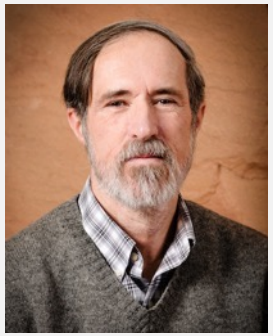
EGI Energy & Geoscience Institute
AT THE UNIVERSITY OF UTAH
Since 1972

Energy Fluids & Minerals

Rasoul Sorkhabi, Eiichi Setoyama, Christopher Kesler, Thomas Cook, Bryony Richards, Rohit Ramgire, and Palash Panja

Energy Fluids & Minerals Group

Milind Deo, PhD
Director
Prof. Chem Eng.



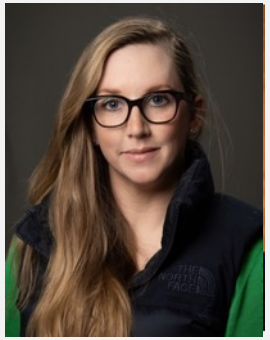
(Pitch) Allen, PhD
Research Professor

John McLennan, PhD
Professor

Tony Doré, PhD
Advisor

Rasoul Sorkhabi, PhD
Research Professor

Eiichi Setoyama, PhD
Biostratigraphy/
Source Rocks

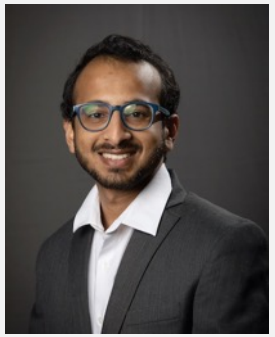


Bryony Richards, PhD
Research Scientist

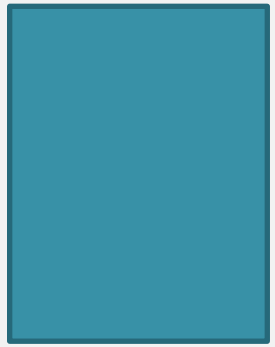
Palash Panja, PhD
Chemical Engineer

Thomas Cook
Software Engineer

Chris Kesler
GIS and Data



Rohit Ramgire
Data scientist



Sedimentology
Sequence/Seismic
Stratigraphy

THE UNIVERSITY OF UTAH **EGI**

Dr. Milind Deo
EGI Director & Professor Chemical Engineering

Energy & Geoscience Institute

Energy Fluids & Minerals

Carbon Capture & Sequestration

Geothermal Energy

Energy Systems Efficiency Grid

collaborations

Chemical Engineering
Civil & Env. Engineering
Materials Sci & Eng.
Geology & Geophysics

DEEPWATER

SHALE

Energy Fluids & Minerals

GAS
HC, H_2

CRITICAL MINERALS

Outline of Presentations

8:30 – 8:35	Introduction to EGI Energy Fluids & Minerals
8:35 – 8:55	EGICONNECT: Online Global Database for EGI Corporate Associates / Christopher Kesler
8:55 – 9:15	iCORDS Offshore: Cloud-based Data Analytics / Thomas Cook
9:15 – 9:35	Natural Hydrogen / Eiichi Setoyama
Break	
9:45 – 10:05	Critical Minerals / Bobby Mohanty
10:05 – 10:25	Hyperspectral Imaging & Critical Minerals / Bryony Richards
10:25 – 10:45	Petroleum Exploration Studies / Rasoul Sorkhabi
10:50 – 11:50	Panel Discussion: Petroleum Industry Leadership in Energy Transition Tony Dore, Sid Jones, John Baza, Bill Gould , Kristie McLin, Sidney Green
11:50 – 12:00	Service Award Presentation to John Baza / Alan Walker

EGI CA Program

https://egi.utah.edu/

EGI Corporate Associates (CA) Benefits Package
Annual subscription: $55k

- EGIConnect: Access to Online Global Database
- Research Consortia & New Research Studies: Cost-shared and discounts for CAs
- Peer Assist with EGI Scientists (one week free)
- Training Courses (one week)
- Analytical and Lab Services. Discounts for CAs
- Monthly Technical Webinars
- EGI Annual Technical Conference
- 50% Discount on iCORDS Offshore Database

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EGI CONNECT
ONLINE GLOBAL DATABASE

Online Global Database for Corporate Associates

Christopher Kesler, Eiichi Setoyama & Rasoul Sorkhabi

EGICONNECT: Online Global Database

Value: > $850 million of research available for a fraction of the cost

- > 900 Completed EGI Reports
- > 18,000 Technical Documents
- > 4,000 Well Logs
- > 350,000 km 2D Seismic Data

+ maps, theses, and more

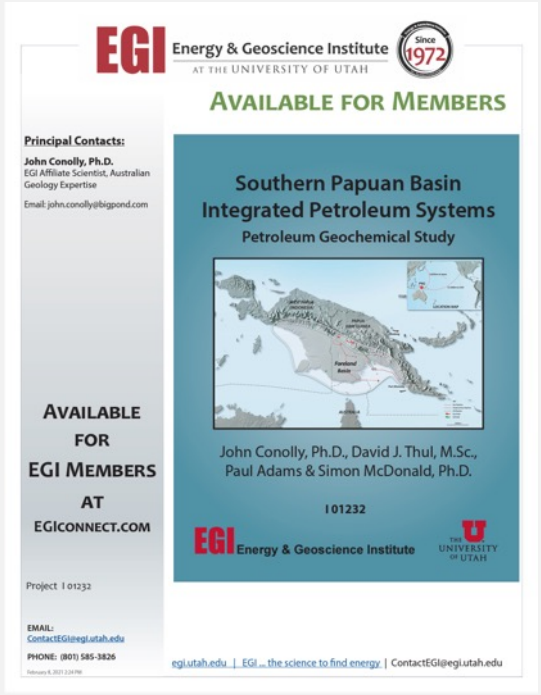
Access **knowledge** and **data**
only available through EGICONNECT

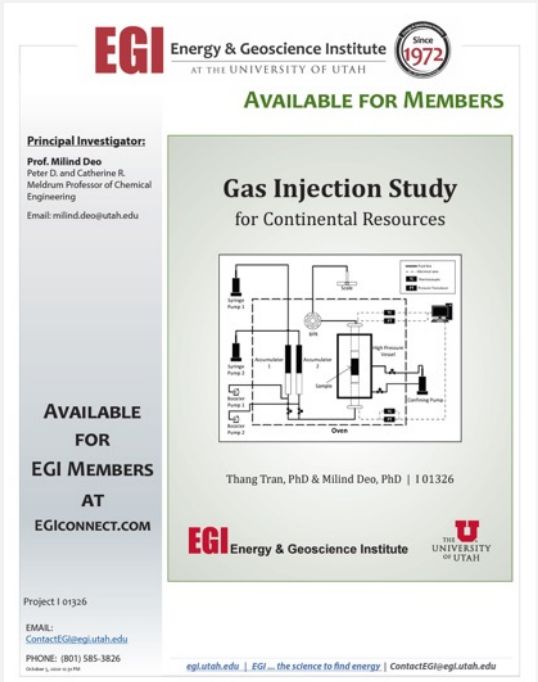
EGI CONNECT
ONLINE GLOBAL DATABASE

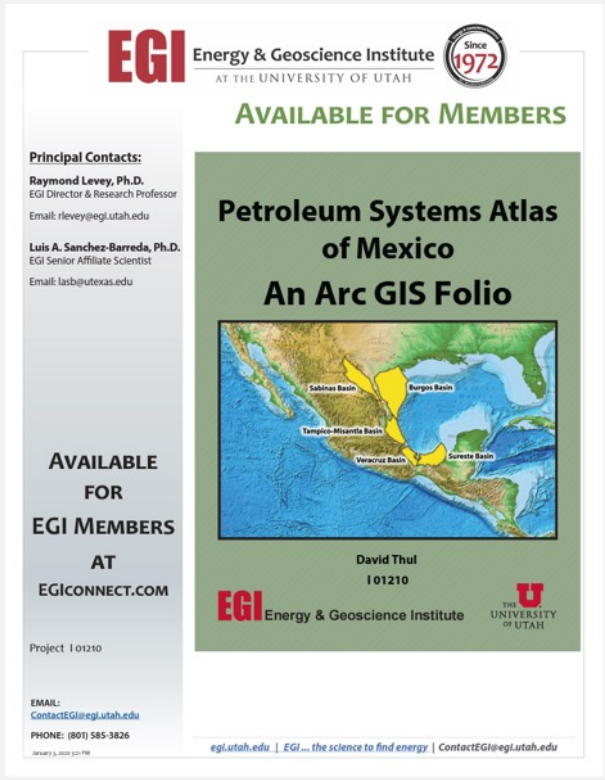
EGICONNECT: Online Global Database

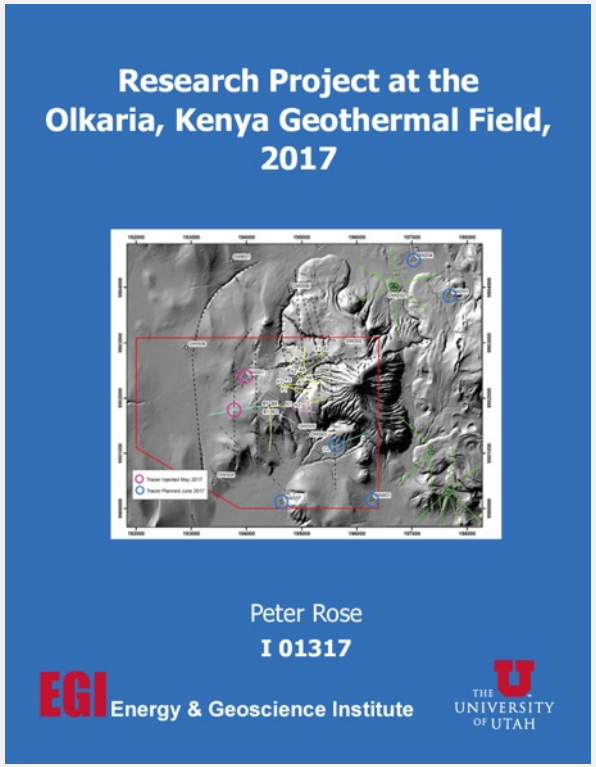
40 New Reports added to EGICONNECT since early 2020

Oil & Gas,
Geothermal,
Tracer Technology









Available to EGI CA members

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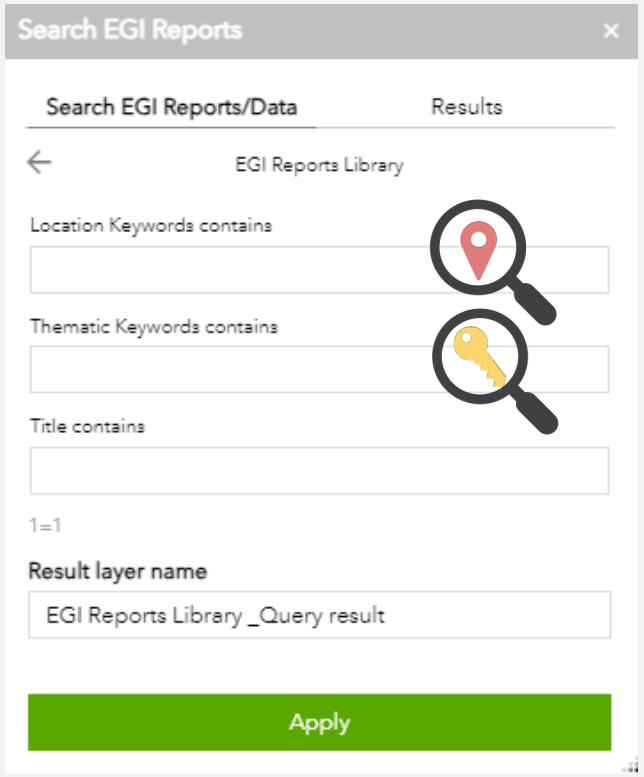
Revamping EGICONNECT

To improve the findability, accessibility, interoperability, and reusability of data on EGI CONNECT ONLINE GLOBAL DATABASE

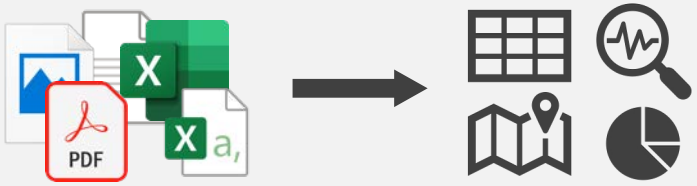
Milestone 1 (in progress)

- Update location keywords
  - ☑ EGI reports
  - ☑ Thesis
- Add new thematic and method keywords
  - ■ EGI reports
  - □ Thesis
- Inventory analytical results
  - ■ EGI reports
  - □ Thesis



Milestone 2

Extract and integrate data



We will prioritize and **digitize maps, tables, and graphs** in reports up on request from EGI CA members

