplinary database.

**Deliverables**

- Statistical and artificial neural network methods, 3-D geostatistical modeling, and case studies of qualitative and quantitative characterization of reservoir heterogeneity;
- Impacts of heterogeneity of reservoir properties on reservoir quality, hydrocarbon accumulation, and production;
- Database of digital results (photos of outcrops, cores, petrology, facies, porosity, permeability, and other properties) of representative unconventional plays
Full Title: Large-scale Geologic Controls on Hydraulic Stimulation

Investment & Timetable: $50k (USD) per Sponsor (based on data*)

Project Completed: Q2 2019

EGI Contacts:
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Project Rationale & Significance:
When simulating hydraulic fracturing, the analyst has historically prescribed a single planar fracture. Originally (in the 1950s through the 1970s) this was necessitated by computational restrictions. In the latter part of the twentieth century, hydraulic fracture simulation evolved to incorporate vertical propagation controlled by Young's modulus, fluid loss, and the minimum principal stress. With improvements in software, computational capacity and recognition that in-situ discontinuities are relevant, fully three-dimensional hydraulic simulation is now becoming possible.

Advances in simulation capabilities enable coupling structural geologic data (three-dimensional representation of stresses, natural fractures, and stratigraphy) with decision making processes for stimulation – volumes, rates, fluid types, completion zones. With this interaction between simulation capabilities and geological information, low permeability formation exploitation can be extended to regions outside the currently dominant basins.

Value & Deliverables:
Currently, the ability to estimate OGIP or OOIP often exceeds the ability to stimulate and economically extract this resource. This inadequacy applies to many tight as well as ultra-low permeability formations – sands or shales. Improved simulation of hydraulic stimulation, amalgamating geologic information (particularly stresses and discontinuities) with controllable engineering parameters – could be of value. Recognizing this, the goals of this work program have been to:

- More fully enfranchise geologic regimes in the stimulation design process. A workflow has been developed (Chapter 3).
- Move the stimulation methodology planning farther upstream. A tool for inferring stresses and discontinuity characteristics during drilling is presented in Chapter 2.
- Develop diagnostic methods that realistically reflect the geologic environments of concern. These would be methods that could be used before, during, and after hydraulic stimulation. Dual porosity methods have been explored for quantifying natural fracture properties - spacing and aperture (Chapter 4).
- Assess geologic signatures that will allow more rock be exposed to recoverable stimulation fluids, to enable fracture aperture to be maintained and to do this with minimized or optimized volumes of treating fluids. This has been done by focusing on post-shut-in pressure decay during DFIT (Diagnostic Fracture Injection Testing), as outlined in Chapters 5 and 6.
Production & Economic Analysis of Tight Reservoirs

**In Development | For Sponsorship**

**Full Title:** Production and Economic Analysis of Tight Reservoirs

**Investment & Timetable:** $TBD (USD) per Sponsor

Duration: TBD months

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**Project Rationale & Significance:**

Liquid production from shales do not follow conventional wisdom due to the highly complex nature of multiphase flow in hydraulically fractured reservoirs. Developing a comprehensive understanding of the kind of impact that various geological, fluid, rock-fluid, completion, and operational parameters have on multiphase flow is essential to shale production evaluation. In addition to developing a theoretical framework, analytical and simulation tools are applied to thousands of wells in prolific liquid plays in the USA. Conclusions from this comprehensive study will help us better understand oil shale behavior and optimize production strategies.

**Value**

- Provide insight to multiphase flow behavior in hydraulically fractured reservoirs using analytical and numerical tools.
- Develop diagnosis tools to help determine the impact of reservoir rock, fluid, completion, and operational practices on liquid recovery.
- Apply acquired knowledge to increase liquid recovery through optimization of completion practices such as fracture and well spacing.

**Key Deliverables**

- Provide semi-analytical tools that capture complex multiphase flow behavior and their application to a robust production data base (over 6000 wells) from prolific liquid plays in the USA such as the Bakken, Niobrara, Eagle Ford, Woodford, and the Permian Basin.
- Apply developed knowledge as reservoir evaluation tools to:
  - Calculate fracture interference time
  - Determine fracture conductivity
  - Determine reservoir depletion
  - Forecast fluid production
  - Estimate EUR
- Identify geological, fluid, rock-fluid, completion and operational parameters and their degree of influence on production through semi-analytical and numerical multivariate analysis.
- Based on the developed theoretical framework, provide a universal fracture and well spacing optimization strategy that considers production and current economic trends such as oil prices.
21 Source Rocks of Gondwana Continents & Margins

Project Rationale & Significance:
An appraisal of organic-rich and thermally mature sedimentary rocks lies at the base of the petroleum system analysis for both conventional (migrated) and unconventional (self-sourced) hydrocarbon plays. A quantitative knowledge of the distribution of source rocks in space and through time has important implications not only for the inventory of rich source-rock formations but also evaluating the geologic conditions favorable for source-rock sweet-spots and the generation of oil and gas in a basin.

