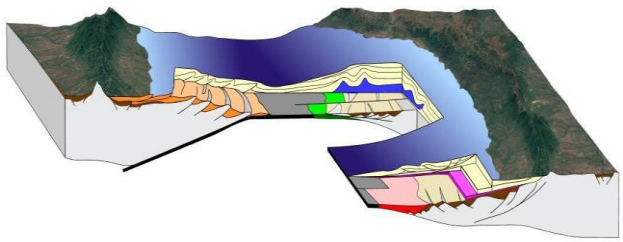
Basin Structure Group – Phase 4

Subscription proposal

Overview

Rift basins and continental margins are ever more important as sites of resource development and potential fluid storage opportunities for the Energy Transition. But fundamental to being able to identify and risk resources and CO_2/CH_4/H_2 storage sites is the need to characterize a basin's structural and stratigraphic architecture and its geodynamic conditions.

Our aims are 1) to address critical research questions across a range of scales and stages in a rift's development, and 2) improve understanding of margin structure and basin evolution and assess how this impacts opportunities and risks in resource management.



A new focus will be on opportunities for CO_2 sequestration by injection of CO_2 into reservoirs as they are depleted of hydrocarbons, and into abandoned gas reservoirs and saline aquifers, achieving security of energy supply whilst reducing environmental impact. Significant uncertainty remains in defining the controls and boundary conditions of continental rift basins and post-rift continental margins, their subsurface reservoirs, and the integrity of caprocks.

The University of Leeds Basin Structure Group (BSG) is led by Dr Richard Collier. Skills in the team encompass structural geology, tectono-geomorphology, sedimentology and geophysics. BSG currently has 6 affiliated staff and ~12 PhD students in Leeds, and we collaborate with leading experts in areas such as petrophysics and geomechanics, in Leeds and internationally.

Research and Training Vision

- Enhance understanding of the interplay of tectonics and sedimentary basin evolution from basin or continental margin scale, to reservoir scale, down to the scale of fracture and pore network systems.
- Further characterize variability of continental margin architecture and its impact on geodynamics, i.e. burial and thermal conditions through time.
- Examine how structural context impacts reservoir distribution, architecture, quality and performance for a range of fluid types.
- Build understanding of critical parameters in regional CO_2 sequestration analysis – including in depleted reservoirs and in potential sub-salt reservoirs
- Evaluate global opportunities for major reservoir/seal fairways for large-scale CO_2 sequestration, e.g. under the salt of the Red Sea/Gulf of Suez.
- Evaluate how tectonic context influences risk with respect to reservoir performance and seal integrity.
- Capacity building and advanced training in resource geology, with focus on rift-related geology and the geological conditions needed for CO_2 sequestration.

Costs

- Standard membership of the consortium costs £90k for 3 years.
- Membership including a company specific PhD project (3.5 years duration) costs £180k.

Established Joint Industry-funded Project (JIP) contract model for sponsors and collaborating partner universities. Assured confidentiality of company-specific data & results.

For more background visit:
http://environment.leeds.ac.uk/institute-applied-geoscience/doc/basin-structure-1
BSG is part of Geosolutions Leeds. Visit http://geosolutions.leeds.ac.uk

Deliverables

Company-wide access to:

- Research results for detailed, integrated and regional research projects
- Access to research results from parallel, non-proprietary BSG rift and continental margin research projects on the South Atlantic, North Atlantic, Aegean, East Africa (Durban to Ethiopia) & Australian margins
- Research outputs delivered through the BSG sponsors' website (Knowledge Transfer Portal)
- Searchable literature and research outputs database tailored to research themes
- Online learning resources
- Access to online BSG research talks and to an annual sponsors' workshop
- Ongoing interaction with BSG staff and students
- Bespoke field trips and training as an optional extra

Research Outputs

Fundamental to BSG research is an observational approach based on 2D and 3D field analogue studies and integration of these results with 2D and 3D seismic reflection data, potential fields data, petrophysical and stratigraphic well data, providing new insights into the processes underlying basin evolution.

Coupling analogue study outputs with geodynamic and structural modelling will produce predictive tools/models that can be applied to global resource geology and quantification of CO_2 and other gas storage opportunities.