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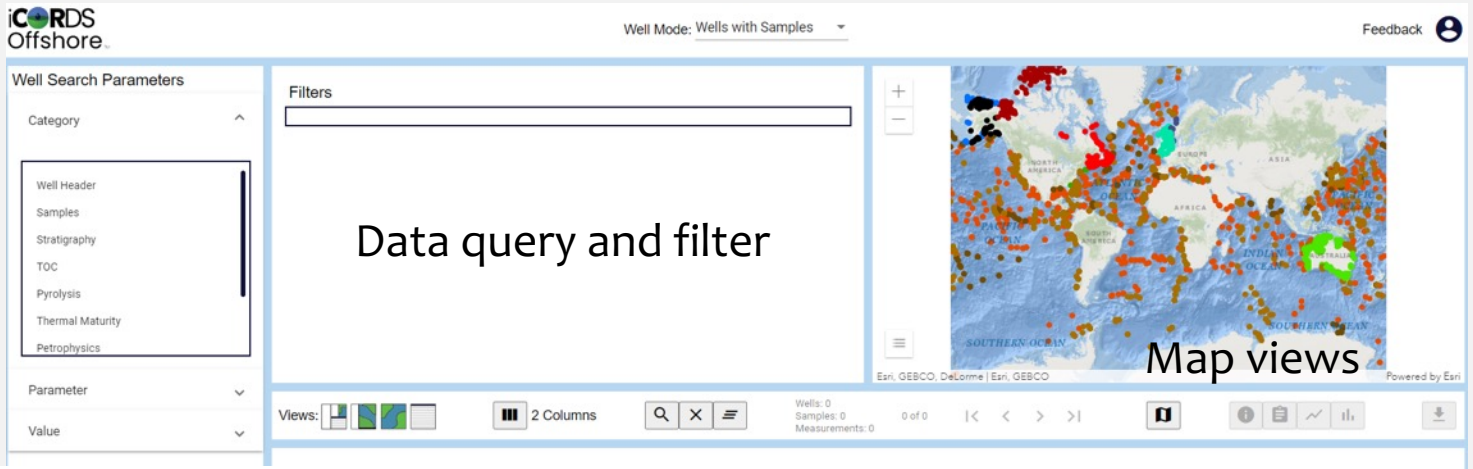
iCORDS™

iCORDS Offshore (Integrated Continent-Ocean Database)

Thomas Cook, Rasoul Sorkhabi & Eiichi Setoyama

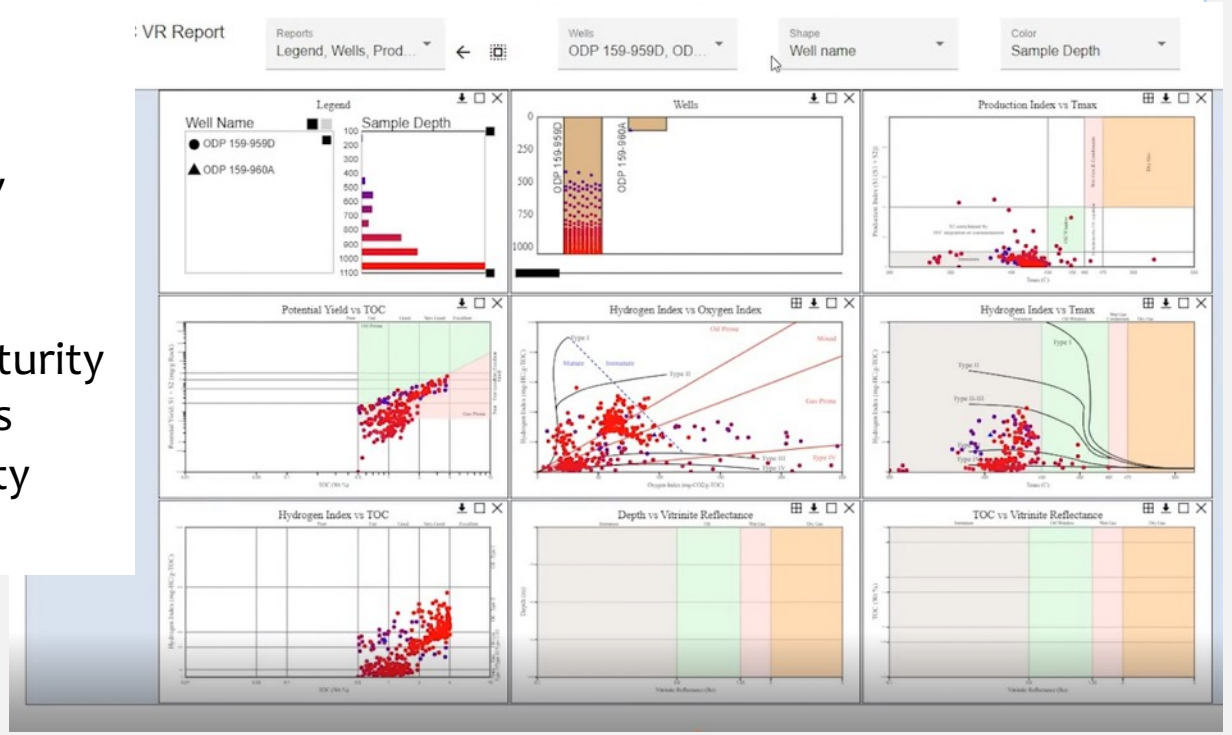


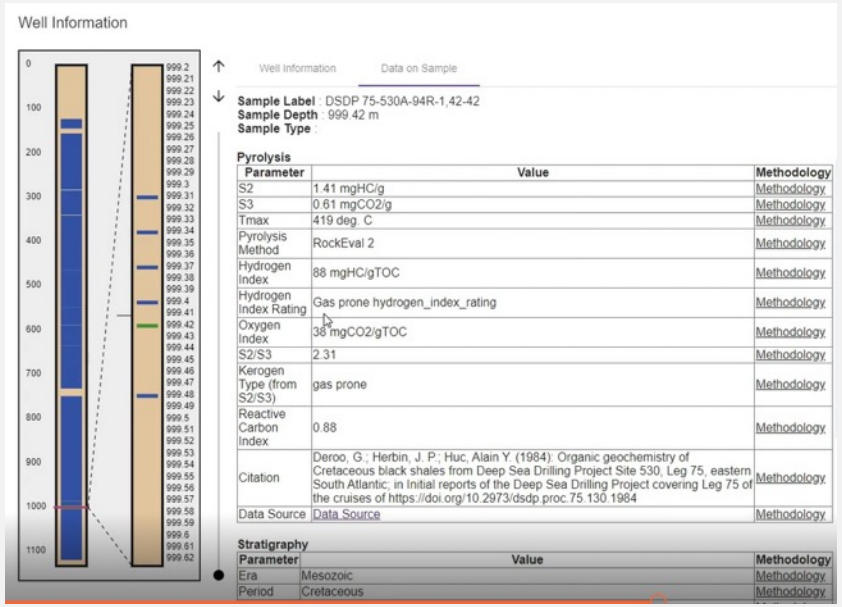
Databank and Data Analytics ~14 million data points thousands of wells

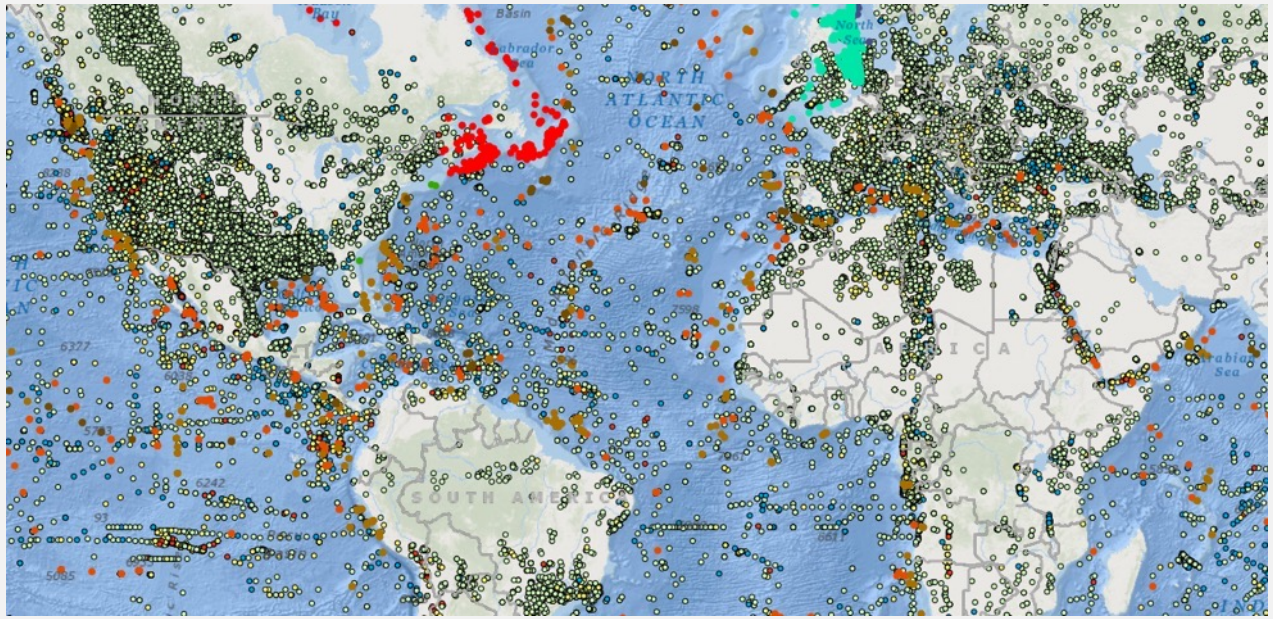
Data Categories:

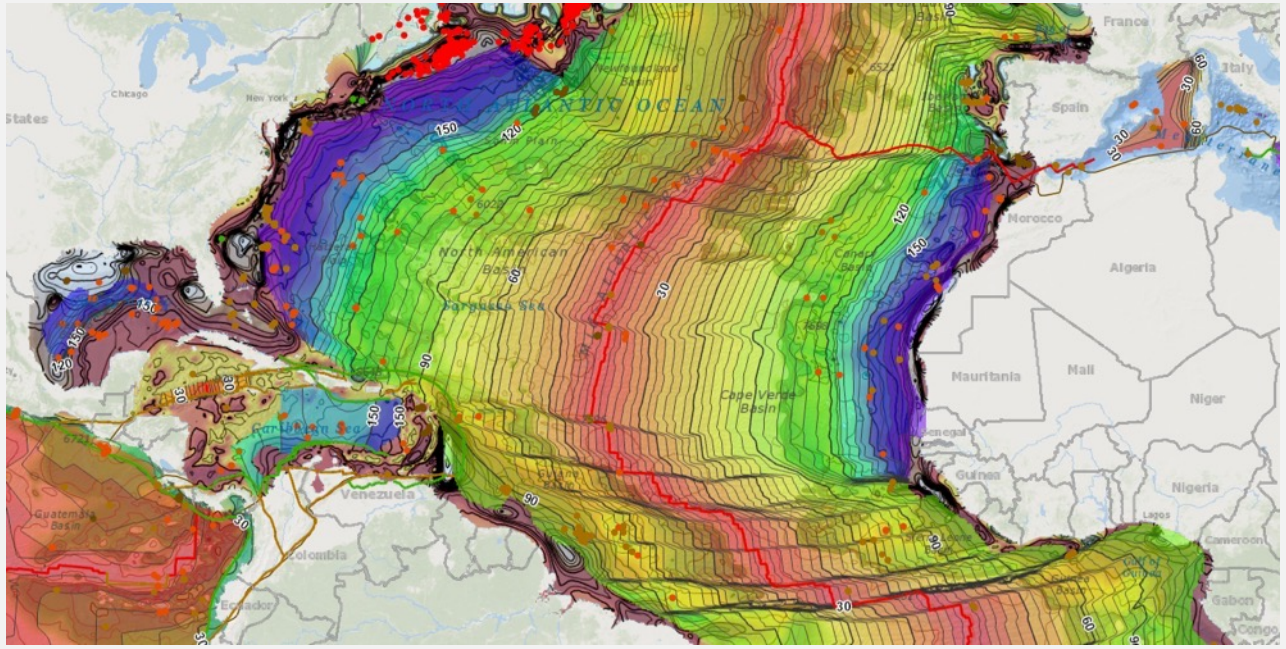
- Well header
- Sample Info
- Stratigraphy
- TOC
- Pyrolysis
- Thermal Maturity
- Petrophysics
- Sonic velocity
- Gas Analysis