The present study aims to assemble and digitize geospatial, geologic, and geochemical data on source-rock formations of various basins on Gondwana continents and margins in a user-friendly and query searchable ArcGIS platform enhanced with geological, geophysical and paleofacies maps.

EGI, with its 46 years of research work in various basins and regions around the world, holds an impressive archive of >850 reports plus thousands of non-EGI reports and papers. In addition, EGI Geochem Lab has over the decades analyzed rock and oil samples from several regions such as South America, Caspian Sea, etc. The main objective of this study is to assemble and standardize a source-rock database primarily from EGI sources supplemented by newer, public sources.

Value
- By better understanding the source rock characteristics of regional and local basins based on a user-friendly database, explorationists can mitigate the risk of charge potential and hydrocarbon generation as part of the overall petroleum system.
- A quick assessment tool for conventional and unconventional play analysis based on source rocks and for assessing data-poor frontier and/or by-passed plays based on regionally correlatable source rocks.

Key Deliverables
- ArcGIS database of source rocks across Gondwana's Continents and Margins (South America, African, Arabian Peninsula, India and Australia) including basinal, stratigraphic, sedimentological, and geochemical attributes (e.g. TOC, Ro, kerogen type, pyrolysis, HC type, etc.) compiled from EGI's proprietary data archive, DSDP-ODP sites as well as from other technical publications.
- ArcGIS maps highlighting distribution of source rocks in space and through geologic history.
22 Source Rocks in Space & through Time, Phase 2

*In Progress | Open for Sponsorship*

**Full Title:** Source Rocks in Space & through Time | Phase 2: North & Central America and Eurasian Basins

**Investment & Timetable:** $87k (USD) per Sponsor
Duration: 24 months

**EGI Contacts:**
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**Project Rationale & Significance:**
An appraisal of sedimentary rocks, which are mature both in terms of their organic carbon content and thermal history, lie at the base of the petroleum system analysis and exploration. While the early history of petroleum exploration was characterized by identifying structural targets, the modern exploration workflow incorporates source rock risk factor as an immediate priority. A quantitative knowledge of the distribution of source rocks in space and through time has important implications not only for the global budget of hydrocarbon resources but also for evaluating the geologic conditions favorable for the generation of oil and gas on a basinal scale.

**Value**
- By better understanding the source rock horizons and characteristics of sedimentary basins equipped with a user-friendly database, explorationists can reduce the risk of charge factor and hydrocarbon generation as part of the overall petroleum system analysis.
- A quick assessment tool for analysis of conventional as well as unconventional (self-sourced reservoir) plays based on source rock data and for assessing data-poor frontier and/or by-passed plays based on regionally correlatable source rocks.

**Key Deliverables**
- An ArcGIS database of source rocks in North & Central America and Eurasian basins (Central America, USA, Canada, Europe, Caucasus-Caspian region, Central Asia, Russia, China, and Southeast Asia) including basin tectonic, stratigraphy, lithology, depositional facies, and geochemical (TOC, Ro, RockEval, kerogen type, etc.) assembled and digitized from EGI’s proprietary data archive, DSDP-ODP-IODP sites as well as from other technical publications.
- ArcGIS geodatabase of source rocks in wells and outcrops and ArcGIS map layers depicting the distribution of source rocks in space and through the geologic history.
**23 “Strike-slip Terrains & Transform Margins”**

**In Progress | Open for Sponsorship**

**Full Title:** “Strike-slip Terrains & Transform Margins” – Structural Architecture, Thermal Regimes, and Petroleum Systems,

Authors: Michal Nemčok, Anthony G. Doré, Helen Doran & Andreas Henk

**Investment & Timetable:** $10k (USD) per Sponsor

Duration: 18–24 months

**EGI Contacts:**

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**Project Rationale & Significance:**

A combination of academic research and successful exploration on both South American and African sides of the Equatorial Atlantic and along the Coromandal segment of the Eastern Indian margin provides us with growing evidence about numerous key differences between extensional and transform margins. The proposed project, drawing encouragement from recent discoveries at transform margin segments, will explore those differences, define the factors which cause them, and define their role in order to develop hydrocarbon exploration models for transform margins.

We are requesting sponsorship to prepare and deliver a systematic manual on exploration in strike-slip and transform margin regions and improve the understanding of their petroleum systems. The anticipated results are highly relevant to future successful exploration, to development of the new generation of exploration geologists, and to internal oil company training programs.

