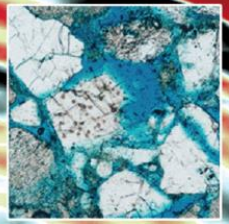
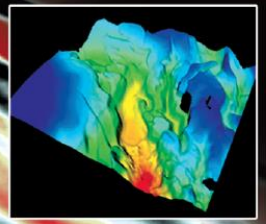
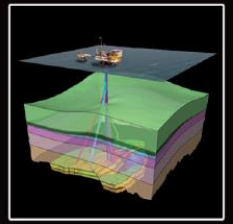

# Committee Responsibilities

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The workshop is divided into 4 sessions (2/day):

- Syn rift heatflux and subsidence (Day 1)
- Post rift heatflux and subsidence (Day 1)
- Current state of Basin Modelling (Day 2)
- Future of predicting heatflow and subsidence in areas where classic models are failing us. (Day 2)

Each session will comprise of a series of talks followed by a breakout discussion on an issue/question or topic relevant to the material presented.

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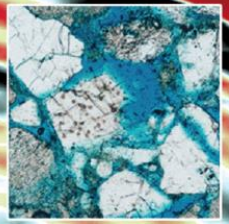
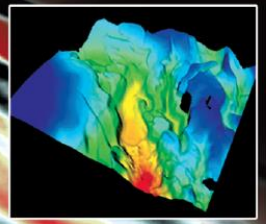
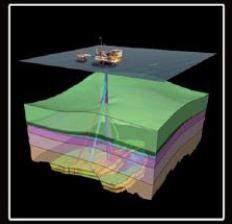

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The Breakout Discussion will each have a similar format:

- Lecture Theatre: A sub group of the committee will introduce the topic to all delegates. (10 mins)
- Breakout Rooms: Sub Groups (pre assigned) will move to your breakout rooms (30 mins)
- Lecture Theatre: All groups return to the Lecture Theatre for a group feedback sessions (20mins)

***Please note the groups are pre assigned to ensure a mixture of disciplines and experiences. You will stay in the same group for Day 1 and a different group for Day 2.***

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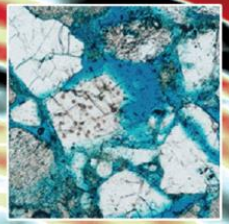
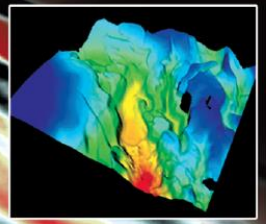
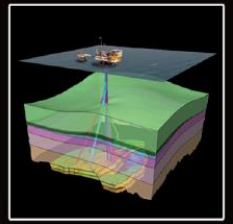