Data table display and export

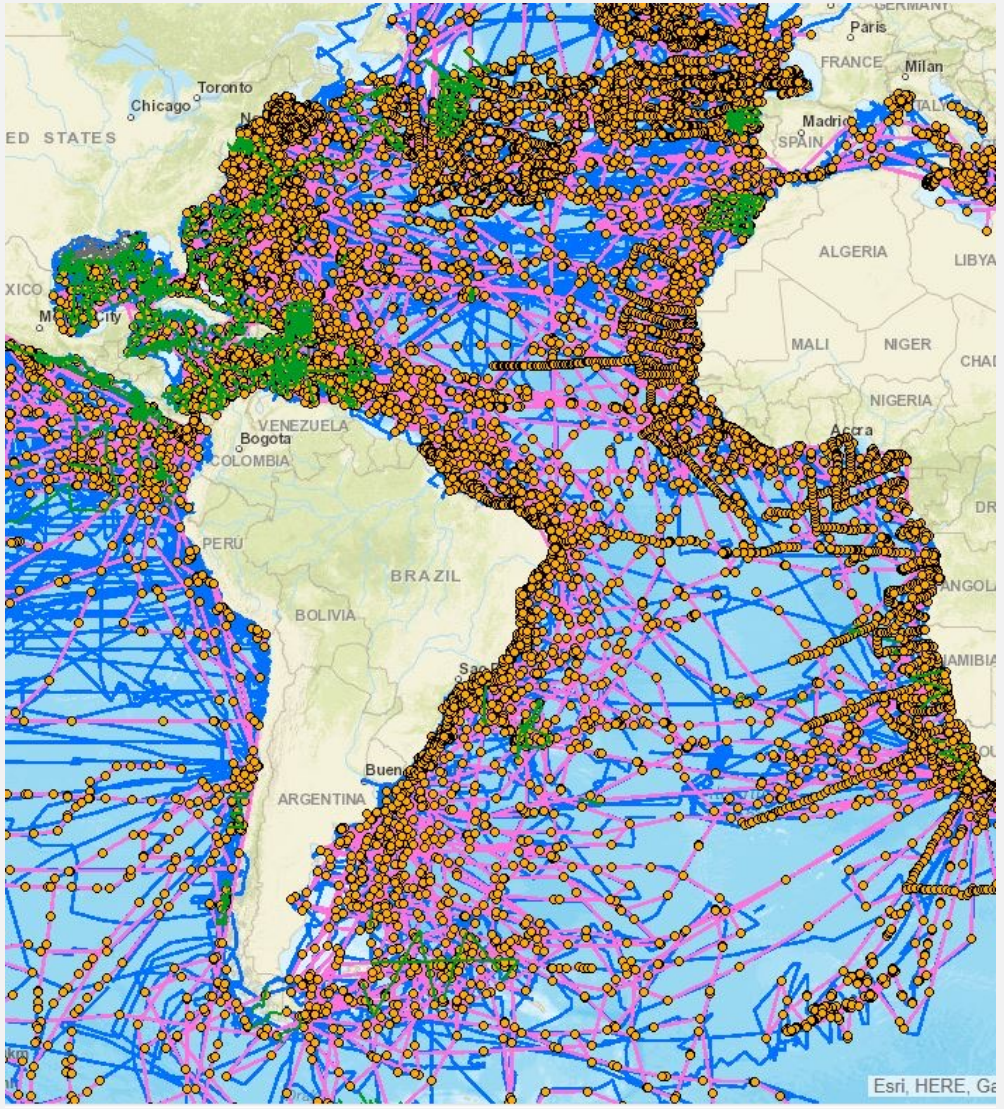


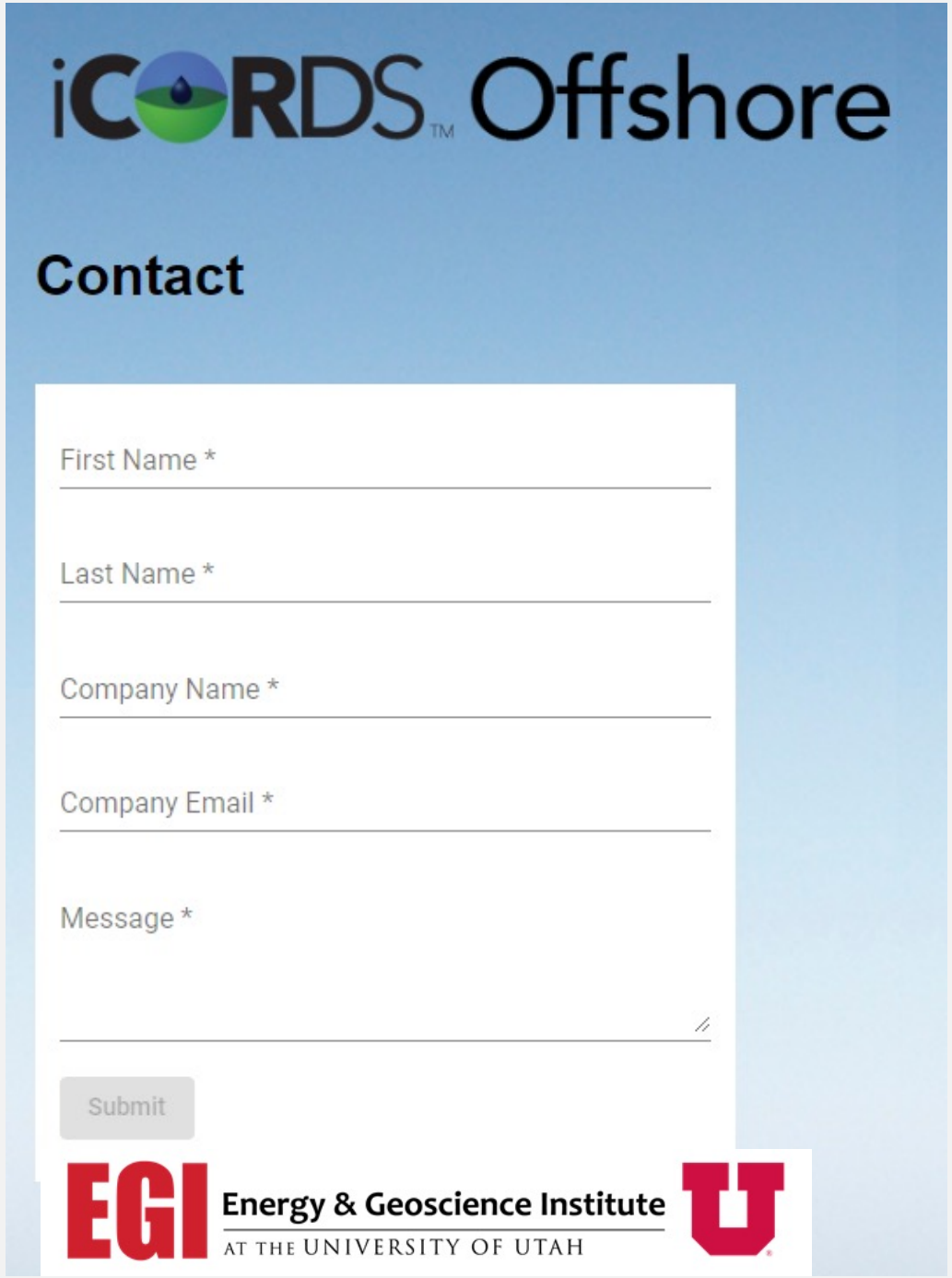






5 million km Seismic data
60,000 heat flow data
+ supportive geologic maps





https://icordsgeo.org

- *Google Cloud-based data service*
- *Direct web access &*
- *Analytics ready tools*
- *Annual subscription to our clients*

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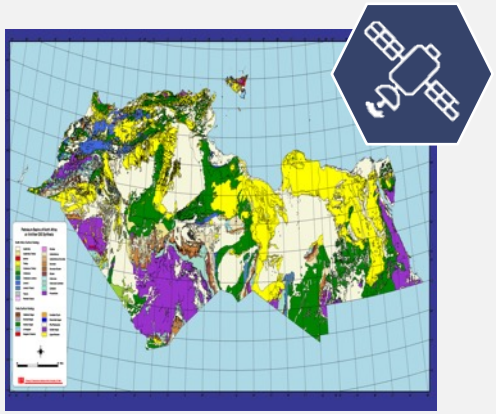
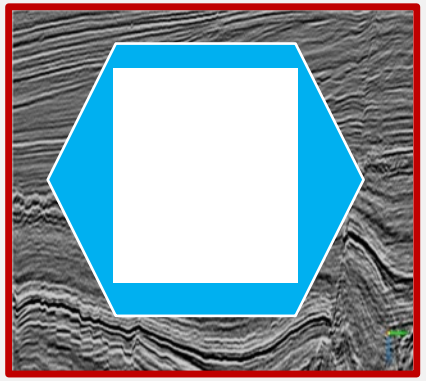
Petroleum Exploration Studies

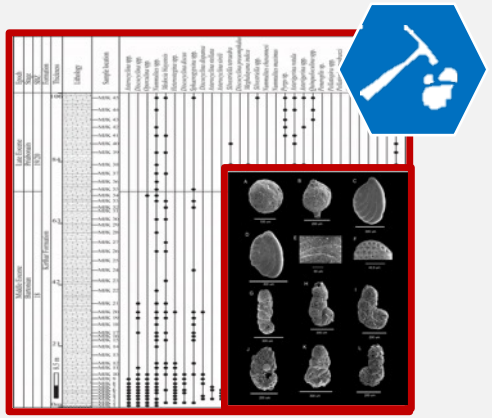
Expert Domains



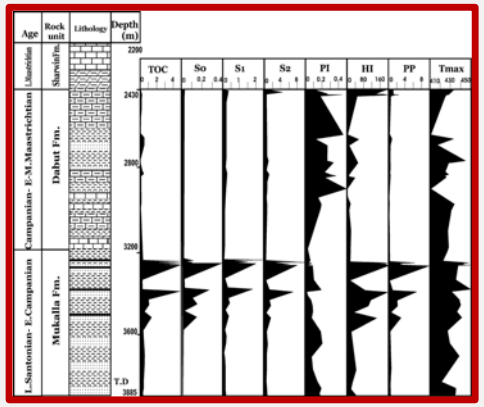
Geospatial Mapping



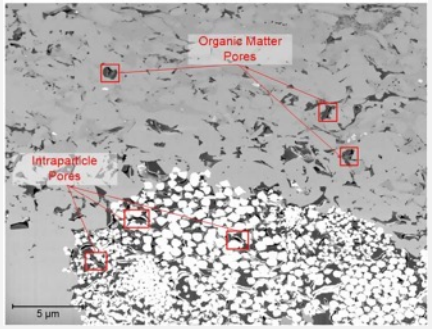
Structures & Tectonics



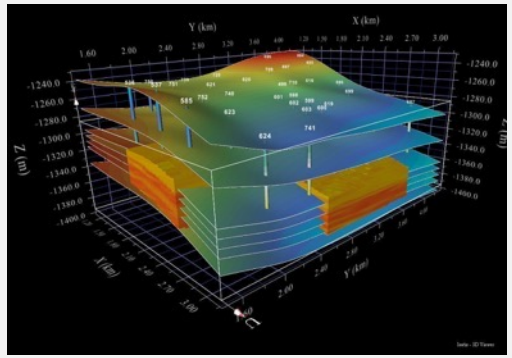
Chronostratigraphy & Paleoenvironment



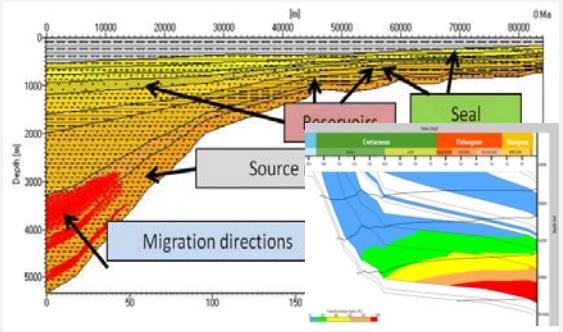
Geochemistry



Petrography & Imaging



Reservoir Modeling & Petrophysics

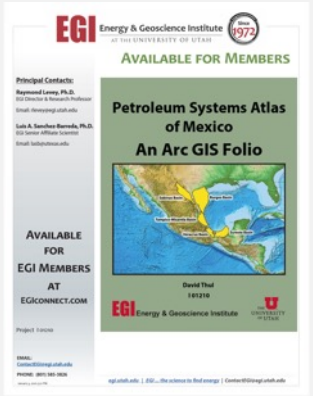


Basin and Petroleum System Modeling

Fields of Activities

CA PROGRAM MEMBERSHIP $55K/YEAR

EGI Corporate Associates receive immediate access to EGIconnect



EGI
Energy Fluids & Minerals

STUDIES/ PROJECTS: REGIONAL THEMATIC

DATABASE WEB-BASED APPS SUBSCRIPTION

iCORDS™

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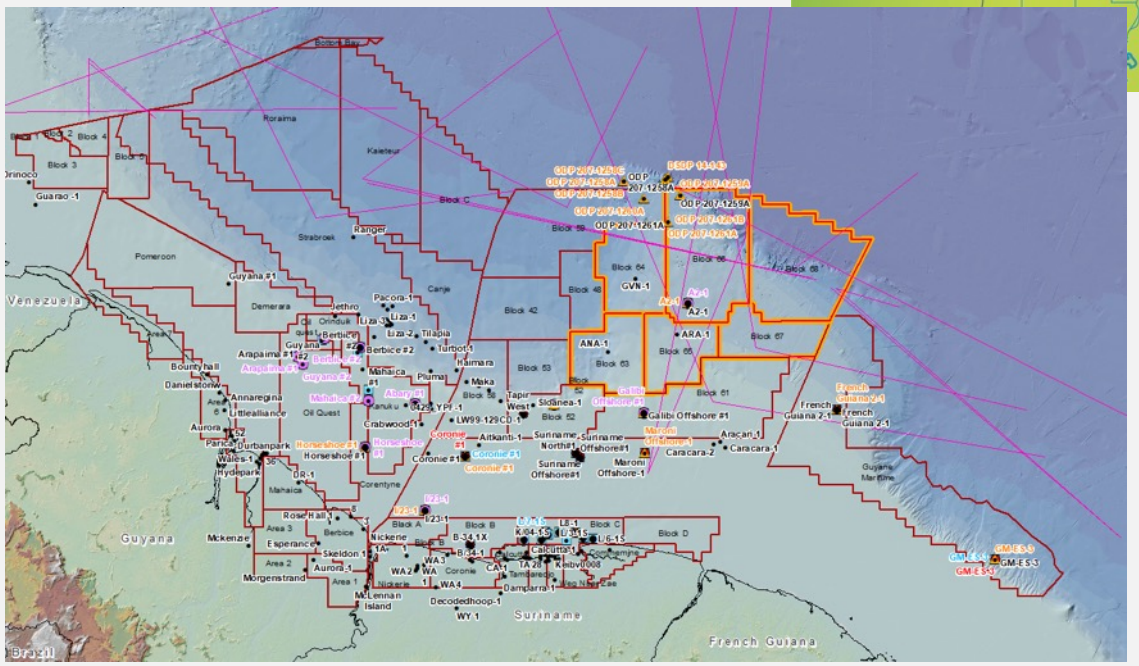
Current Studies & Projects

1) Guyana-Suriname Basin Study
2) Red Sea-Gulf of Suez Basins
3) East Africa Oil-Gas to Source Correlation
4) Ultra-deepwater Oil Fields: Petroleum Systems Atlas
5) Source-rock Organofacies Prediction using ML
6) Gas Basins of Africa
7) Shale Studies