The strategy is to merge results of the current literature and own research, and turn them into a 500-page book titled “Strike-slip Terrains and Transform Margins—Structural Architecture, Thermal Regimes and Petroleum Systems” published by Cambridge University Press. Our target is to deliver a comprehensive manual on exploration in these two settings by mid to late 2019.

**Deliverables:**

- Block 1. Structural architecture, basin development and fluid flow in strike-slip terrains and transform margins
- Block 2. Thermal regime in strike-slip terrains and transform margins
- Block 3. Petroleum systems in strike-slip terrains and transform margins

Additionally, each chapter will be converted into a PowerPoint slide show. The entire collection of slide shows will represent a comprehensive short course that can be used as internal training tool for sponsoring companies interested in the exploration of strike-slip and transform margin settings for new venture and exploration teams.
24 Systematics of Foreland & Foredeep Basins

In Development | For Sponsorship

Full Title: Systematics of Exploration in Foreland and Foredeep Basins
A Joint EGI-Industry Project with application to the controlling factors of petroleum systems in different types of foreland and foredeep basins

Investment & Timetable: $70k (USD) per Sponsor
Duration: 12 months

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Project Rationale & Significance:
The strategy is to develop a new and better appreciation of factors controlling the structural development of the aforementioned three different foreland/foredeep basin settings (Module 1). Using the structural development as a foundation, a better appreciation of uplift/exhumation and sedimentation models in the aforementioned three different foreland/foredeep basin settings will be developed (Module 2). Both modules 1 and 2 feed into the development of play concept elements characterizing the three foreland/foredeep basin settings and their controlling factors.

Value
- Determination of factors controlling dynamic and kinematic histories of the aforementioned three different foreland/foredeep basin settings
- Determination of factors controlling the development of specific structural architecture characterizing each of the three different foreland/foredeep basin settings
- Determination of factors controlling spatial and temporal distribution of uplift and exhumation of the evolving accretionary wedge on one side and the evolving topography of the overridden plate on the other side for all three foreland/foredeep basin settings
- Determination of factors controlling the sediment transport and distribution systems of all three foreland/foredeep basin settings
- Determination of factors controlling the sediment accumulation in all three foreland/foredeep basin settings
- Determination of play concept elements characterizing all three foreland/foredeep basin settings
- Determination of their main controlling factors
- Determination of petroleum systems characteristic for all three foreland/foredeep basin settings.

Deliverables
- Folio with integrated write-up, figures, tables, maps and cross sections, organized in chapters addressing individual points listed as anticipated results
- Arc GIS format documentation of case studies
25 Thermal History of Transform Margins

*In Progress | Open for Sponsorship*

**Full Title:** Thermal History of Transform Margins | Evaluation with application to reservoir rock distribution and source rock distribution and thermal history, with an emphasis on Equatorial Atlantic and Western Australia

**Investment & Timetable:** $65k (USD) per Sponsor
Duration: 12 months

**EGI Contacts:**
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**Project Rationale & Significance:**

The strategy is to develop a new and better appreciation of the factors controlling structural architecture and basin development in transform margin settings (Module 1). Synthesis of this knowledge with that gained by earlier studies (Nemčok et al., 2004, 2012a, 2016) will then be used to tackle the mechanisms and factors controlling depositional systems of transform margin settings (Module 2). Both modules 1 and 2 feed into (a) the development of the thermal models characterizing different transform margins, also affected by lower crustal flow, (b) the development of the reservoir rock distribution models, and (c) the development of source rock maturation history models typical for transform margins.

The main motivation for this study is to understand the thermal history of transform margins and spatial and temporal distribution of regions with a ductile lower crust. Such understanding would provide the foundation for studies trying to address the spatial distribution of source and reservoir rocks, and the maturation histories of all candidate source rocks. In order to develop this foundation, we use a numerical modeling approach to study both the thermal and lower crustal flow histories at transform margins, in particular the temporal and spatial distribution of the ductile lower crust in relation to the migrating heat source represented by the traveling ridge and its sandwiching zones of oceanic crust.

**Value**

- Determination of thermal histories of different transform margins
- Determination of how the rapid local pull-apart thinning influences such thermal history
- Determination of mechanisms and factors controlling the source rock maturation history with an attempt to develop a predictive tool

**Deliverables**

Arc GIS project (Arc Map v. 10.3), which contains:

- Folio with integrated write-up, figures, tables, maps and cross sections, organized in chapters addressing individual points listed as anticipated results
- Arc GIS format documentation of case studies
Recently Released | Available to all Members

These following project reports have recently been released from the two-year period of sponsorship confidentiality. All current EGI members may download these reports at EGIconnect.com. When the GIS product is larger than 5GB the data will be delivered via a secure transfer site.