# Day 1 Groups and Rooms

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| Lower Library | Lecture Theatre 1 | Arthur Holmes Room (15 max) | William Buckland Room (15 max) | Fellows Lounge | Lecture Theatre 2 |
|---|---|---|---|---|---|
| Andrew Ball (Shell) | Andy Carr (GES) | Anne Mcafee (Corelabs) | Adam Cheng (Equinor) | Anapgorn Intawong (Spectrum) | Andrea Licciardi (UoRennes) |
| Andy Alvey (Badley) | Daniel Minguez (Chevron) | Antonio Martin Monge (Repsol) | Christine Fides (Anadarko) | Colin Grant (Shell) | Charlotte Nielsen (Total) |
| Antonie Clausse (Total) | David Gombosi (Exxon) | Ben Andrews (Anadarko) | Christine Yallup (Halliburton) | Dani Schmid (GeoMod) | Clay Painter (Conoco) |
| Arka Sarka (UoManchester) | Frank Desinois (Total) | Bennett Haworth (Ark) | Fausto Mosca (Murphy) | Iain Scotchman (Scotchman GeoChem) | Daniel Palmowski (SLB) |
| Busayo Olowokere (UoBenin) | Gianreto Manatschal (UoStrasbourg) | Christine Heine (Shell) | Ian Davidson (Earthmoves) | Josh Steinberg (Ratio) | David McLean (Anadarko) |
| Christian Nino (GALP) | Graham Baines (Halliburton) | Duncan Erratt (Exxon) | Keith Maynard (Woodside) | Kerry Gallagher (UoRennes) | Duncan Mc Gregor (McGeology) |
| Emmanuel Pettinotti (Ophir) | Guillermo Perex Drago (Beicip) | Geoffry Mohn (UdeCergy) | Mark Longacre | Marianne Mc Caughey (Nexen) | Erica Greenhalgh (BGS) |
| Garry Karner (Exxon) | Harald Karg (Wintershall) | John Hopper (Geus.Dk) | Matt Warner (Ophir) | Mark Ireland (BP) | Herbert Volk (BP) |
| Hamish Young (Sasol) | Jeff Reinprecht (Kosmos) | Lucy Heaton (Nexen) | Richard Corfield (BP) | Michael Nirrengarten (Total) | James Pindell (UoCardiff) |
| Hans Morten Bjorseth (Equinor) | Jeff Winterbourne (BP) | Marie Callis (Beicip) | Roger Baudino (Repsol) | Mohamed Gouiza (UoLeeds) | Mark Tomasso (Kosmos) |
| John Scotchmer (Premier) | Karyna Rodriguez (Spectrum) | Ned Kovas (Noble) | Sabrina Innoceti (Exxon) | Narimane Benaouali (Repsol) | Martine Hardy (Exxon) |
| Lawrence Gill (BP) | Kirk Schafer (Noble) | Nicky White (UoCambridge) | Stefan Punnette (BP) | Neil Pigott (Hess) | Michael Clutterbuck (Impact) |
| Marta Perez-Gussinye (UoBremen) | Lorcan Kennan (Shell) | Teresa Sabato Ceraldi (BP) | Tim Reston (UoBirmingham) | Paul Bellingham (Ion) | Michal Nemcok (EGI) |
| Richard Bray (SRC) | Nicola Dakin (Nexen) | Thomas Theuissen (UoBergen) | Venessa Monteleone (UoSouthampton) | Rod Graham (UoImperial) | Pauline Chenin (UoStrasbourg) |
| Sheona Masterton (Getech) | Robert Tscherny (Conoco) | William Prentergast (BP) | Wen Shi (UoManchester) | Suzanne Beglinger (Equinor) | Phillip Thompson (Shell) |
| Tim Minshull (UoSouthampton) | Stephen Jones (UoBirmingham) | | | Lars Ruepke (UoKiel) | Steve Lawrence (SRC) |

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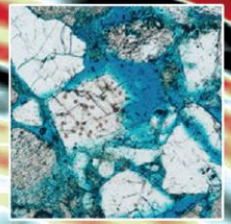
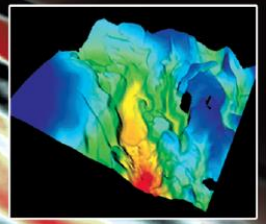
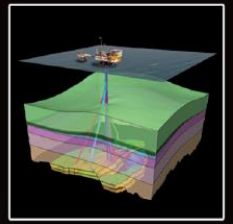

# Day 2 Groups and Rooms

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| Lower Library | Lecture Theatre 1 | Arthur Holmes Room (15 max) | William Buckland Room (15 max) | Fellows Lounge | Lecture Theatre 2 |
|---|---|---|---|---|---|
| Andy Alvey (Badley) | Arka Sarka (UoManchester) | Andrew Ball (Shell) | Andy Carr (GES) | Adam Cheng (Equinor) | Andrea Licciardi (UoRennes) |
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| Suzanne Beglinger (Equinor) | Steve Lawrence (SRC) | | | Lars Ruepke (UoKiel) | Wen Shi (UoManchester) |

PETROLEUM GROUP

# The Committee

Jonathan Hull –Committee Member of the Petroleum Group of the Geological Society of London and currently employed by Ophir Energy plc.
The mandate of the Petroleum Group is to be at the leading edge of petroleum geoscience and foster links between industry and institutions. We believe the workshop format, multi disciplinary nature of the topic and depth of expertise of the attendees the will deliver on this mandate.