Guyana-Suriname Basins Study

- ArcGIS package
- SR Geochemical Data
- Integrated Well Stratigraphy
- New Paleofacies Maps
- Other geologic maps

US $40,000
US $32,000 EGI CA Members
(20% discount)

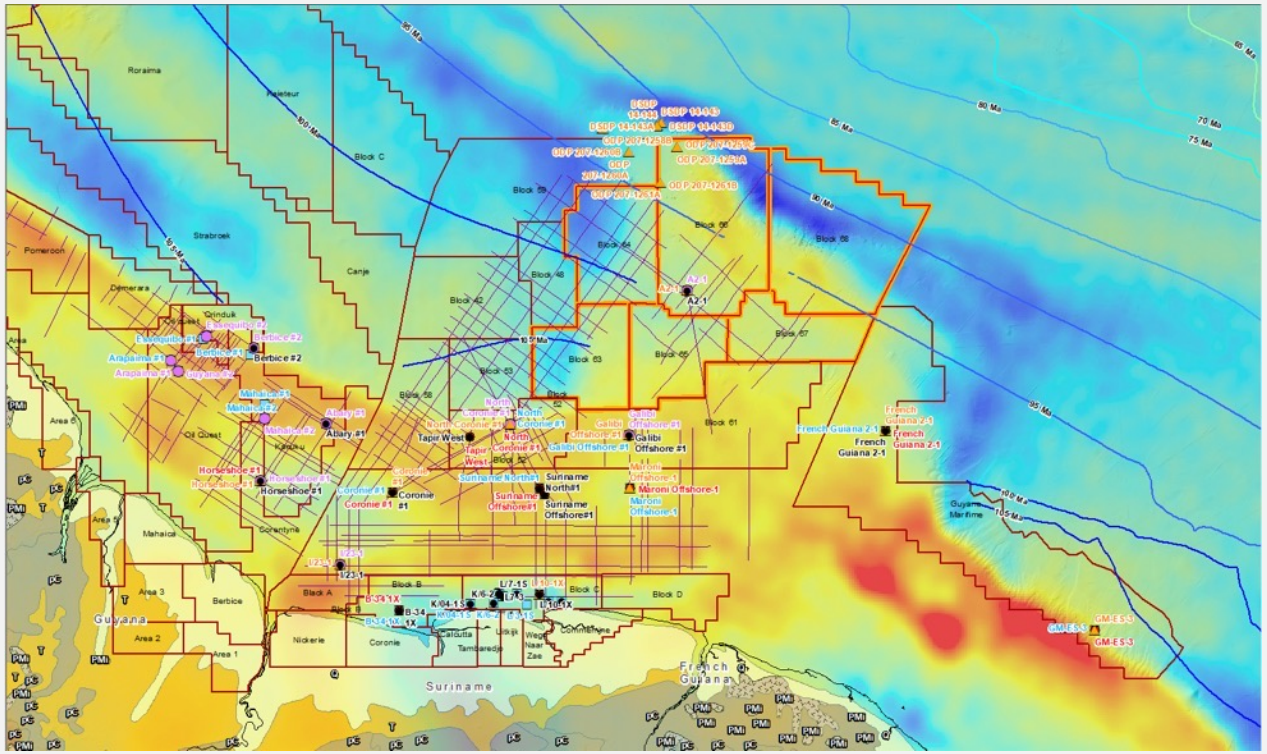


Abary-1
Arapaima-1
B/34-1X
Berbice-1
Berbice-2
Coronie Offshore-1
Demerara A2-1
Essequibo-1
Essequibo-2
French Guiana 2-1
Galibi Offshore-1
GM-ES-3
Guyana Offshore-2
Horseshoe-1
I/23-1X
K/04-1S
K/6-2
L/10-1X
L/3-1S
L/5-1
L/6-1S
L/7-1S
L7-2S
L7-3
L/8-1

DSDP 14-144
DSDP 14-144A
DSDP 14-144B
ODP 155-942A
ODP 155-946A
ODP 207-1257A
ODP 207-1257B
ODP 207-1257C
ODP 207-1258A
ODP 207-1258B
ODP 207-1258C
ODP 207-1259A
ODP 207-1259B
ODP 207-1259C
ODP 207-1260A
ODP 207-1260B
ODP 207-1261A
ODP 207-1261B

Mahaica-1
Mahaica-2
Maroni Offshore-1
North Coronie-1
Suriname Offshore North-1
Suriname Offshore-1
West Tapir-1

Geochem: 29 Wells
Strats: 49 wells

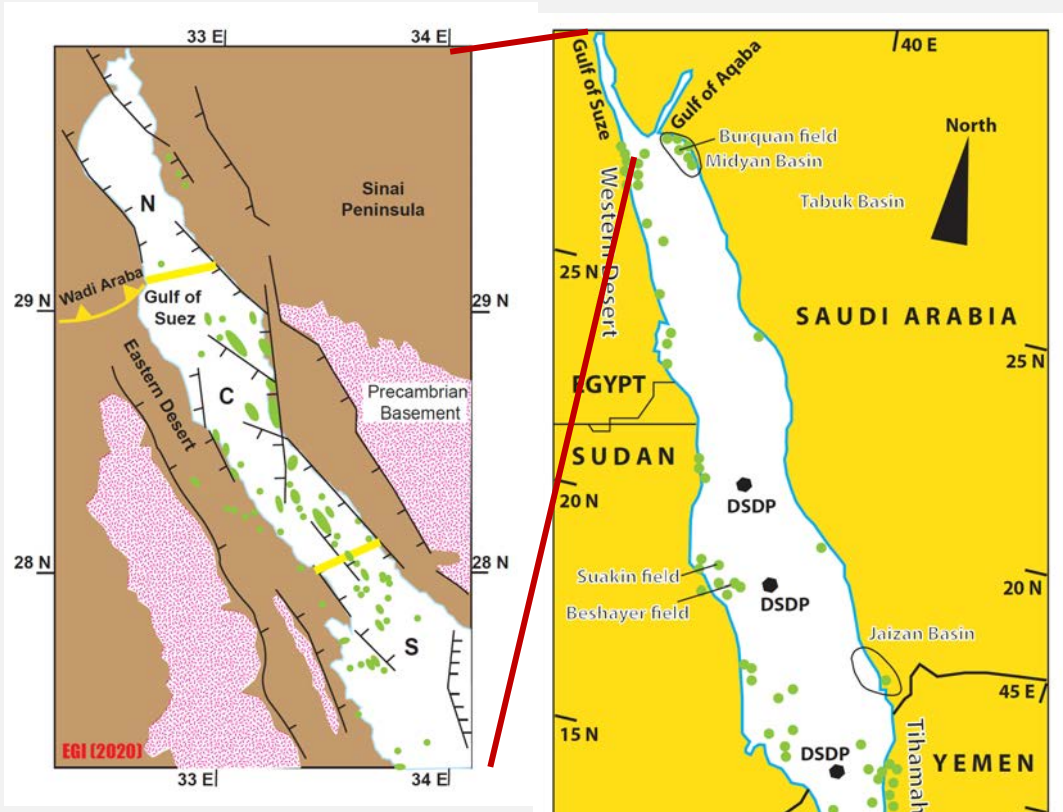


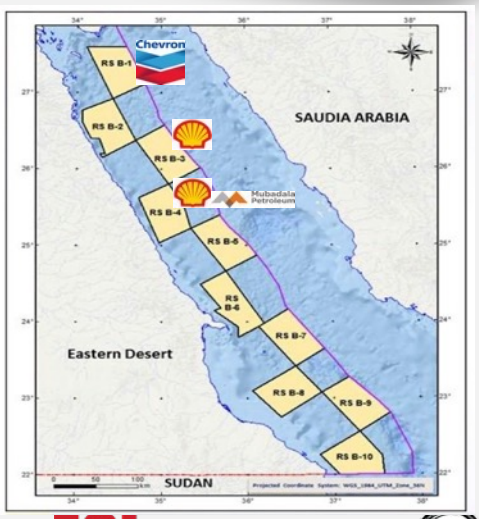
Red Sea-Gulf of Suez Basins

Two sets of deliverables:

(i) EGI's processed seismic sections (>600 SGY files) and well logs (>400 LAS files) from Egypt and Gulf of Suze;

(ii) ArcGIS database of regional maps, integrated stratigraphic charts of wells, geochemical data, and paleofacies maps of the Red Sea and Gulf of Suez basins.



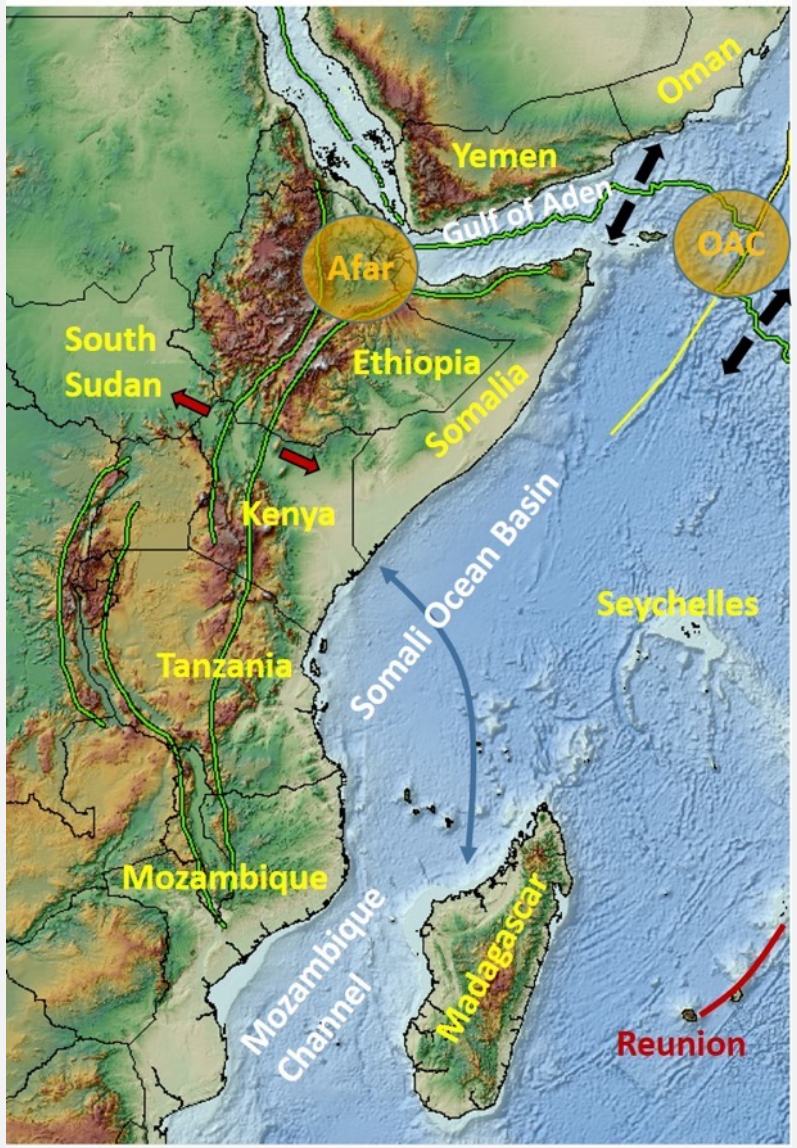


The Study Report is delivered on ArcGIS platform. Digital Seismic and Well Logs are delivered separately in association with EGI's seismic vender.

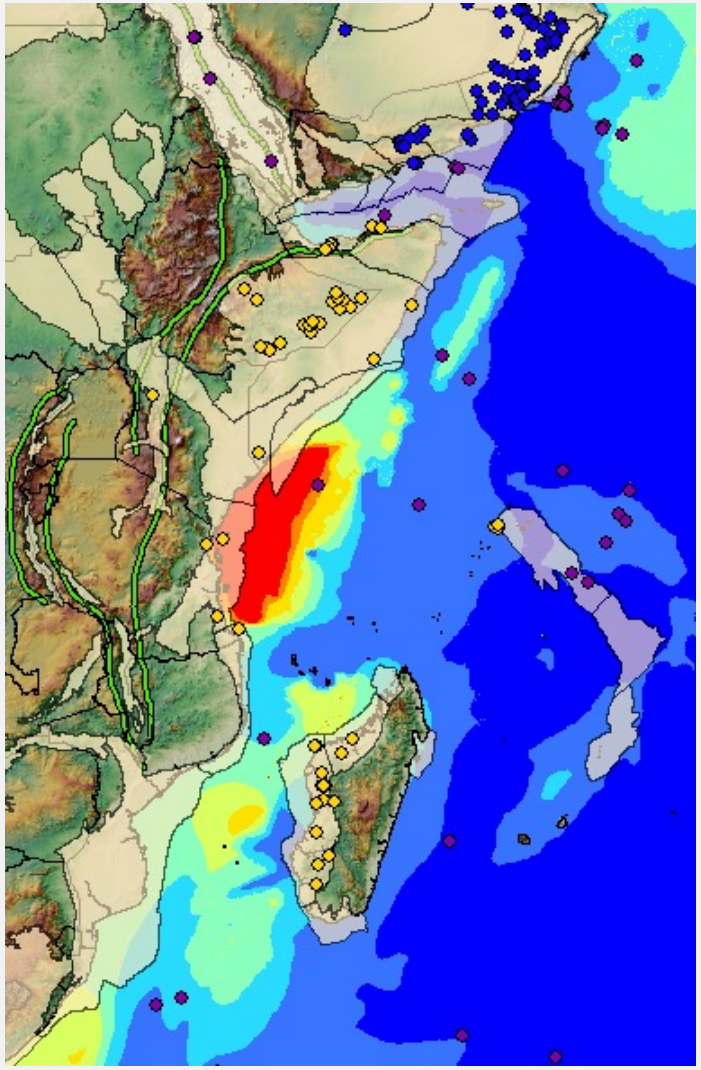
US $120,000 EGI CA Members;