EXCLUSIVE ACCESS TO EGI MEMBERS

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(Note: EGIconnect supports Internet Explorer 10+, Google Chrome, Mozilla Firefox & Safari)
A) Central Eurasia Shales

**Completed | Recently Released & Available to all Members**

**Full Title:** Central Eurasia Potential of Shale Liquids and Gas  
**Project Completed:** Q4 2015

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**Project Rationale & Significance:**  
Modern concepts of shale stratigraphy indicate highly variable depositional conditions that lead to heterogeneous grain size, composition, and variable organic matter preservation. This project collected a significant number of new samples representing 10 initially identified basins eventually narrowed to four key basins (West Siberia, Timan Pechora, Volga Urals and Dniepr Donets) for in-depth evaluation.

**Value:**
- Evaluated more than 1000 new and existing analytical samples (comprising organic geochemistry, mineralogy and petrology);
- Evaluated fourteen (14) 1D calibrated geohistorical and petroleum system models;
- Evaluated seven (7) interpreted regional seismic surfaces;
- Created a number of new databases from data gathered from the public domain for each basin;
- Translation of key scientific literature;
- Interpretation of new analytical results;
- Comprehensive summaries for each of the four key basins;
- Comparison of key parameters of shale liquid and gas rich resources from the four studied basins with those from some of the most successful USA shale plays;
- Strategic advantage in the evaluation of major shale systems in Central Eurasia

**Deliverables:**
- Digital Arc GIS product with detailed database of measured properties and attributes and final report
- Summary of each of the 10 initially identified basins and comprehensive description, summary, analysis, and conclusions for the four basins selected for further detailed study;
- Sample passports hyperlinked to individual point feature classes in ArcGIS including comprehensive instant information about organic matter, mineralogy, and petrology;
- Unified ArcGIS library representing collected data and new analyses
B) Central Utah-Nevada Deep Plays

**Full Title:** Central Utah-Nevada Deep Plays | ArcGIS Maps & Database, Shale & Oil Analysis, and Basin Evolution

**Project Completed:** Q1 2016

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- Dr. Greg Nash | Research Associate Professor | Principal Investigator
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**Project Rationale & Significance:**

The Central Utah-Nevada region covers a large part of the Great Basin bounded by the Rockies/Colorado Plateau on the east and the Sierra Nevada Mountains on the west. The region includes the Lower Paleozoic shelf of the North American continent which has been affected by a series of tectonic collisions (fold-and-thrust belts) from Late Paleozoic through Eocene times, and upon which the Neogene Basin-and-Range extensional basins were superimposed. The Paleozoic-Mesozoic plays of the region offer important frontier exploration targets both for conventional and unconventional oil and gas resources.

**Value:**

- Providing insight into the hydrocarbon potential of both conventional and unconventional shale plays of the highly faulted Paleozoic section across Central Utah-Nevada, explorationists can more quickly focus on those areas of highest potential.
- Characterizing known source rocks and correlating them to oils produced from the few existing fields and natural seeps, explorationists will have a better understanding of the Petroleum System(s) yet to be discovered within this complex tectonic regime.
- Exploration risk and cost can be reduced by having a better understanding of the depositional facies of key shale intervals and their present day structural orientation.

**Deliverables:**

- An ArcGIS Knowledge-database: Integrating geological, geochemical and geophysical data.
- Geochemical analysis and description of shale horizons to characterize the source rock potential from deep wells (including geothermal wells) as well as outcrop samples.
- Geochemical analysis of oil samples from fields and seeps to better understand and identify the oil family and oil-source rock correlation.
- Paleofacies maps of the Paleozoic sediments beneath the Great Basin of Central Utah-Nevada.
- Three (3) East-West regional transects depicting plausible shale plays.
- A detailed faults-fractures map highlighting the (a) tectonic genesis, orientation and relative population of lineaments and fractures and (b) basement-cover relationships using both satellite images and field observations.
- A bibliographic geoscience database for the region.
C) China Shale, Phases 1 & 2

Completed | Recently Released & Available to all Members

Full Title: China Shale Gas and Shale Oil Plays | Phase 2: Integrated Shale Reservoir Characterization in Primary Basins

Project Completed: Q2 2015

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Project Rationale & Significance:
Enhance the geologic understanding of the most promising marine and lacustrine shales from four primary basins/regions (Sichuan (key marine gas-producing basin), Yangtze Platform outside Sichuan (area of interest and bidding blocks), Ordos (key lacustrine oil and transitional gas-producing basin), and Bohai Bay (key lacustrine oil-producing basin) by acquiring new samples and expanding the tests performed on the new and existing samples. Laboratory evaluation of marine and lacustrine shales using traditional assessment tools and new testing tools, procedures, and measurements to characterize geochemistry, mineralogy, petrophysical properties, gas and/or oil content and brittle response/“fracability” of Chinese shales, especially for the lacustrine shales.