1) Geotransects – Building on existing studies, we will expand the BSG website database of regional scale sections which capture the structural architecture and reservoir/seal elements of rifted continental margins

2) Regional maps of CO_2 reservoir distribution and seal integrity confidence levels (for regions prioritised by sponsors)

3) Website access to research presentations, papers, theses, posters, field guides, research summaries and general resources

Future projects are likely to include:

- Tectonic and stratigraphic nature of the rift-to-drift transition; lateral variation in margin structure.
- Tectonic, palaeoenvironmental and diagenetic controls on pre-, syn- and post-rift reservoir distribution, architectures, quality and connectivity.
- Role of inherited pre-rift crustal fabrics in influencing structural evolution and reservoir development.
- Critical parameters for estimation of CO_2 fluid behaviour and storage capacities.
- CO_2 caprock integrity; analysis of containment confidence in depleted and saline reservoirs.

Themes to be prioritised in discussion with sponsors.

Knowledge Transfer Portal

See overleaf how our bespoke BSG research website will give you access to project results and to results from worldwide studies of the structural and stratigraphic evolution of rift basins and continental margins, and their reservoir/seal systems.

For further information please contact:
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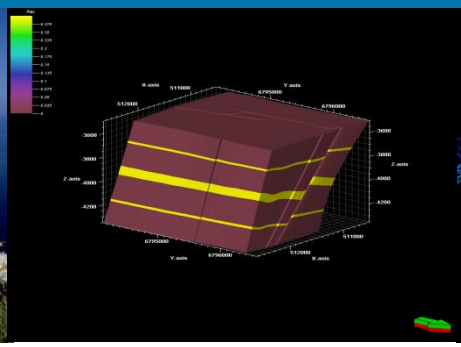
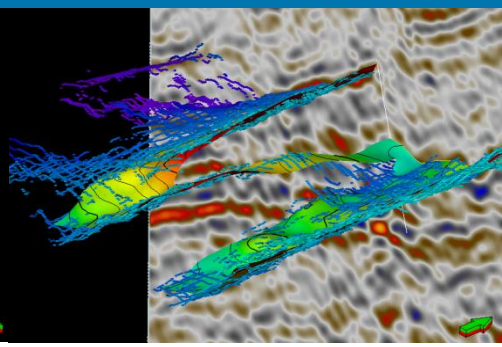
Project sponsors and participants will have access to our

KNOWLEDGE TRANSFER PORTAL

Training resources for reducing uncertainty in basin evaluation, production, CO_2 storage