US $140,000 non-CA Companies

East African Basins & Petroleum Systems
Oil/Gas to Source Correlation



New Project Proposal



Deliverables

1) Stratigraphic Charts
2) Paleofacies Mapping (Permian-Pliocene)
3) Structural mapping of the region
4) Geochemical data
5) Petromod modeling
6) Seismic Images
7) Play concepts on cross sections
8) Regional correlation of basins

ArcGIS Report Package
Project meetings

Geographic Coverage

Southern Arabian Peninsula:
Yemen, Oman
Gulf of Aden

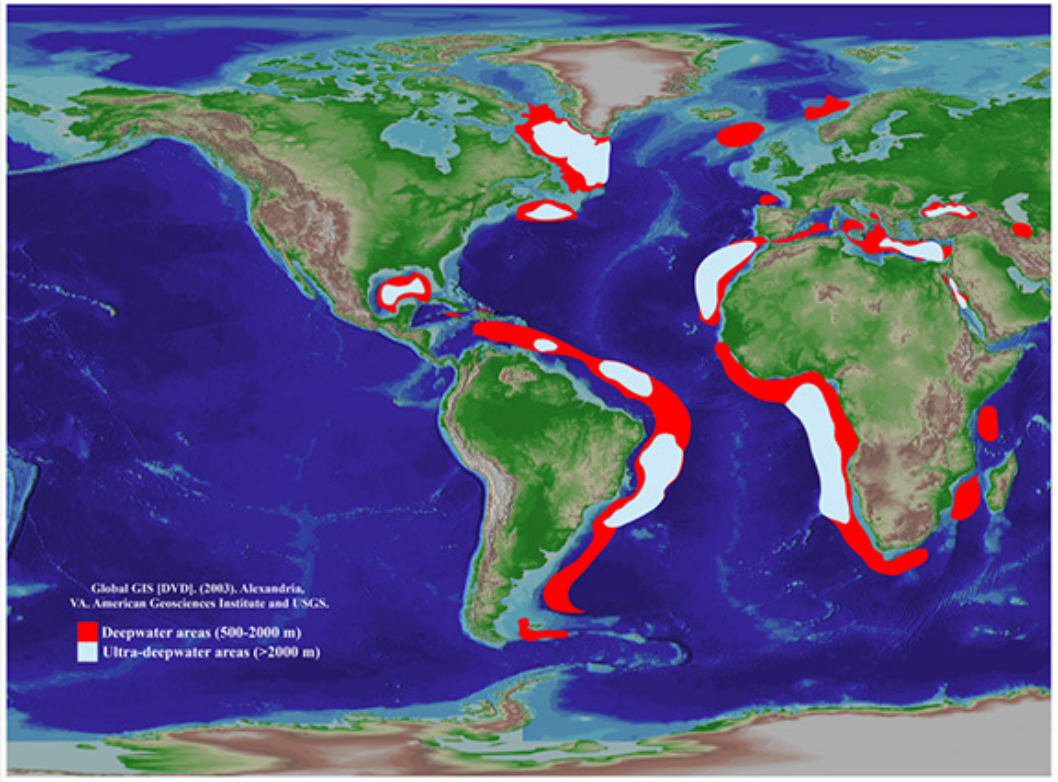
East Africa:
Ethiopia, Somalia, South Sudan, Uganda, Kenya, Tanzania, Mozambique

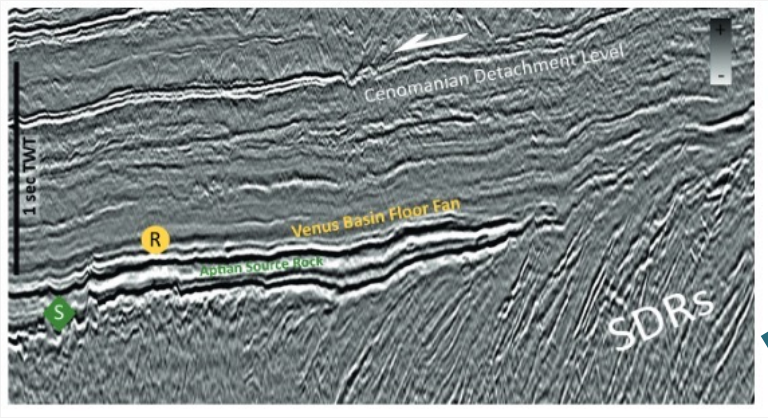
Somali offshore basin
Mozambique channel

Madagascar
Seychelles

Ultra-deepwater Fields: Atlas of Petroleum Systems

What makes ultra-deepwater fields work or fail?
Data synthesis and comparative analysis





Hedley et al. (2022)

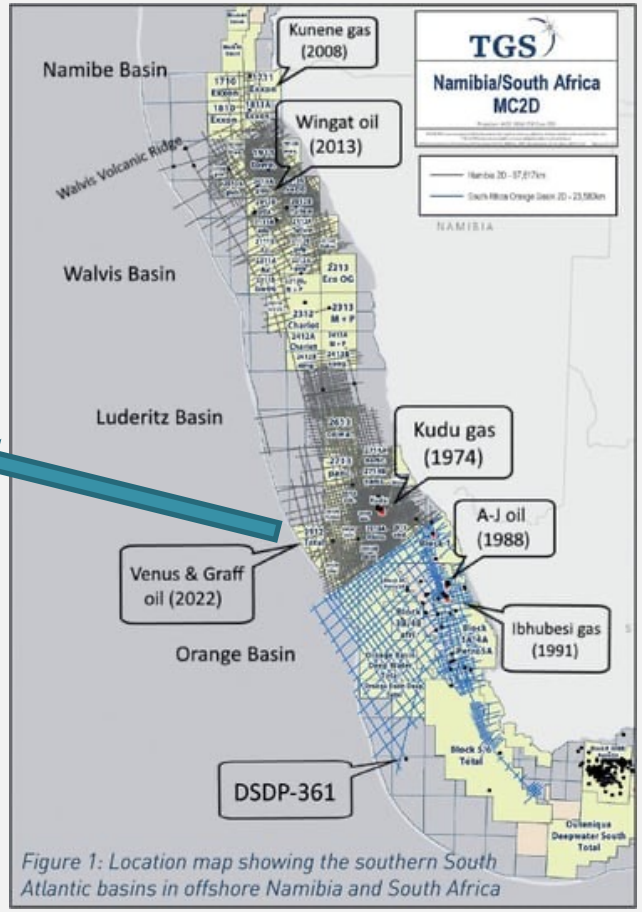
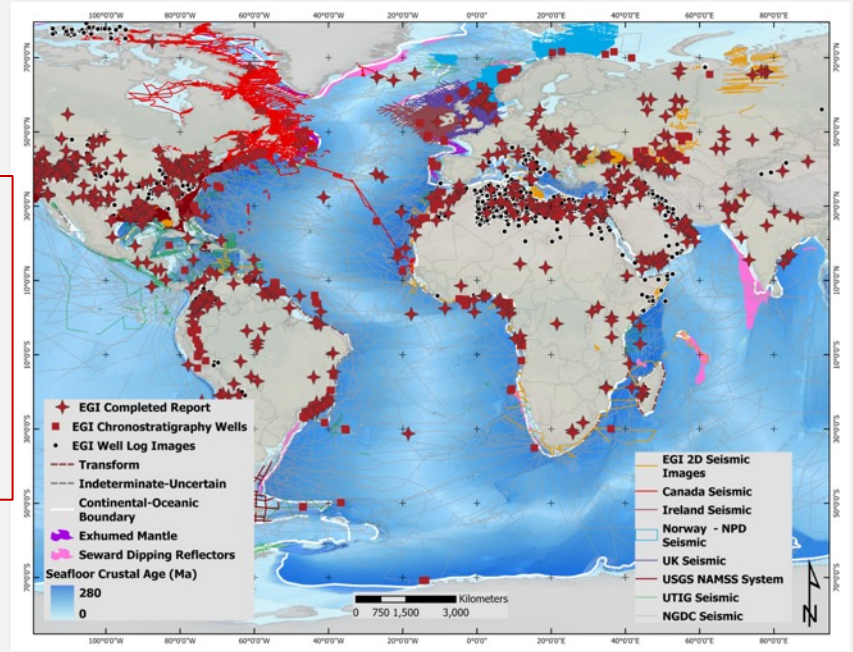


Figure 1: Location map showing the southern South Atlantic basins in offshore Namibia and South Africa

Methodologies

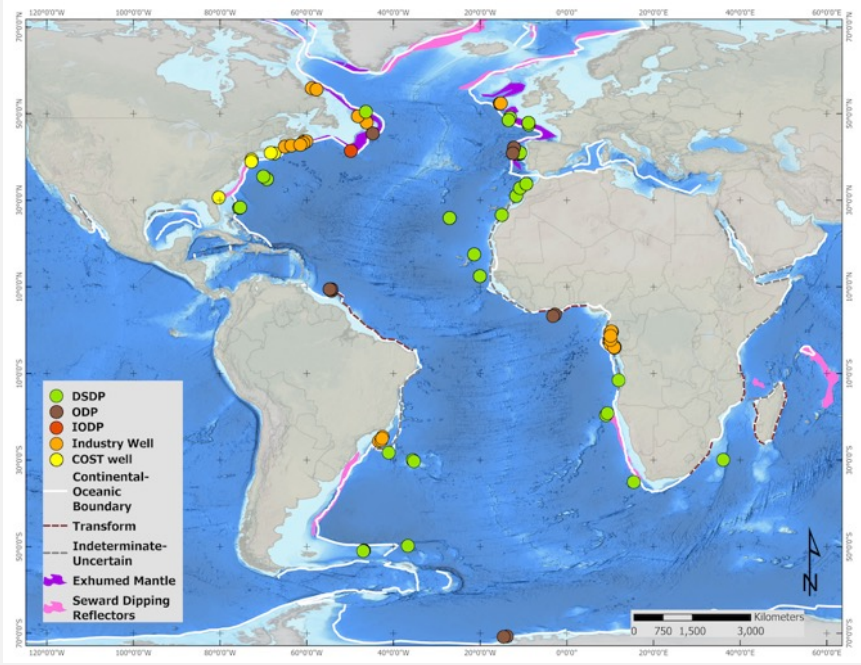
- Geophysical, structural, and thermal data
- Stratigraphic and geohistory analysis
- Geochemical data
- Paleotectonic and paleofacies mapping
- Petroleum system modeling & play fairway risking



Key questions

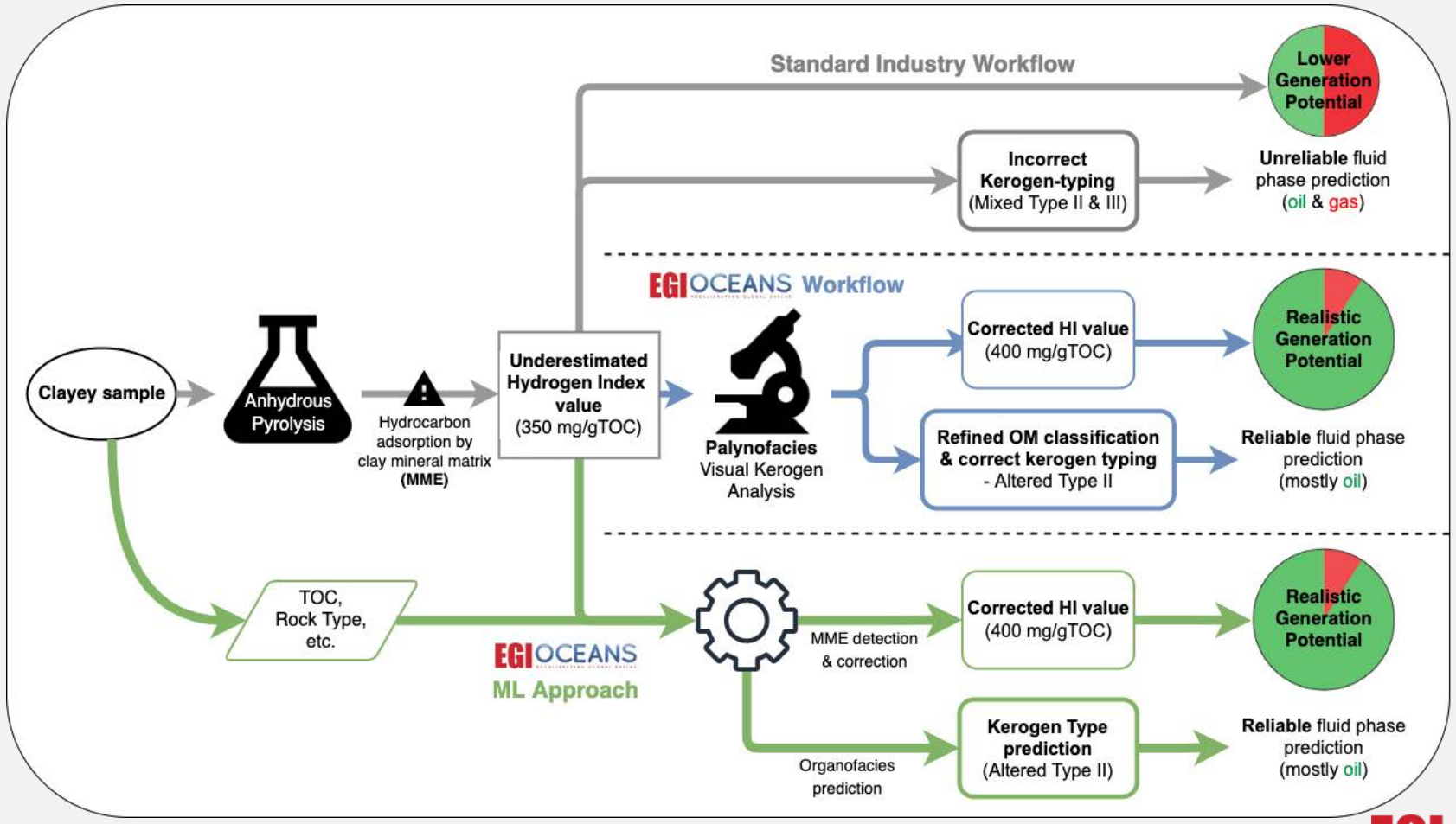
- Impacts of continental margins and ocean floor structures for the development of ultra-deepwater petroleum systems
- Development of prolific source rocks in areas presently characterized by ultradeep water
- Source to reservoir migration and entrapment
- Comparison & evaluation of play concepts