Value:
- Catalog characteristics from seismic reflections, well logs, image logs, mineralogy, and geomechanical properties (where possible) for typical, recently drilled shale wells.
- Correlate geologic properties and geomechanical measurements; e.g., relationships between mineralogy, rock fabric, storage capacity, and geomechanical parameters.
- Conduct representative hydraulic fracturing simulations/fracture propagation forecasts for representative marine and lacustrine shales. Interrelate these with geological characteristics. The goal is to attempt to establish differences between vertical and aerial fracture growth behavior and fracture potential/morphology (natural and induced) for various marine and lacustrine shales.
- Develop relationships (between similar and dissimilar shales) employing the database that has/is being developed to aid in evaluation and inference of various shale properties.
- Provide detailed quantitative and qualitative comparisons between properties of U.S. producing marine shales and China’s most promising marine and lacustrine shales to understand the merits and potential downsides.
- Expand the database by including new core and outcrop sample testing and revise interpretations that will guide the appraisal and exploitation of Chinese shales.

Deliverables:
- Digital ArcGIS product with detailed database of measured properties and attributes.
- Presentations from project review meetings.
- Final report delivered in print and electronic formats.
Full Title: EGI Oceans | South Atlantic Regional Assessment of Deepwater Petroleum Systems: Re-evaluation & New Sample Analyses of Key DSDP-ODP Study Sites

Project Completed: Q3 2017

EGI Contacts:
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Project Rationale & Significance:
Investigations from the southern South Atlantic DSDP-ODP sites that were drilled in the 70’s, are indicating large-magnitude shifts in the revision of their age models, especially in the Lower Cretaceous and Upper Jurassic sections.

Over 200 samples were analyzed from 20 study sites in the South Atlantic to augment the regional synthesis results. The composite standard methodology of absolute age calibration via the graphic correlation technique was employed for the new sample analyses.

Samples collected were analyzed using standard methodologies to assess kerogen richness, quality, kinetics, and prepared for molecular chemistry evaluation.

Deliverables

- Improved age re-synthesis: Based on interpretations via new sample acquisition and analysis, the age-depth interpretations have been updated comprehensively improving the resolution of the age models, including some large shifts, especially in the Falkland sector.
- Paleoenvironmental interpretations from new data improved the existing interpretations, and paleofacies maps were generated for selected source rock related time intervals, e.g., Tithonian, early Aptian, mid-to late Albian.
- Chronostratigraphic cross-sections: Improved chronostratigraphic cross-sections illustrate the regional chronostratigraphy and distribution of biofacies.
- Source rock characterization for richness, maturity, kerogen type, and kinetics.
- Geochemical logs: Posted depth standardized data for geochemical log for age-depth interpretation of results.
- Anhydrous pyrolysis kinetic values for elected source intervals.

For advanced Source Rock Reclassification see: 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 (EGI Ref# I01350)
E) Flow in Nanoporous Rocks

Full Title: Flow in Nanoporous Rocks | Measurement of Relative Permeabilities in Synthetic Nanoporous Materials & Shale Samples

Project Completed: Q1 2017

EGI Contacts:
Dr. Milind Deo | Principal Investigator | Chair & Professor, Department of Chemical Engineering, University of Utah,
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Project Rationale & Significance:
In our previous work, we have shown that matrix permeability is one of the most important properties that govern recoveries of liquids from shales. With that background, the importance of measuring absolute, let alone relative permeability, mandated serious consideration of measurements being currently used. EGI has developed equipment and procedures for measuring saturation pressures, and absolute and relative permeabilities. In this project, we created a relative permeability database for different shale samples with relevant fluid pairs, acknowledging the difficulties an operator would encounter in measuring relative permeability on a routine basis. These measurements might be considered as being close to ground truth at least at a core scale. This project was aimed at measuring properties systematically in shales samples, and in calibrated (lab-created) mesoporous materials (porous materials with nanometer sized pores).