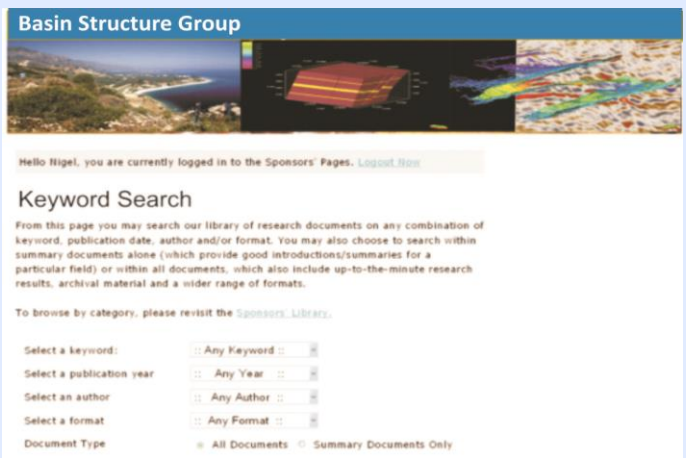


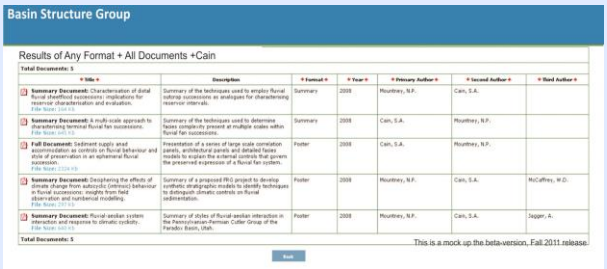


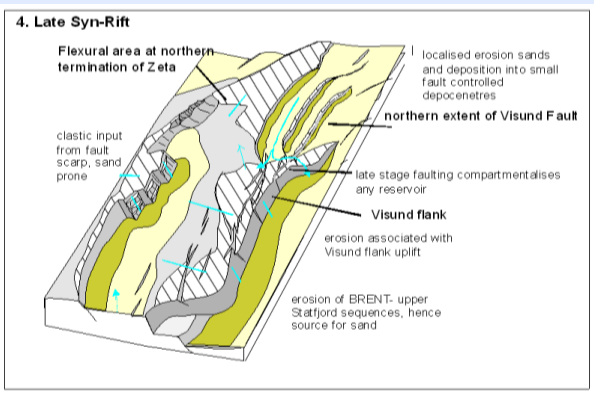
A key element of the project deliverables is Knowledge Transfer of our research results in a manner that can be integrated with company needs. We also synthesise research published in appropriate journals and provide background resources through *Fundamentals of Basin Evolution*

1. Research Deliverables

Project research deliverables will be made available through the BSG sponsors' Portal and include video and powerpoint presentations, papers, theses, posters, field guides, research summaries and general resources.





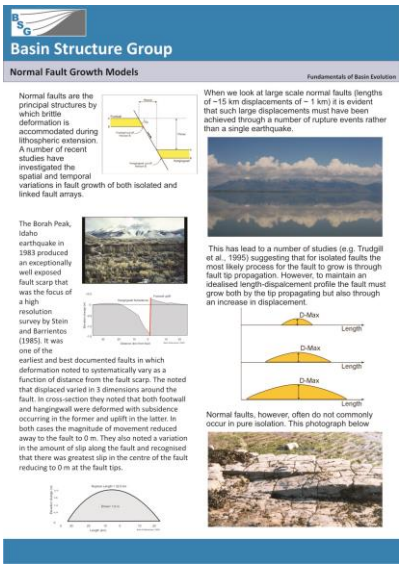


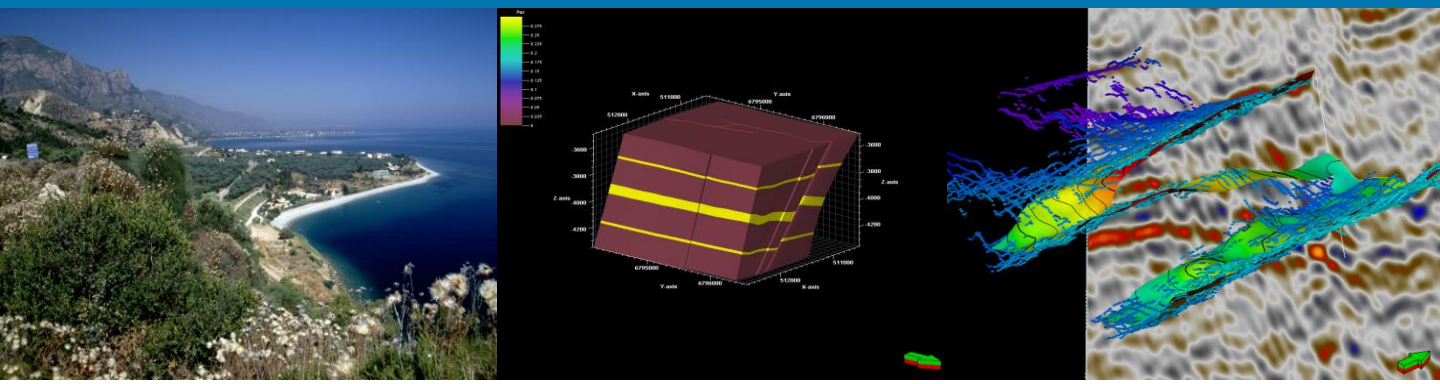
2. Fundamentals of Basin Evolution

Get up to speed quickly with a set of focussed self-learning guides if a topic is new or you want to catch up on recent developments

- Top 5 Must Read papers
- Fundamental Background
- Recent Developments
- Application of structural models to the interpretation of seismic data
- How to apply it to data analysis

Topics will cover aspects of applied structural geology and sedimentary basin evolution, covering rift basins, foreland basins, strike-slip systems, salt