Plays



EGI Oceans Organofacies ML Model for Source Rocks

A unique, low-cost, and expeditious tool for assessing organofacies, generation potential, and phase, using existing data sets, **without the need for additional detailed analyses**

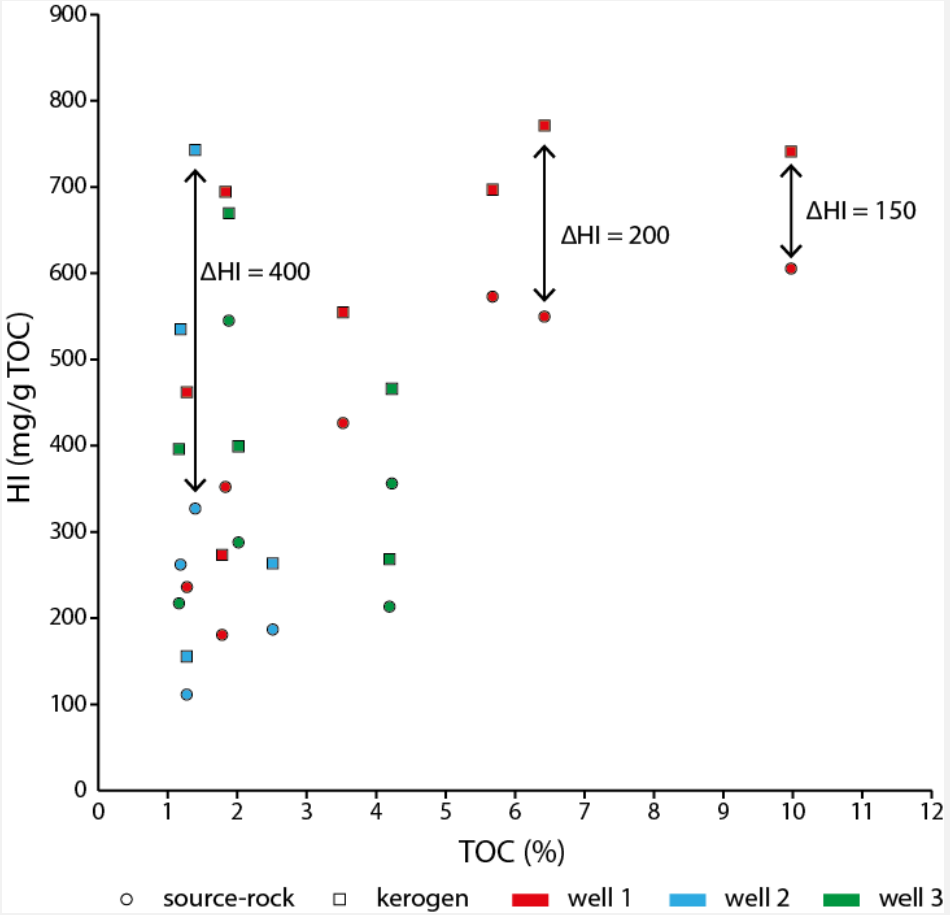


EGI Oceans: Mineral Matrix Effect

Mineral matrix effect (MME) = when pyrolysis is made on bulk rocks, the mineral matrix can retain hydrocarbons (clay) or produce more CO_2 (carbonate) especially when TOC is low (< 3%)

Generally, MME will lower HI values when TOC < 3 %. In some extreme cases, MME can lower HI values even at high TOC (≈ 8 %)

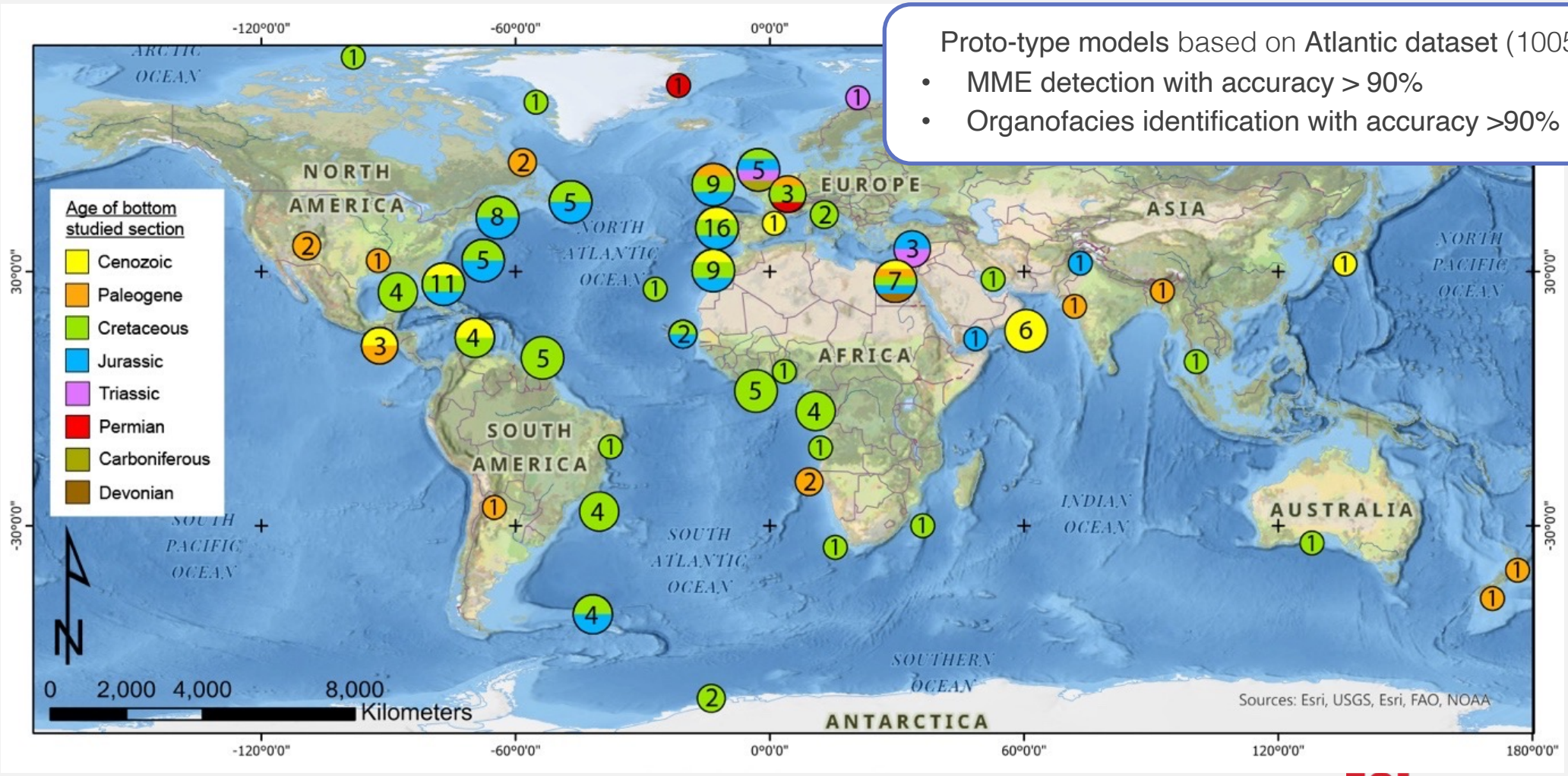
High risks of underestimating source rock potential



Comparison of bulk source rock and kerogen HI values of lacustrine samples

EGI Oceans Training Data Location

> 2000 samples from EGI Oceans (South, Central and North Atlantic) + Literature



Proto-type models based on Atlantic dataset (1005 samples)

- MME detection with accuracy > 90%
- Organofacies identification with accuracy >90%

EGI Oceans Organofacies ML Model: Summary

Deliverables

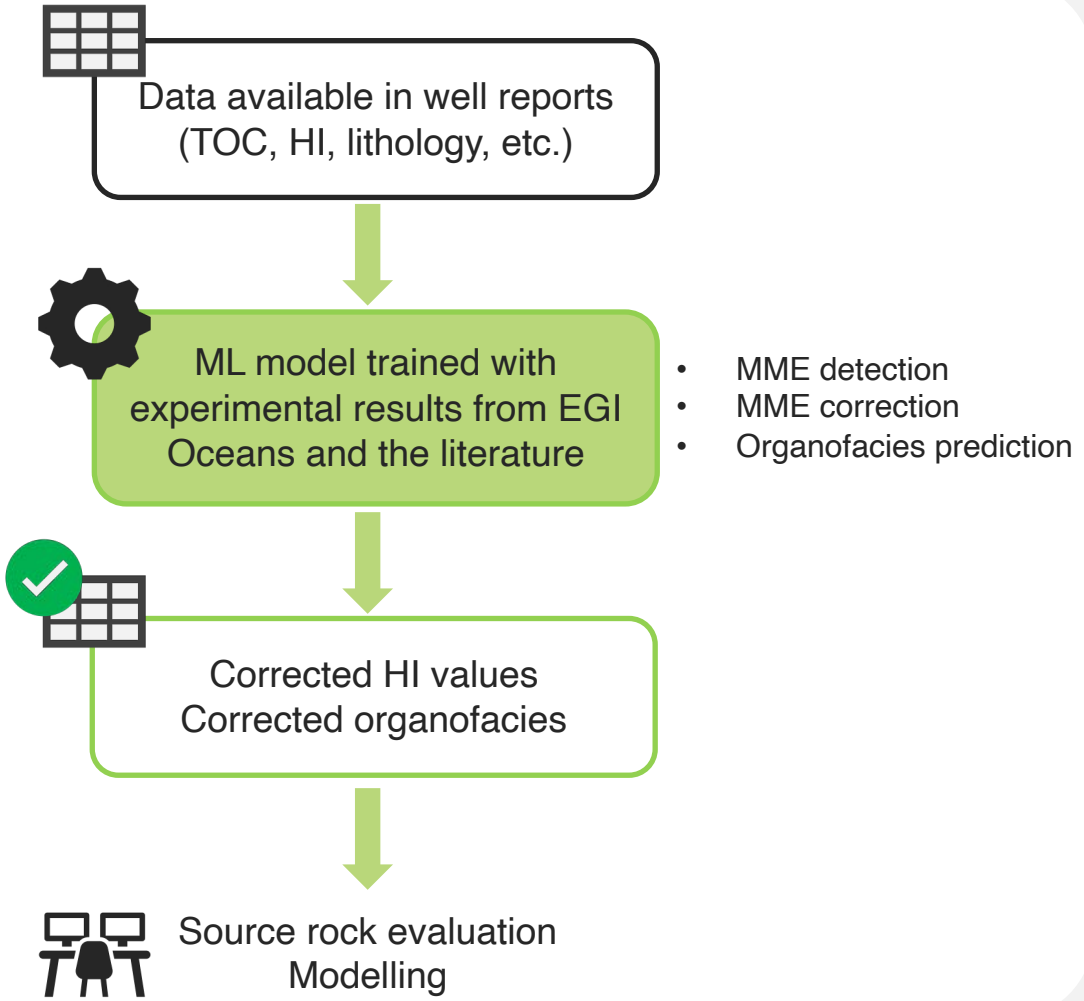
- ML models to:
  - identify samples with the MME,
  - correct their HI values, and
  - determine organofacies
- A **user-friendly interface** for applying the ML models to new data sets (**web app**)
- The global training dataset