Julian Moore has a PhD in shale sedimentology and petrophysics. He has 15 years experience in industry (12 BP; 3 APT) much of which has involved practical application of geoscience to petroleum exploration and resource exploitation.

Tiago is a Petroleum Systems Analyst with IGI with over 10 years industry experience. His particular focus is on understanding the thermal evolution of rift basins and passive continental margins, using a wide range of observational and modelling techniques and software, and integrating geological, geophysical and geochemical data

“Sascha Brune is a group leader at the German Research Centre for Geosciences - GFZ Potsdam.
He is using numerical models to understand and quantify geodynamic processes of rifting and continental breakup across the scales."

Helen Doran is an independent consultant with over 18 years of industry experience. Her recent work and interest focuses on understanding heat flow and subsidence around passive margins, how it changes from the proximal into the distal domains and how this change impacts our perception of plays.

Alex Bump is an Advisor and Head of Discipline for Structural Geology at BP Exploration. He has worked on 5 continents and has a keen interest in regional structural architecture, subsidence and heat flow

Nick Kusznir, Professor of Geophysics at University of Liverpool, has co-led industry consortia research projects (iSIMM, MM2, MM3, MM4, M5) focusing on rifted continental margin structure and formation processes. In collaboration with Badley Geoscience and industry he has worked on over 80 deep-water frontier exploration projects applying quantitative basin analysis and crustal thickness mapping using gravity inversion.

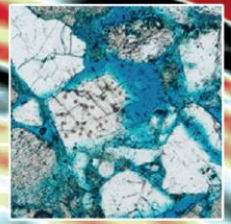
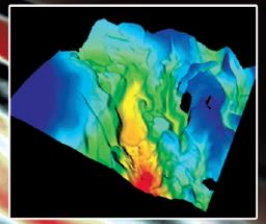
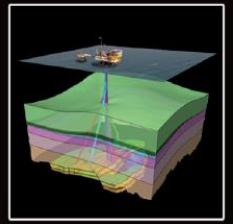
Dave Quirk is a geoscientist who currently works for Cairn Energy in Edinburgh but lives in Denmark with his wife and daughter and is European thanks to an Irish passport. He carries out research in Kiel with Lars Ruepke on rifting and continental breakup, at Manchester University on salt tectonics, on resource prediction at oil companies and on real rocks in the Isle of Man.

Mark Thompson was with BP for 36 years before his retirement in 2014. He has a background in basin analysis, play fairway analysis, prospect analysis, structure, especially of passive margins. Currently teaches courses for Nautilus.

Mike Norton is an independent consultant with over 30 years of industry experience specialising mainly in the structural geology of rifts and passive margins. He is particularly interested in the multiple stages of rifting and magmatism associated with the break-up of continents.

Gareth Roberts is a Lecturer in Earth Science at Imperial College London.
He has developed observations and theory to understand how topography, the lithosphere and sedimentary archives are affected by and record histories of mantle convection.

Ken McDermott is a structural geologist with Ion Geophysical specialising in the development of rifted margins, in particular conjugate Atlantic margins. He is interested in the tectonostratigraphic and structural evolution of magma-poor, magma-rich, and transitional systems and their effect on margin scale petroleum systems.