KNOWLEDGE TRANSFER PORTAL continued

3. Literature Knowledge Base

- Literature database will be further developed to be searchable by publication type, topic, author, year, journal.
- Results can be marked and retrieved on your personal computer by email.
- The system links through to 'Google Scholar' to locate a source from where the full article can be obtained.
- 'BSG' Recommends' facility where we flag key papers within several principal research themes
- A star rating system to suggest its impact, coupled to a short summary of relevance for key papers

4. Integrated Research/CPD/Training

Project consortium members will have access to:

- MSc Structural Geology with Geophysics (Leeds) students for research projects aligned to business & research needs
- Opportunity to send staff on field courses, including MSc trips to SW England and Spanish Pyrenees (charged separately)
- In house/online/field training courses (charged separately)

For further information please contact:
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RECENT BSG activity and outputs

1. Current PhD projects include:

- 3D geometry and evolution of magma-rich vs magma-poor continental margins - *Mike Shotton*
- Role of strike-slip faulting in continental margins - *Sissy Vassilieou*
- Early syn-rift tectono-sedimentary interactions, Gulf of Corinth Rift, East African Rift System, Afar - *Mohamed Mohamed, Junaid Arif, Thamer Alghamdi*
- Red Sea rift evolution, including volcanic-rich syn-rift fills and fault-bounded, marine carbonate platform geometries & associated fluid flow and vuggy reservoir properties - *Mohammed Alsuhbi, Mohammed Afsafri*
- Understanding and prediction of fractured carbonate reservoir permeabilities - *Hager Atef, Wurood Alwan*

2. Recent PhD theses (since 2019) include:

- The influence of basement structure and volcanics on the evolution of the Uruguayan margin - *Holly Rowlands*
- The crustal architecture of a magma-rich margin across the rift to drift transition: Insights from the Pelotas Basin, Uruguay - *Sergio Gamez Galicia*
- Evolution of a microcontinent during continental break-up; re-evaluating the Falklands Plateau – *Roxana-Mihaela Stanca*
- Tectono-geomorphological evolution of the Northern Red Sea margins – *Saleh Alqahtani*
- Integrating gravity and magnetic data with remote sensing in structural modelling of the Benue Trough (middle and lower) of Nigeria – *Ezekiel Yenne*
- Prediction of sub-seismic faulting and fracturing in Mesozoic carbonate rocks, Southern Gulf of Mexico - *Ulises Rodríguez Del Angel*
- Controls on the evolution and character of deep-water syn-rift depositional systems – *Tim Cullen*
- Controls on the stratigraphic architecture of shallow marine systems in syn-rift basins – *Bonita Barrett*

3. Examples of recent publications:

- Alqahtani et al, 2022. Uplift evolution along the Red Sea continental rift margin from stream profile inverse modelling and drainage analysis. *J. Afr. Earth Sci.*, 192, 104551
- Barrett et al, 2020. Quantitative analysis of a footwall-scarp degradation complex and syn-rift stratigraphic architecture, northern Carnarvon Basin, NW Shelf, offshore Australia. *Basin Research,* doi.org/10.1111/bre.12508
- Cullen et al, 2021. Deep-water syn-rift stratigraphy as archives of Early-Mid Pleistocene palaeoenvironmental controls on sediment delivery. *Frontiers in Earth Sci.*, 2021, 9, 715304
- Hao et al, 2020. Rift migration and transition during multiphase rifting: Insights from the proximal domain, northern South China Sea rifted margin. *Marine and Petroleum Geology,* 123, 104729-104729
- McNeill et al, 2019. High-resolution record reveals climate-driven environmental and sedimentary changes in an active rift. *Scientific Reports,* 9:3116. doi.org/10.1038/s41598-019-40022-w
- Markwick et al, 2021. *Reclus*, a new database for investigating the tectonics of the Earth: An example from the East African margin and hinterland. *Geochem., Geophys., Geosystems*, 22 (11), doi-org.10.1029/2021gc009897
- Stanca et al, 2022. The tectono-stratigraphic architecture of the Falkland Plateau Basin; implications for the evolution of the Falkland Islands Microplate. *Gondwana Research,* **105**, pp. 320-342

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