The GRI method of measuring permeability in shales consists of crushing the rock, exposing this to pressure and measuring pressure decay. Our findings for liquid permeabilities measured using flow-through experiments are very different from GRI (crushed rock method) measurements and brings into question GRI permeabilities. This project addressed different measurements to see the effects of core pre-treatment on flow-through liquid permeabilities. Selected cores were scanned, thin sections were studied, and SEM images were obtained. The data showed enormous mineral complexity, micro fractures filled with anhydrite, and a number of other features. Liquid permeabilities may be fluid dependent. This will have significant implications on how numbers are entered in reservoir simulation.

Outcome & Deliverables:
- Detailed characterization of shale samples from various plays including Bakken, Niobrara, and the Permian Basin.
- Porosity measurements using multiple measurement methods and correlation of the porosity with characterization at the nanoscale.
- Permeability measurements using pressure-pulse and flow-through measurements and comparisons.
- Water-oil and gas-oil relative permeability measurements.
F) Improved Liquid Recovery in Shales

Completed | Recently Released & Available to all Members

**Full Title:** Improved Liquid Recovery in Shales | Optimization for Field Development

**Investment:** $50k (USD) to Sponsor the completed project

**Project Completed:** Q4 2016

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**Project Rationale & Significance:**
It is evident that liquid recoveries, even under reasonably ideal conditions are only on the order of 10%. Improving these recoveries is extremely important for economic sustainability of producing liquids from shales. Our research in Phase 1 and 2 of Liquids from Shales (EGI reports I 00973) also showed that developing a comprehensive understanding of underlying processes and optimization requires integration of robust geological modeling, hydraulic fracturing representation, and accurate simulation of the stimulated reservoir volume.

This next generation of research is designed to develop tools for optimizing recovery of fluids in shales and identify improved recovery processes. Project tasks will be focused toward understanding creation, characterization and effect of stimulated reservoir volumes on improved liquid recoveries in unconventional reservoirs. Research will also be performed on understanding the overall logistics of development – hydraulic fracture spacing, well spacing, gas and water injection possibilities, for secondary recovery.

**Project Outcomes & Deliverables:**
- Optimized Hydraulic Fracturing Parameters – pump rates, water volumes, proppant sizing and loads, number of perforation clusters, spacing, sequencing, etc.
- Effect of different fracture geometries and morphologies on liquids production – including the effect on GOR
- Well development plans – evaluation of water production rates and volumes and optimization of well spacing
- Economically optimum production conditions for shales producing gases and liquids for given geologic conditions and with the best possible representation of hydraulic fracture patterns and the stimulated reservoir volume
- Best practices and guidelines for improved recovery options including infill drilling, pressure maintenance and injection of fluids
G) Liquids From Shales, Phases 1 & 2

**Completed | Recently Released & Available to all Members**

**Full Title:** Liquids from Shales | Phase 2: Reservoir Description & Dynamics

**Project Completed:** Q1 2014

**EGI Contacts:**
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**Project Rationale & Significance:**

The production of liquids from shales has revolutionized the oil industry. In this second phase of research, we continued in our comprehensive quest at understanding all of the components that contribute to optimum exploitation of shales for liquids. These included geologic considerations, geomechanical modeling, reservoir engineering evaluations, and environmental aspects. We have learned and documented that geologic characterization at various scales is important in establishing producibility and optimum recovery.

Sections 2–5 of the report focus on geologic evaluations. Detailed geologic characterizations of the Niobrara are discussed to establish the role of geology on production, the results have identified the property with the strongest correlation to production. An examination of pore-level characterization and a detailed workflow of shale characterization at the pore scale fill out the geology sections.

Sections 6–11 deal with various engineering operations. The material balance methodology utilized production data and fluids characterization. The method developed makes it possible to obtain pressure profiles and saturation information, and to estimate reservoir permeability prior to interference with another hydraulic fracture. The development of this method for all types of reservoir fluids, and associated data analysis technique, were significant achievements in this project. This analytical tool for matrix permeability determination is available to all sponsors.

**Deliverables:**

- Determination of key geologic parameters that contribute to liquid production and methods for the development of quantitative geologic models with relevance to flow in liquid shale plays
- Development of multiphase flow pressure-variability in oil and condensate recoveries
- Relationships for variability in recovery, etc., with respect to all of the important parameters in a multivariate system. Development of selected response surfaces and surrogate models
- Study of the variability in the morphology of the hydraulic fractures in shales with changes in mechanical properties and/or mineralogy
- New reservoir engineering analysis tools in the form of modules or spreadsheets
- A workflow to simulate a combination of hydraulic and natural fractures. This work will be developed further and continued in Improved Recovery of Liquids from Shales
H) More Efficient Hydraulic Fracturing Systems

Full Title: More Efficient Hydraulic Fracturing Systems for Ultra-tight Shale Reservoirs

Project Completed: Q1 2016

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Project Rationale & Significance:

Commercial exploitation of low mobility gas reservoirs has been improved by multi-stage hydraulic fracturing of long horizontal wells. Favorable exploitation has been correlated with large fracture surface area in contact with the shale matrix – this surface area being created by high rate and high volume injection of low viscosity water-based fluids. The environmental and economic implications of using large volumes of water (millions of gallons per well) are attracting considerable stakeholder and regulatory attention.