# Committee Responsibilities

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| | | | |
|---|---|---|---|
| Day 1 | Framework Sessions | Chair | Jonathan Hull/Mike N |
| | Session 1 Talks | Chair | Dave Quirk and Sascha Brune |
| | Break out Session 1: Syn-Rift Heat flux; Duration and Severity (1 hr)<br>• 10 mins intro in Lecture Theatre with all delegates<br>• 30 mins breakout in individual groups and assigned rooms<br>• 20 mins feedback with all delegates in Lecture Theatre | Session Leaders | Alex Bump/Mike Norton/Ken Mc Dermott |
| | Session 2 Talks | Chair | Julian Moore/Tiago Cunha |
| | Break out Session 2: Post Rift Heat Flux; Causes and Culprits (1 hr)<br>• 10 mins intro in Lecture Theatre with all delegates<br>• 30 mins breakout in individual groups and assigned rooms<br>• 20 mins feedback with all delegates in Lecture Theatre | Session Leaders | Nick Kusznir/Gareth Roberts/Mark T |
| | Post Breakout Talks (last 2 of day) | Chair | Julian Moore/Tiago Cunha |
| Day 2 | Into Key Note/Welcome Day 2 | Chair | Jonathan Hull (welcome)/ Mike N |
| | Session 3 Talks | Chair | Nick Kusznir/Gareth Roberts/Mark T |
| | Break out Session 3: The current state of modelling. Is it good enough? (1hr)<br>• 10 mins intro in Lecture Theatre with all delegates<br>• 30 mins breakout in individual groups and assigned rooms<br>• 20 mins feedback with all delegates in Lecture Theatre | Session Leaders | Julian Moore/Tiago Cunha |
| | Session 4 Talks | Chair | Alex Bump/Mike Norton/Ken Mc Dermott |
| | Break out Session 4: The future of predictive models. How can we improve? | Session Leaders | Dave Quirk and Sascha Brune |
| | Final Group Discussions<br>Helen Doran will collate all feedback to form a summary for the final session | All | All (committee to act as coordinators/control the discussions). |

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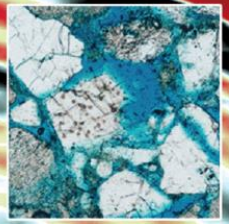
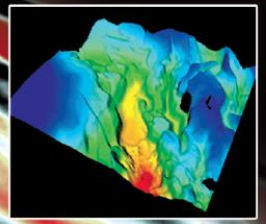
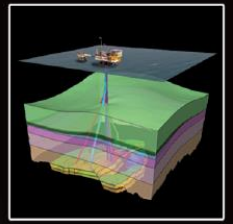

# Committee Groups

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| | Breakout Session 1 | Breakout session 2 | Breakout Session 3 | Breakout Session 4 |
|---|---|---|---|---|
| Session Leaders (Intro and Wrap Up) | **Alex Bump/Mike Norton/Ken Mc Dermott** | **Nick Kusznir/Gareth Roberts/Mark T** | **Julian Moore/Tiago Cunha** | **Dave Quirk and Sascha Brune** |
| Lower Library | Dave Quirk and **Mike Norton** | Dave Quirk and Jonathan Hull | Dave Quirk and Ken Mc Dermott | **Dave Quirk** and Gareth Roberts |
| Lecture Theatre 1 | Julian Moore and **Alex Bump** | Tiago Cunha and Alex Bump | **Tiago Cunha** and Mike Norton | Tiago Cunha and Mark Thompson |
| Arthur Holmes Room | Tiago Cunha and **Ken McDermott** | **Mark Thompson** and Ken McDermott | Gareth Roberts and Helen Doran | Mike Norton and Jonathan Hull |
| William Buckland Room | Mark Thompson and Gareth Roberts | Julian Moore and **Gareth Roberts** | **Julian Moore** and Mark Thompson | Julian Moore and Helen Doran |
| Fellows Lounge | Nick Kusznir and Jonathan Hull | **Nick Kusznir** and Helen Doran | Nick Kusznir and Alex Bump | Nick Kusznir and Ken Mc Dermott |
| Lecture Theatre 2 | Sascha Brune and Helen Doran | Sascha Brune and Mike Norton | Sascha Brune and Jonathan Hull | **Sascha Brune** and Alex Bump |

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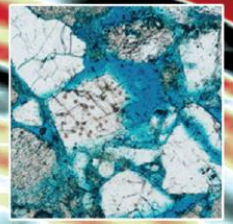
# BREAKOUT SESSION 1



# Breakout session 1 Syn-rift heat flux

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Main themes

- The McKenzie model:  Where does it work and where doesn't it?
- Subsidence change with time: How does this vary with rift type.
- Magmatism: Does it precede, accompany or follow rifting (or all of the above)? Implications for subsidence and heatflow.