Duration

9 months

Cost

32k USD for CA members
40k USD for Non-CA members



EGI Gas Basins of Africa: The Energy Transition Bridge

Research premise

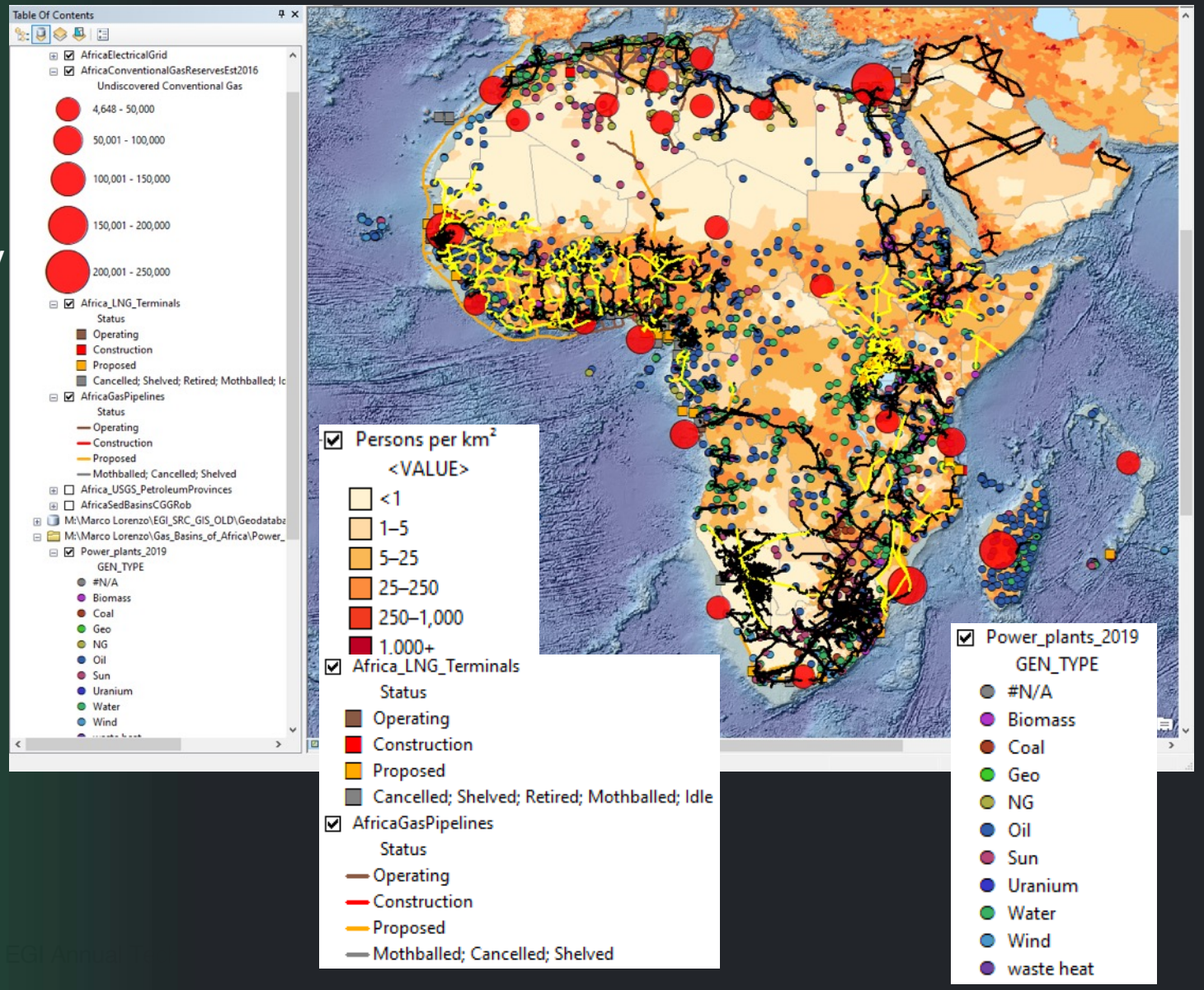
Assessment of access to affordable, reliable, sustainable natural gas to support the development and implementation of green energy

Decision support system

- Geospatical visualization
- Holistic evaluation (Geoscience, Infrastructure, Environment, Socioeconomics) with a unified ranking scale

Deliverables

- Report (chapter for each basin and country)
- ArcGIS project with database used for analysis

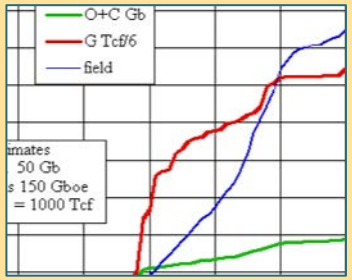


EGI Gas Basins of Africa

UPSTREM → → **DOWNSTREAM**

General Data

- Country/countries
- Area of basin
- Key plays
- Discovery/first production
- HC balance (oil/gas)
- Gas type (e.g. wet/dry)
- Creaming curve/history
- Remaining reserves
- Conventional/unconventl.
- **Stranded/undeveloped gas**



Petroleum System Data

- Tectonic history
- Stratigraphy
- Maps & cross-sections

CONVENTIONAL

- Source/reservoir/seal
- Resources & key fields
- Yet-to-find

UNCONVENTIONAL

- Hydrocarbon density
- Producibility
- Sweet-spotting

Development & Production Options & Challenges

- Political issues
- Cycle times
- Environmental issues

- Onshore/offshore
- Development methods
- Offtake

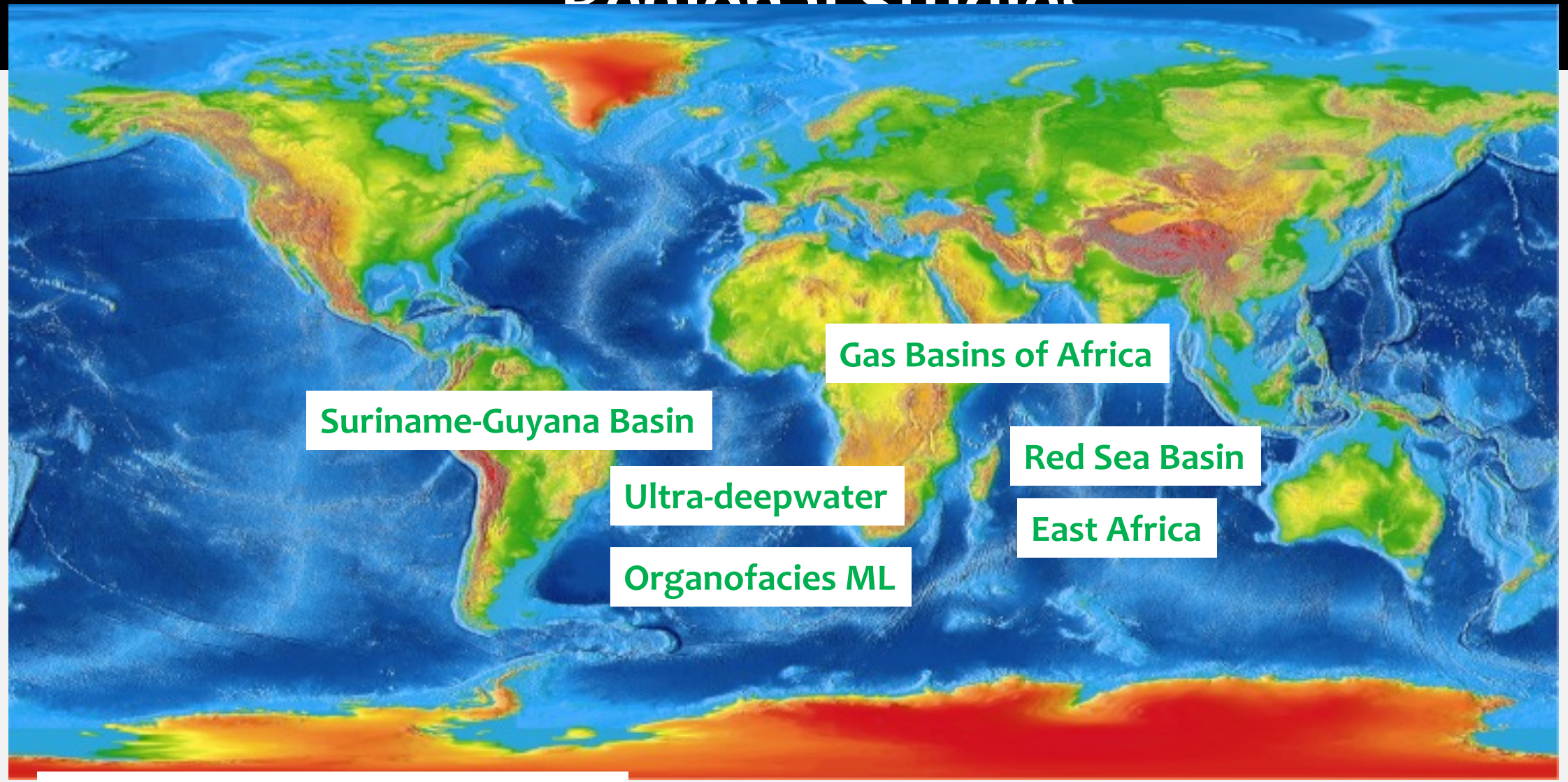
- Frackability
- Water Issues
- Local facilities
- Security

Infrastructure & Market Options & Challenges

- Regional demand
- Pipelines
- Routes
- LNG/regassification
- Planned infrastructure
- Geopolitical constraints
- Macroeconomic constraints