Our previous investigation of shale gas production has suggested that:

- The primary (propped) fractures are the main channels for gas production.
- The secondary (unpropped) fracture network contributes little towards gas production. It remains as a primary depository of the fracturing fluid, but this is of little benefit. Since most of the fracturing fluid enters the secondary fracture network (from which it is probably imbibed into the shale matrix), it is perhaps not surprising that only 20 to 30% of the treatment fluid is returned during well clean-up and early production.
- Large scale slickwater fracturing is very inefficient: the volume of the productive fractures represents only a small percentage of the volume of the fluid pumped.

We now propose a new project that will develop an alternate perspective on the impact of controllable fracturing parameters on the productivity of shale reservoirs. These can include pump rate and pressure and fluid type and viscosity, for example. The investigation will use semi-analytical and numerical techniques to model fracture development, and include specifically the role played by the natural fractures and pressure-sensitive leakoff from the main fractures. The proposed methodology is similar in principle to that adopted in our earlier investigation of shale gas production characteristics. Using analytic techniques wherever possible, we seek a middle path between empirical correlations on the one hand and large-scale numerical simulations on the other.

We envisage three levels of modeling:

- An isolated, individual secondary fracture opening from a main primary hydraulic fracture
- Primary fracture development, including pressure-sensitive leakoff, to an array of secondary fractures
- Primary fracture development incorporating a continuous pressure-sensitive leakoff coefficient

In each of these hierarchical steps in the model development there is interplay between the fluid mechanics of flow in the primary and secondary fractures and the stress field that opposes primary and secondary fracture opening.

Our objective is to identify more efficient fracturing fluids and fracturing protocols that would use a smaller volume of fracturing fluid to achieve a greater productive fracture surface area.
I) Shale Gas Production Analysis, Phases 1 & 2

Project Rationale & Significance:

As we outlined at the start of Phase 1, the key to the identification of prospective shale gas plays and to the development of enhanced exploration, production and stimulation technology is an understanding of the production mechanisms. In turn, this depends on the availability of a model of the production process that represents the physical aspects of the reservoir and the completion and provides a satisfactory match with available production data.

In Phase 1 we developed a rigorous, semi-analytic, physics-based model of gas production from tight shales that recognized the distinguishing features of these reservoirs and allowed us to identify the major production drivers. The new model allows us to analyze production data from many wells as quickly as conventional decline curve analysis, but has the advantage of being rooted in the physics of the process. Consequently, it provides a predictive and interpretive capability that is lacking in empirical models or, for that matter, large scale reservoir simulators.

Deliverables – Phase 2:

Phase 2 used the semi-analytic production model from Phase 1 and the understanding gained from it to:

- Better characterize shale gas production through various stages of the production process including early-time transient (influenced by variable drawdown), linear flow and boundary-dominated flow. This involved the development of an improved asymptotic model and an improved (and unique) method of data interpretation, leading to better forecasts of EUR, particularly with limited production data. Industry interpretation of the restricted choke technique was critically assessed.

- Improve understanding and application of decline rates and decline curve analysis; this includes a critical assessment of industry perceptions in the use of decline rate and decline curve analysis.

- Provide an estimate of stimulated reservoir volume and productive reservoir volume. We developed a method of identifying well-to-well interference and assessing its impact on well productivity. We provide guidelines as to appropriate well-to-well spacing.

- Develop a preliminary interpretation of oil production rate from shales by adapting the semi-analytic techniques developed for shale gas production.
J) Sheared Margins of Western Australia, Phase 1

Completed | Recently Released & Available to all Members

Full Title: Sheared Margins of Western Australia | Initial Phase of the Australia and New Zealand Margins Initiative

Project Completed: Q4 2015

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Project Rationale & Significance:
This project refined the existing general timing of break-up of large margin segments with detailed break-up propagation timing, associated different vertical movement histories of different margin segments, and addressed associated thermal histories of individual margin segments.

Value

- A refined timing of break-up for large margin segments with detailed break-up propagation timing, associated distinct vertical movement histories of different margin segments, and a better understanding of the associated depositional histories of individual margin segments.
- Identified exact locations of extensional and sheared margin segments along the Western Australian margins and determined their exact break-up propagation with time, associated uplift histories, magmatism and depositional histories;
- Ascertained their role in the petroleum system to facilitate development of hydrocarbon exploration models.