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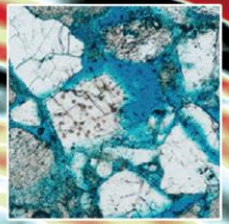

# Breakout session 1 Syn-rift heat flux

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Discussion topics and session deliverables

1. Where does the McKenzie rifting model break down? What is truly anomalous?
2. How do we define syn-rift? How does the “sag phase” observed in the South Atlantic fit in?
3. Why do some margins move quickly to break-up (e.g. South Atlantic transform, ~10 Ma), while others have protracted rifting (e.g. Greenland-Norway >100 Ma)? Why does break-up happen when and where it does?
4. Are SDRs part of the syn-rift and what do they imply for dynamic support and heatflow duration/timing?
5. What are the changes in elevation/water depth during evolution of rifting?

1. Show types of basin on a global map - *what would we show?*

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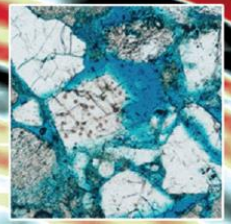

# Breakout session 1 Syn-rift heat flux

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Factors affecting the syn-rift

- Position on the margin (proximal/distal)
- Type of margin (volcanic/non-volcanic/hybrid)
- Driving force for rifting (regional tectonics/plumes)
- Nature of the crust before break-up (cratonic/mobile belt/earlier rift zone)
- Overall symmetry (mirror image/upper&lower plate)

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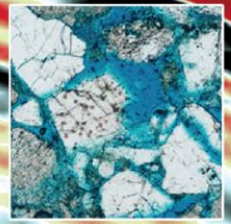
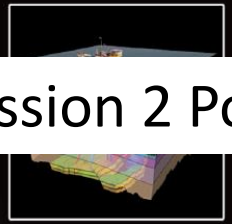
# BREAKOUT SESSION 2





# Breakout session 2 Post rift heat flux

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Context

- Observation: post-rift heat flow in some basins appear anomalously high or low long after rifting has ceased.

- The problem: these events may have a positive or a negative impact on SR maturity and reservoir quality or their impact may be overestimated by use of present day temperature data.

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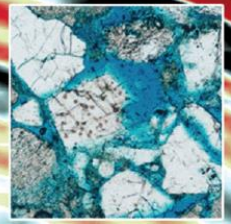

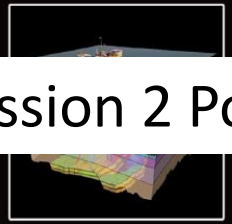

# Breakout session 2 Post rift heat flux

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Discussion topics and session deliverables

1. Identify basins with anomalous post-rift heat-flow - providing a reference (or pers. comm).

2. Discuss the geo-processes that might contribute to ‘anomalous’ heat flow during the post-rift phase in order of importance.

3. Show basins with anomalous post-rift heat-flow on a global map together with their possible geo-process causes.

4. What are the gaps in our knowledge and how might we fill them (eg industry consortia, workshops, courses) that we as a group can start up?

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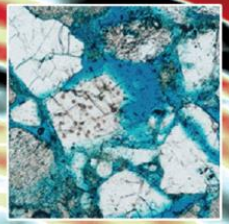

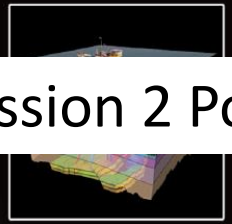

# Breakout session 2 Post rift heat flux

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## Geo-processes affecting the post rift

- Nature of the crust (continental/transitional/oceanic)
- Time since spreading and magnitude of the heat flow anomaly (including underplating)
- Intraplate magmatism (hot spots) - duration and timing of magmatic events
- Effects of a passing ridge on a major oceanic transform
- Thermal blanketing
- Fluid circulation (pore water expulsion and hydothermal)
- Mantle convection (dynamic topography)
- Other processes?

