Hydrocarbon Exploration Models in Deep Water Rift and Passive Margin Settings

Background:

The members of the EGI team proposing this project have been continuously funded through various research projects over the past 10 years to study deep-water passive margins and design predictive exploration tools to reduce exploration risk. This previous research identified several unresolved problems, which we plan to address in this study.
Widely-spaced regional 2-D seismic grids can provide a misleading picture of the regional context needed for successful exploration. Dense 3-D seismic-based programs, in contrast, focus at the prospect level and consequently do not provide sufficient regional context about the depositional section under investigation. What is required are exploration models that bridge these regional and prospect level scales to improve understanding of the elements and processes contributing to basin and petroleum systems development.

The initial geological problem to be solved is understanding basin development through the transformation of disorganized rifting to organized seafloor spreading. Thus, we must look at the evolution from indecisive continental rift basins and imperfect accommodation zones (Tanganyika) to pseudo-volcanic lineaments and transfer faults (Turkana) to gradual, tortuous, and probably sub-aerial spreading (Afar) to opening (Red Sea), if located on the successful limb of a triple junction to discern how these environments affect petroleum system elements and processes.
Of course all of the petroliferous margins are much more complex, more segmented, and more controlled by deep thermodynamics than we tend to envision. This is especially true on continental shelf edges. Perhaps the best way to imagine these exploration terrains is as a bunch of small, fault-connected basins divided by accommodation zones and transfer faults that hoped to evolve into transform faults, and did so rather imperfectly, or not at all.

As a result, one can imagine a series of basins with varying thermal regimes strung along the continental margins, usually oriented at two different oblique directions to the original margin. The kitchens may generate hydrocarbons but they may well end up on the dividing (and overlying) structures. Successful exploration in deep water margins seems to require a capability of model-driven interpretation of the imaging data, focusing on basin development, an understanding of controlling factors to predict thermal history, and the implications of both of these factors on the presence or absence of essential petroleum system elements and processes.

Purpose:

The main purpose of the study is to improve understanding of petroleum systems in rifted passive margins. The approach is modular, the anticipated results highly relevant to future successful exploration, and the cost is modest.

Project strategy:

The strategy is to develop a new and better appreciation of the factors controlling structural architecture, basin development, and fluid flow in rifted margin settings (Module 1). Synthesis of this knowledge will then be used to tackle what is perhaps the most enigmatic aspect of these environments–the factors controlling thermal regimes and temperature peculiarities of rift and passive margin settings (Module 2). The final phase (Module 3) is the construction of composite models of petroleum systems based on the results of the two previous phases.

Project:

Module 1. Structural Architecture, Basin Development and Fluid Flow in Rifts and Passive Margins

Rationale:

Phase 1 accumulates and synthesizes the structural and fluid flow knowledge necessary for fact-based and forward-thinking exploration plans in the deep water of rifted margin settings. The work begins with delineation of extension directions, which is necessary for the proper lay-out of geophysical surveys; includes determination of crust types, which are necessary for definition of different petroleum system candidates; determination of structural segmenting features, which define the sizes and geometry of a potential petroleum system; and determination of structural timing events, which is necessary for specification of source/reservoir/trap/seal temporal relations. The work concludes by answering the question of why certain passive margin segments are so prolific and why others are (or should be considered) dry. Ultimately, this means a true understanding of the continuum that exists between pure rift systems and pure pull-apart basins, and how the continuum applies to petroleum systems.

Anticipated Results:

1) Basic description of structural styles in passive margin settings, including extension directions, key structural elements, and hydrocarbon occurrences
2) Mechanics of rifting and transition to drift phases

3) Determination of unstretched continental, thinned continental, proto-oceanic, and oceanic crustal boundaries in the study areas (i.e., South, Central, North and Equatorial Atlantic, East Africa, Southern California and Mexico)
4) Determination of timing of rift and/or transform events, thermal subsidence, and continental breakup
5) Role of crustal composition and compositional variations on evolving rift margin architectural development and on breakup locations
6) Role of pre-extensional tectonics and anisotropy on evolving rift structural styles and the effects of syn-extensional tectonics/anisotropy on passive margin structural style
7) Role of syn-extensional deposition and erosion on evolving structural styles of passive margins and effects of tectonics on deposition and erosional patterns
8) Fluid flow models along oceanic fracture zones (transforms), hot spot or hot line-associated volcanic chains and continental transfer fault systems

Module 2. Thermal Regime in Rifts and Passive Margins

Rationale:

Phase 2 develops the thermal foundation for successful (and unsuccessful) petroleum system determinations. The work consists of evaluation of critical factors influencing the maturation history of source rocks in deep water rift and passive margin settings, including the effects of deposition, structural framework, erosion, deformation, and movement of geothermal fluids along oceanic fracture zones, hot-spot/hot line-related volcanic chains and continental transfer zones.

Anticipated Results:

1) Role of pre-rift heat flow on syn-rift thermal regimes and effects of syn-rift heat flow on thermal regimes of passive margins
2) Influence of structural and stratigraphic architecture on thermal regimes
3) Role of syn-rift deposition and erosion on thermal regimes of rifts and the effects of post-rift deposition and erosion on thermal regimes
4) Effects of deformation on thermal regimes
5) Roles of fluid movement on thermal regimes

Module 3. Petroleum Systems in Rifts and Passive Margins

Rationale:

Phase 3 develops knowledge of source rock distribution, source maturation history, reservoir distribution, seal quality, potential migration scenarios, trap candidates and preservation issues. The work evaluates the effects of movement of geothermal fluids

along oceanic fracture zones, hot-spot/hot line related volcanics and continental transfer zones on diagenetic history of reservoirs and seals. A knowledge of reservoir distribution works with prediction tools designed to assess continental margin vertical motion histories and the controlling factors on sediment distribution through breaches of these marginal uplifts.

Anticipated Results:

1) Models of source rock distribution, maturation and expulsion
2) Models of reservoir quality distribution
3) Sealing characteristics
4) Models of hydrocarbon migration
5) Trapping styles
6) Hydrocarbon preservation

Deliverables:

1) Folio with integrated write-up, figures, tables, maps and cross sections
2) Arc GIS format documentation of case studies

Timing:

Three year project in three modules (phases), with results and conclusions delivered at the finish of each module.

Budget: Three Year Commitment

Hydrocarbon exploration models in rift and passive margin settings-Total years	
EGI Salaries	$ 856,147
Other Costs	223,857
Total Budget	**$ 1,080,004**
Number of Sponsors	9

Cost per Sponsor	**120000**

Hydrocarbon exploration models in rift and passive margin settings Year 1	
EGI Salaries	$ 265,702
Other Costs	118,022
Total Budget	**$ 383,724**
Number of Sponsors	9
Cost per Sponsor	**42636**

Hydrocarbon exploration models in rift and passive margin settings Year2	
EGI Salaries	$ 260,986
Other Costs	106,782
Total Budget	**$ 367,769**
Number of Sponsors	9
Cost per Sponsor	**40863**

Hydrocarbon exploration models in rift and passive margin settings Year 3	
EGI Salaries	$ 238,620

Other Costs	89,892
Total Budget	**$ 328,511**
Number of Sponsors	9
Cost per Sponsor	**36501**

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