Deliverables:

- ArcGIS formatted databases and full documentation.
- A folio with integrated write-ups, figures, tables, maps, and cross sections in print and electronic formats
- Structural architecture maps with indication of break-up trajectory advance with time along both extensional and sheared margin segments extending from the Browse Basin (Scott Plateau) in the North to the Perth Basin (Naturaliste Plateau) in the South
- Magmatic product distribution maps; exhumation histories of all involved margin segments with indication of sedimentary response to exhuming areas
- Map of sediment entry points and five pseudowells with expulsion timing covering all involved margin segments
K) Source Rocks in Space & through Time, Phase 1

Completed | Recently Released & Available to all Members

Full Title: Source Rocks in Space & through Time | EGI ArcGIS Database, Distribution Analysis, & Paleogeography | Phase 1: Gondwana Continents & Margins

Project Completed: Q1 2017

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Project Rationale & Significance:
Sedimentary rocks, which are mature both in terms of their organic carbon content and thermal history, lie at the base of the petroleum system analysis. A quantitative knowledge of the distribution of source rocks in space and through time has important implications not only for the global budget of hydrocarbon resources but also for evaluating the geologic conditions favorable for the generation of oil and gas on a basinal scale. An enormous body of data on source rocks by new analytical techniques and from various basins around the world has been collected in recent decades. EGI, with its four decades of research work in various basins and regions of the world, holds an archive of thousands of reports and documents, which can constitute a valuable database on global source rocks. This research work is also timely in view of the recent trends in the industry to drill directly into source-rock targets. The project is to be conducted as an industry-funded research consortium. Given the wide scale, expectations and implications of the project, active participation of experts from the sponsoring companies in the project work is greatly encouraged.

Value

- By better understanding the source rock characteristics of regional and local basins based on a user-friendly database, explorationists can mitigate the risk of charge potential and hydrocarbon generation as part of the overall petroleum system.
- A quick assessment tool for conventional and unconventional play analysis based on source rocks and for assessing data-poor frontier and/or by-passed plays based on regionally correlatable source rocks.

Deliverables

- An ArcGIS database of source rocks across Gondwana’s Continents and Margins (South America, African, Arabian Peninsula, India and Australia) including basinal, stratigraphic, sedimentological, and geochemical attributes (e.g. TOC, Ro, Kerogen type, rock eval, etc.) compiled from EGI’s proprietary data archive, DSDP-ODP sites as well as from other scientific publications.
- ArcGIS maps highlighting distribution of source rocks in space and through geologic history.
L) UK Shales

Completed | Recently Released & Available to all Members

Full Title: UK Shale Gas
Project Completed: Q1 2016
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Project Rationale & Significance:
The EGI/Imperial joint UK Shale Gas project has been designed to build on the depth of UK geological knowledge residing at Imperial College and the skills and techniques in shale oil and gas evaluation developed and employed by EGI Scientists at the University of Utah. With the impending UK onshore 14th licence round it was felt that an independent (from government) assessment of the UK Shale Gas resource potential be undertaken. Phase 1 of the project was specifically targeted at the Carboniferous shales of northern England and the Jurassic shales of southern England that had previously been identified as the source of conventional petroleum fields in the onshore UK.

An extensive geological sampling program was undertaken at the BGS Core Store facilities in Keyworth in Nottinghamshire. The samples were sent to EGI in Salt Lake City for geochemical and petrological/mineralogical analyses using state of the art pyrolysis and petrological investigation techniques. The results of this analysis were combined with an extensive literature and 2D seismic based mapping to derive maps of ‘Sweet spot’ locations for Shale oil and gas potential in the UK. The database has been captured using the ArcGIS software platform.

The new geochemical and mineralogical data has provided critical information regarding the potential for shale oil and gas resources in the UK. Previous understanding of these Jurassic and Carboniferous shales has been reviewed and revised models for their distribution and effectiveness have been presented. The resource estimates provided by the BGS & DECC in advance of the 14th UK Onshore Licence Round have been compared with the results of this study that has concluded that some significant revisions in resource estimates may be required.

Deliverables:
Over 200 samples were collected from the BGS Core Store in Keyworth Nottinghamshire, England. The majority of the samples were 5 cm diameter core chips collected at half-meter intervals through key zones of interest. In the absence of core material selected cuttings were sampled for completeness.

- ArcGIS project of wells, seismic and maps from previous onshore UK conventional studies
- 2D seismic from UKOGL database
- Analysis of organic rich shales of the Carboniferous & Jurassic
  » Presence, Richness, Maturity, Burial & uplift history, Documentation