Geoscience Analysis | **Engineering Analysis**

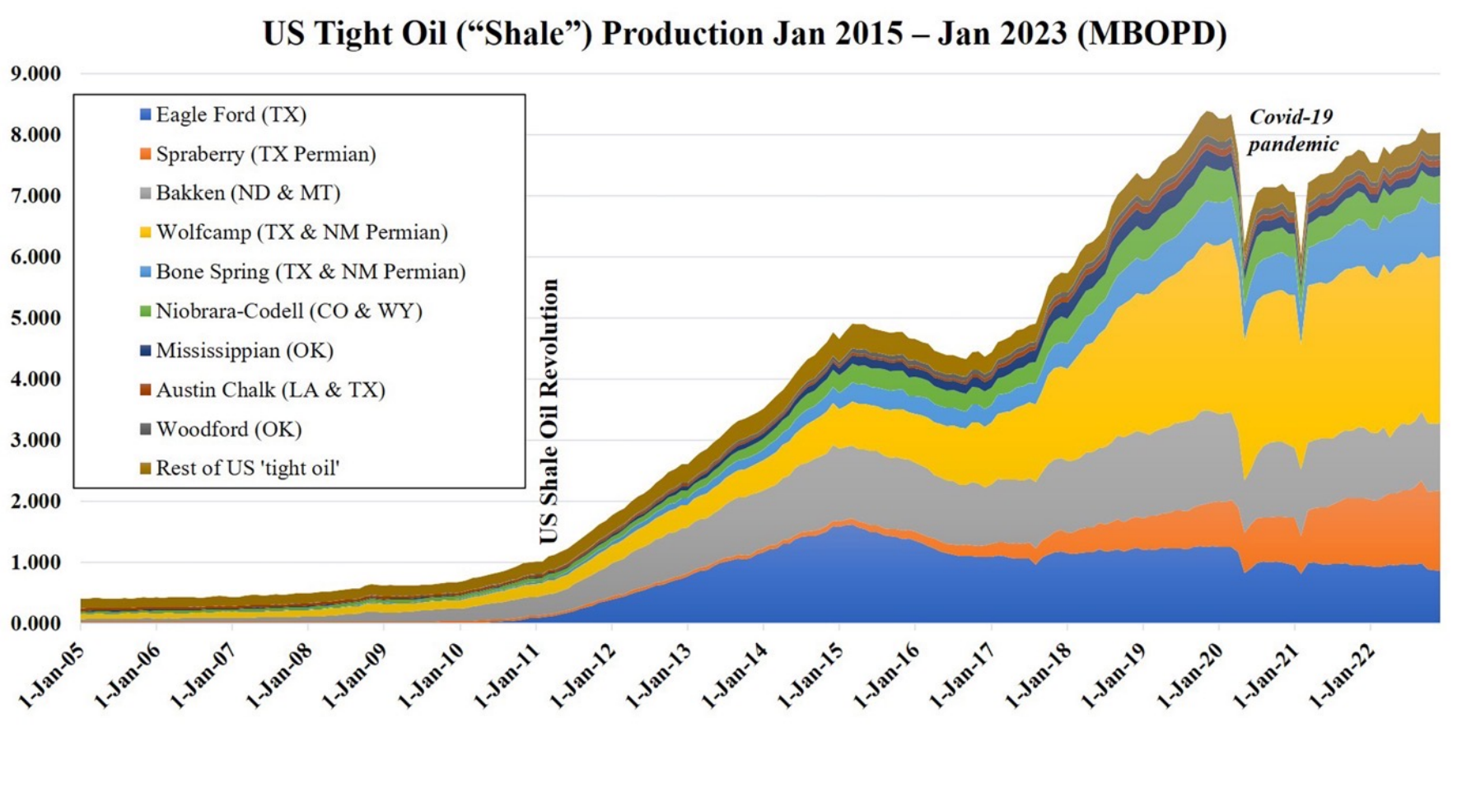
Regional Studies



Suggestions are welcome

Shale Studies

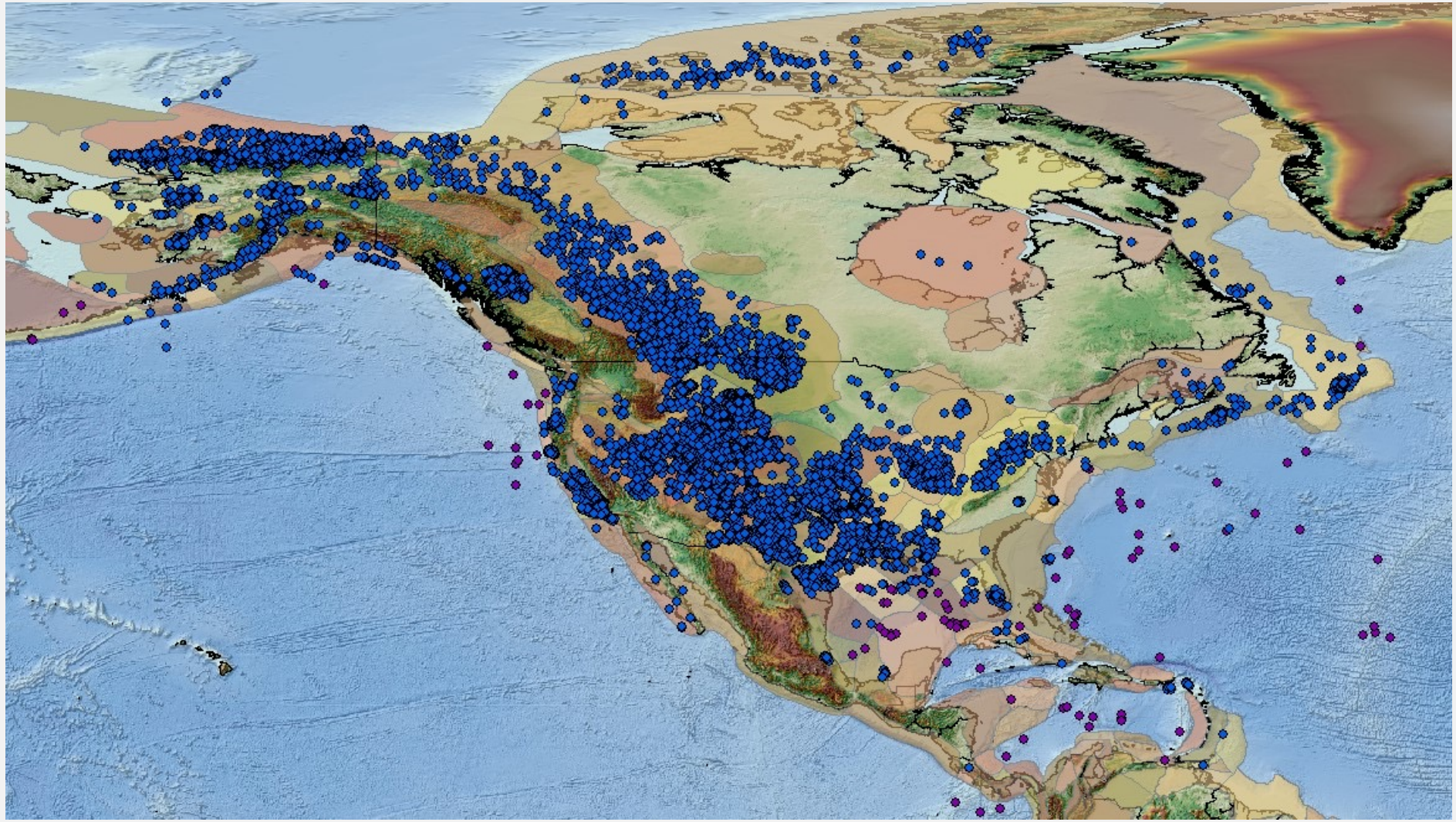
The US Shale (Tight Oil) Revolution



2010 Total US production
5.9 MBOPD 10% of US Total

2023 Total US production
12.4 MBOPD 70% of US total

Source Rocks of North & Central American Basins

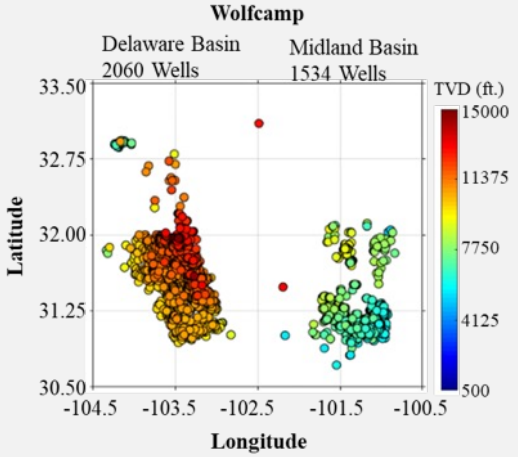


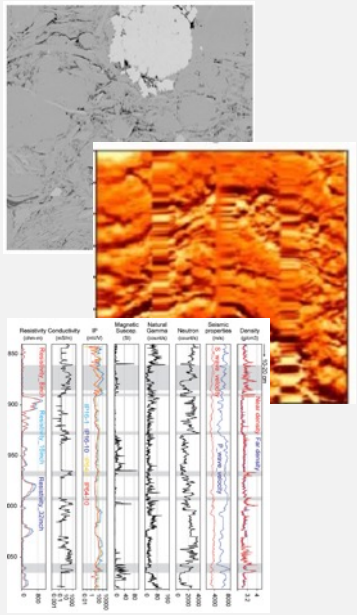
ArcGIS Database

- source rock formations
- USA, Canada, Mexico & Caribbean basins
- Conventional (migrated) and unconventional (self-sources) plays
- >20,000 wells
- Geospatial info
- Formations, stratigraphic age, lithology, depositional facies
- Geochem data (TOC, pyrolysis, kerogen type, thermal maturity, source rock quality

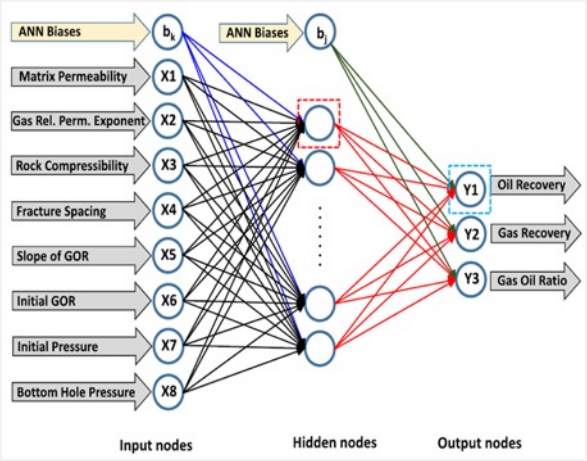
Reverse Engineering and ML Techniques to Characterize Shale Sweet Spots

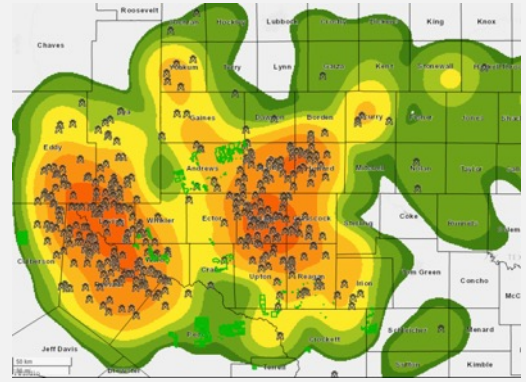
Production Data + **Geodata** → **ML Algorithms** → **Oil Sweet Spots**





$$Y = \sum (weight * input) + bias$$





Input Nodes

Output Nodes

Society of Petroleum Engineers

SPE-201730-MS

Data Analysis of the Permian Basin Wolfcamp and Bone Spring Leads to Better Understanding of Production Sweetspots

Rasoul Sorkhabi, Energy & Geoscience Institute, University of Utah, Salt Lake City, Utah; Palash Panja, Energy & Geoscience Institute, University of Utah, Salt Lake City, Utah Department of Chemical Engineering, University of Utah, Salt Lake City, Utah

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Not All Shales Play the Same Game: Comparative Analysis of US Shale Oil Formations by Reverse Engineering and Petroleum Systems

Rasoul Sorkhabi*[1], Palash Panja[1,2], 1. Energy & Geoscience Institute, University of Utah
2. Department of Chemical Engineering, University of Utah.

This paper was prepared for presentation at the Unconventional Resources Technology Conference held in Houston, Texas, USA, 26-28 July 2021.

ARMA 22–480 https://doi.org/10.56952/ARMA-2022-0480

ARMA american rock mechanics association

Geomechanical Controls on Production Performance of Austin Chalk and Eagle Ford Oil Wells in Southern Texas

Palash Panja
Energy & Geoscience Institute, University of Utah, Salt Lake City, Utah, USA
Department of Chemical Engineering, University of Utah, Salt Lake City, Utah, USA
Rasoul Sorkhabi
Energy & Geoscience Institute, University of Utah, Salt Lake City, Utah, USA

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URTeC: 3866019

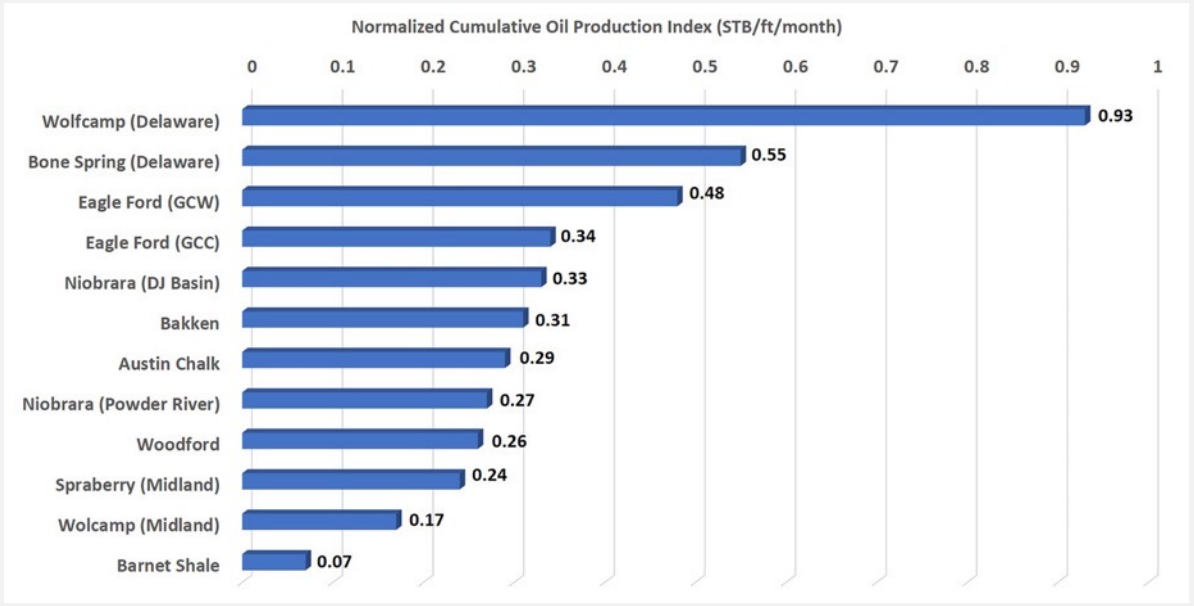
Production Sweet Spots of Eight US Shale Plays Constrained by Data Analytics of Normalized Production Index, Payzone Depth, and Initial GOR

Rasoul Sorkhabi*[1], Palash Panja[1,2], Milind Deo[1,2]
1. Energy & Geoscience Institute, University of Utah, Salt Lake City, UT, United States.
2. Chemical Engineering, University of Utah, Salt Lake City, UT, United States.

This paper was prepared for presentation at the Unconventional Resources Technology Conference held in Denver, Colorado, USA, 13-15 June 2023.

Ranking of the US shale plays using data science: Insights into oil production performance /

Rasoul Sorkhabi, Palash Panja & Milind Deo



AAPG EXPLORER August 2023

Which Are the Best Shale Plays in the U.S.?

August 2023 David Brown, Explorer Correspondent

What are the highest-ranked shale oil plays in the United States? Here's an easy answer:

It depends on who's doing the ranking.

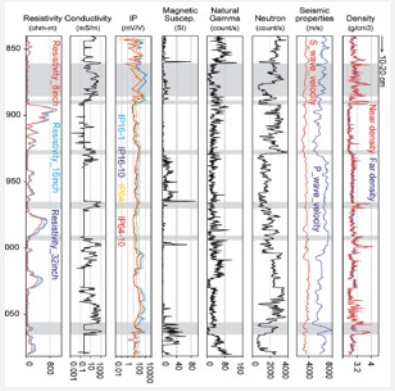
More to the point, it depends on the evaluation criteria and ranking methodology applied.

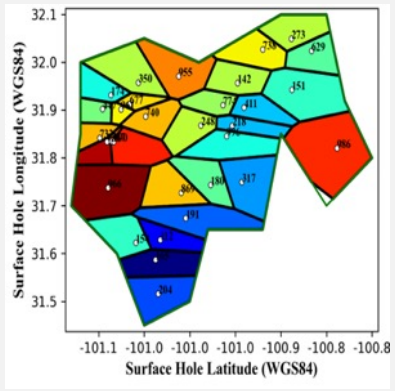
A new analysis from the University of Utah's Energy and Geoscience Institute ranks 12 U.S. tight-oil shale formations based on data from almost 37,000 producing horizontal wells, using a specially designed software package.

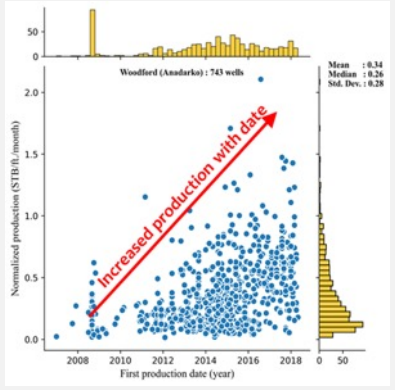
"We should not view shale plays as simply an engineering issue – that is, simply frac them irrespective of their geological conditions. We believe that geological parameters have huge

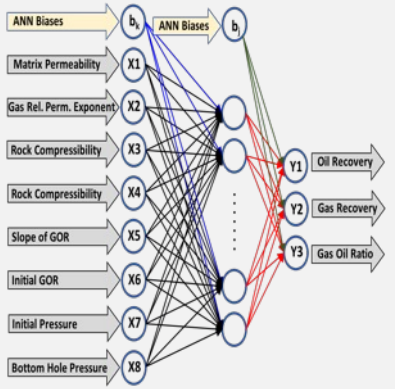
Shale Smart Web App

	Reservoir Characterization	Reserve Estimation	Field Development	Data Analytics	Production Forecast
Output					
Core Method	Log interpretation / Material Balance method	Digitization of image	Voronoi diagram / spatial distribution	Python Libraries and visualization tools	Surrogate models
Inputs	Log, production data, PVT, initial conditions	Isopach maps	Well locations and data	Production, completion and well Data	Geologic, completion, operational parameters









- TOC
- Porosity
- Water saturation
- Permeability

- Area of contour
- Rock volume
- User defined zone
- Initial hydrocarbon

- Averaged properties
- OOIP, recovery, EUR
- New wells placement
- Field development

- Production Decline
- Sweet Spot
- Impact of completion
- Impact of technology

- Rate and recovery
- Sensitivity study
- Uncertainty analysis
- Time series prediction

Thank you for your attention!

Rasoul Sorkhabi
rsorkhabi@egi.utah.edu