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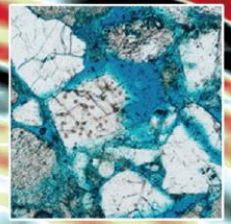

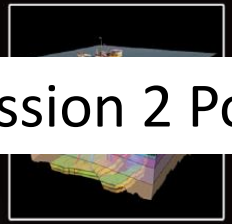

# Breakout session 2 Post rift heat flux

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Case histories from this conference with anomalous post-rift heat flux

- Exmouth Plateau (sediment blanketing)
- Voring (underplating)
- DW Sergipe and Potiguar (magmatism)
- Benguela (magmatism)
- DW Gulf of Guinea (magmatism)
- Labrador Sea (basement inheritance)
- South China Sea (magmatism)
- Onshore East Greenland (magmatism)
- Mauritania-Senegal (magmatism)
- Rockall Trough (magmatism)
- Post Miocene subsidence NWS Australia (mantle convection)
- South Labrador Sea, Chidley Basin (low HF: nature of the crust)
- Other anomalous areas identified during workshop discussions?

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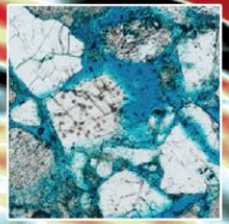
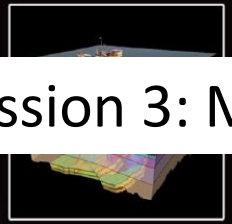
# BREAKOUT SESSION 3





Breakout session 3: Modelling

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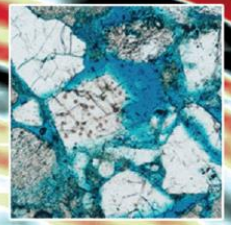
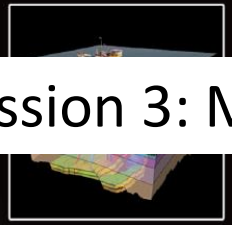
# *The current state of modelling: is it good enough*

1) Some statistics.
2) The observation & the problem
3) Some suggested discussion points.





# Breakout session 3: Modelling

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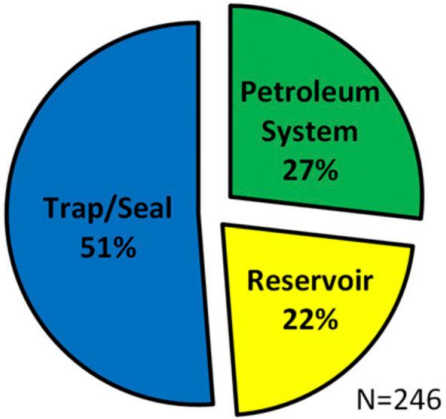
***Exxon paper***
***Rudolph & Goulding (2017)***

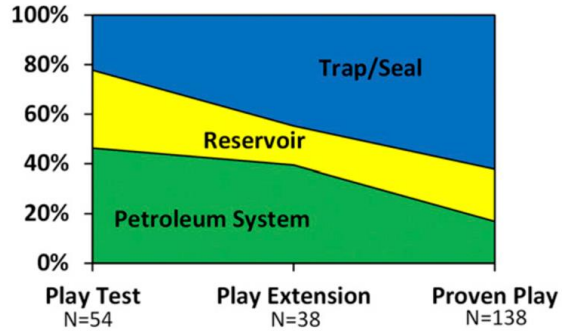
## *The current state of modelling: is it good enough*

All wells:



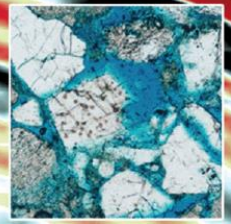

In proven plays, trap and seal risk is preeminent . This is more commonly a prospect-specific issue. Within proven plays, reservoir and especially hydrocarbon system aspects are calibrated by regional control and therefore are somewhat lower risk.

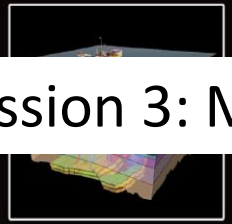
Wells by play maturity.




For unsuccessful wildcats, the critical risk factors vary by play maturity. Nearly half of dry holes that were play tests or play extensions failed because of hydrocarbon system elements—source presence, maturity, migration, or timing (Figure above). Most commonly, petroleum system risk contains a play-scale aspect, with success or failure critically influencing the outlook for adjacent prospects.

***How do you know the trap worked if there is no charge?***





# Breakout session 3: Modelling

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***The current state of modelling: is it good enough.***

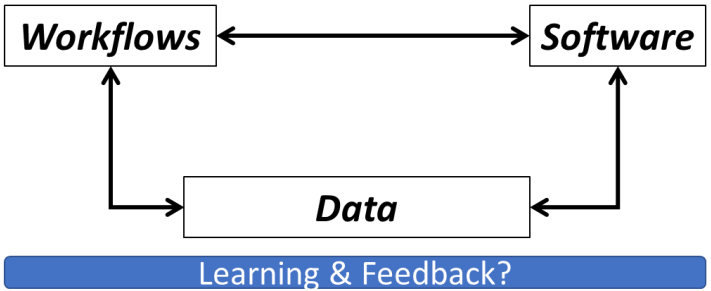
## The observation.

Dry holes in exploration settings are commonly attributed to a Petroleum systems failure. To what degree does this reflect issues in heat flow prediction?

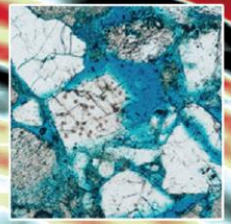
## The problem.

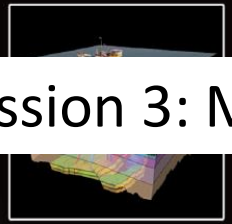
Thermal and subsidence modelling are arguably the most accurate tools in the context of the petroleum systems analysis. Passive margins, in their deep-water environments, on the other hand, are only recently explored for HC's, and data in the public domain is still scarce. A lot of effort has been put into modelling calibration data is sparse and perhaps inadequate. Sharing data, as possible, and debating concepts is therefore timely.

Some suggested discussion points:




***Some themes and interactions to think about***





# Breakout session 3: Modelling

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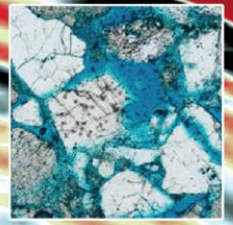
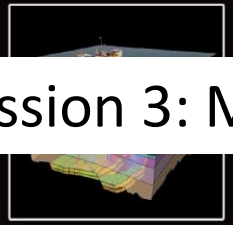
1) Different models (DDS, syn-rift/early post rift serpentinization & magmatism etc) and classification systems (Magma-poor/rich, Symmetric/Asymmetric/Upper/Lower plate) have been proposed to describe passive margins. But what implications do they have for post-rift heat flow and SR maturity? Do any provide a predictive framework that has been adequately calibrated? Discuss and present back to the room how this can be best addressed across the industry.
[*request every group to say if they agree or disagree with the statement; if they agree provide three (or more) things they would like to seen done to improve things*]

2) Heat-flow prediction is dominated by the forward modelling approach. Is this optimal for the problem we face?
[*are there completely different approaches to tackle the issue? should more use be made of inverse approaches - not currently available in commercial packages*]

3) Are the software packages we use to model petroleum systems appropriate to deal with the burial-thermal history of sediments in passive margin deep water environments?
[*again request every group to say if they agree or disagree with the statement; and what can be done to improve the models… provide 3 things*?





# Breakout session 3: Modelling

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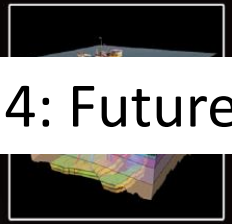
4) Is calibration part of the problem. Data collection is challenged by budgets - typically we only get LWD temps; when data is collected deep water sections are frequently poor in vitrinite. Do we need some new methods for calibration?
[*Sub-question are we collecting enough data? are we collecting the right data? Should/Could we share data (e.g. BHTs, gradients, maturity) faster? If our wells aren't adequately calibrated what chance do we have to estimate our prediction error? if we can't do this how can we learn and improve?*]

5) Can prediction failures be mainly attributed to the inadequacies in the software, workflow or operator?
[*if we could improve one thing out of software, workflows or training for our modellers what would it be? what would be more efficient/beneficial to replace in the short term, software, workflows or training?*

6) How compelling are the evidences of post-rift regional vertical movements and fluctuations of the geothermal gradients? Do we know enough about the mechanisms to incorporate them in the models and make predictions?

# BREAKOUT SESSION 4





# Breakout session 4: Future of Modelling

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**Break out Session 4: The future of predictive models. How can we improve?**

*Context to be discussed up front by session leaders (10 mins):*

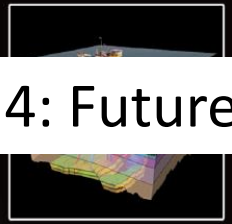
**Overview and recent modelling advances:**

- Modelling is the only tool that links structural aspects and physical material properties.
- Computational power has increased drastically -> Higher resolution, larger domains, more complexity
- Predictive modelling:  subsidence & basement heat flow evolution, rifted margin asymmetry

**Outstanding problems:**

- Additional processes required to match real data
- Elevation during rift-breakup – are dynamic topography or trapped magma the only valid mechanisms?
- Integration of wide range of data sets (e.g. stratigraphic thicknesses, palaeobathymetry, β factors, maturity & palaeotemperature indicators, present day heatflows, etc.)





# Breakout session 4: Future of Modelling

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**Break out Session 4: The future of predictive models. How can we improve?**

*For Discussion: In Breakout Groups (25mins):*

**First-order questions (will be adopted according to previous break-out sessions):**

Which problems do we yet have to solve (e.g. palaeo-bathymetry at break-up, heatflow in deepwater)

Is there a need to better link observational data, data-driven models and a-priori forward models?
- if yes, what should be our next steps? E.g. Joint research activities, workshops, training courses, …

How best to integrate multiple, diverse data types? Can we truly be predictive or are we just fitting data?

How can we effectively connect & integrate individual modelling efforts? Sharing routines, data, models?

How can we make the results relevant & applicable to those outside the modelling community?

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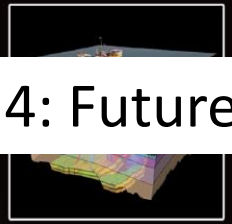

# Breakout session 4: Future of Modelling

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**Break out Session 4: The future of predictive models. How can we improve?**

*For Discussion: In Breakout Groups (25mins):*

**Reserve questions:**

Which uncertainties should we focus on (e.g. initial layer thicknesses, mantle properties, melt processes, sediment heterogeneity)?

Do we tweak input parameters to get the answer we want? How do we know which parameters to tweak?

Can we make geodynamic models predictive rather than just reacting to the latest structural ideas?

When ought we say a structural model does not work & we should start again?

Can we explain the subsidence & heatflow history of world class oil basins outside NW Europe?

Which mathematical algorithms for which problems?

Future vision - which research directions will be important in 10 years from now?

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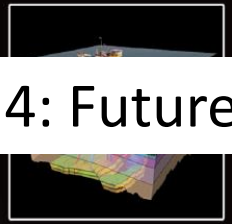

# Breakout session 4: Future of Modelling

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**Reserve questions – Part 2:**

Can we do more than just test sensitivities on the latest structural models?

Modelling is simplification.  Do we get this right?

Modelling methods - which tools are best suited for different problems?

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