

# ATLANTIC IRELAND 2010

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A One Day Conference on the Latest Research  
into Ireland's Offshore Hydrocarbon Potential  
Sponsored by PIP-ISPSG



## PROGRAMME & SHORT ABSTRACTS

**Location:** Burlington Hotel, Dublin, Ireland

**Date:** 2<sup>nd</sup> November 2010 – 08.30 to 18.00 hrs

**Audience:** Researchers, exploration companies, geophysical contractors, government departments & agencies, international guests.

Edited by:

Martin Davies & Tom Moore



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<div>  <div> <b>Tuesday 2nd November 2010</b>  <b>Atlantic Ireland 2010</b>            Burlington Hotel, Upper Leeson Street, Dublin 4         </div> </div>	
A Research Conference Sponsored by PIP-ISPSPG	
<b>Registration</b>	
07.30 – 08.30	Registration - Coffee served in Poster Room
<b><u>Setting the Scene</u></b>	
08.30 – 08.40	Opening Remarks (DCENR)
08.40 – 08.55	Address by Minister of State Conor Lenihan
08.55 – 09.15	Atlantic Exploration, meeting the challenges - Noel Murphy (PAD, DCENR), Richard Vernon (PIP Secretariat)
09.15 – 09.20	Questions
<b>Session 1 - Petroleum Systems I</b> Chair: Jonathan Craig (ENI)	
09.20 – 09.25	Introduction
09.25 – 09.50	A new Kinematic Plate Reconstruction between Ireland and Canada - Bridget Ady, Richard Whittaker (GeoArctic)
09.50 – 10.10	Regional Tectonostratigraphy; the Irish Mesozoic basins and their comparison with Atlantic Canada counterparts - Yongtai Yang (UCD)
10.10 – 10.30	Pb isotopic composition of Feldspars from Upper Jurassic sandstones in the Northern Porcupine and North Sea basins - Aine McElhinney (UCD)
10.30 – 10.40	Questions
10.40 – 11.15	Coffee - to be served in the Poster Room
<b>Session 2 – Petroleum Systems II</b> Chair: Pat Shannon (UCD)	
11.15 – 11.20	Introduction
11.20 – 11.40	WARRP seismic acquisition across the conjugate North Atlantic margins: Experiment Phase 1 – southwest Ireland to Porcupine Abyssal Plain - Brian O'Reilly (DIAS)
11.40 – 12.00	An update on Petroleum Systems Assessment west of Britain and Norway; implications for Atlantic Ireland's prospectivity - David Mudge (Ternan)
12.00 – 12.20	Sand provenance analysis of the North Atlantic Realm – Christian Knudsen (GEUS)
12.20 – 12.30	Questions
12.30 – 14.00	Buffet Lunch - to be served in the Poster Room



 <p><b>Tuesday 2nd November 2010</b>  <b>Atlantic Ireland 2010</b>          Burlington Hotel, Upper Leeson Street, Dublin 4</p>	
14.00 – 14.20	<b>Session 2 (cont'd)</b> Is the Porcupine Basin a "failed" mega-poor rifted basin? Evidence from very long offset, deep penetration 2-D seismic data – Ken McDermott (University of Birmingham)
14.20 – 14.40	Progress on Nova Scotia's OETR project and the Moroccan conjugate margin – Sonya Dehler (GSC Atlantic/OETR)
14.40 – 14.45	Questions
	<b>Session 3 – Facilitating Exploration</b> Chair: John O'Sullivan (Providence)
14.45 – 14.50	Introduction
14.50 – 15.00	Ireland's data policy; importance of quality technical information; the opportunities provided – Michael Hanrahan (PAD, DCENR)
15.00 – 15.10	Regional long offset 2D seismic data West of Ireland – Nick Blake (ION-GXT)
15.10 – 15.20	Prospectivity review of the PGS Atlantic Margin data set – Andrew Botsford (Petroleum Geo-Services)
15.20 – 15.35	Field Development options in Irish Deepwater Basins – Matt Carolan (Challenge Energy), Guy Woodason (Procyon Oil & Gas)
15.35 – 15.40	Questions
15.40 – 16.10	Coffee - to be served in the Poster Room
	<b>Session 4 – Prospects 2 Go</b> Chair: John Conroy (Shell)
16.10 – 16.15	Introduction
16.15 – 16.30	Prospects for Atlantic Ireland and comparison with neighbouring UKCS - Andrew Vinall (Hannon Westwood)
16.30 – 16.40	PROSPECTS 2 GO - The Dalkey Island Prospect – Rare shallow water high impact oil exploration potential offshore Ireland - Providence Resources
16.40 – 16.50	PROSPECTS 2 GO - Northeast Irish Rockall – A Successful Revelation in Sub-Basalt Imaging - Ciaran Nolan, Serica Energy
16.50 – 17.00	PROSPECTS 2 GO - An overview of San Leon Energy Atlantic Margin prospects and their conjugate margin context – San Leon Energy
	<b>Session 5 - Conference Roundup</b> Chair: Viv Byrne (with all speakers and chairs from previous sessions on podium)
17.00 – 17.30	A summary of the main conclusions of the conference and an opportunity for the delegates to question the panel on more general aspects of the ISPSG research programme
	<b>Poster Session</b>
17.30 – 18.30	All poster presenters are requested to stand by their posters and give a 2 to 3 minute summary of the main points of their poster.
17.45 – 19.30	<b>Reception</b> will be held in the poster room in parallel with the poster session.



**ORAL ABSTRACTS** (in order of presentation)

Speaker is underlined

**Atlantic Exploration - Meeting the Challenges**

Murphy, N.<sup>1</sup>; Vernon, R.<sup>2</sup>

<sup>1</sup> *Petroleum Affairs Division, Dept. Of Communications, Energy and Natural Resources*

<sup>2</sup> *PIP Secretariat*

The Atlantic Basins of Ireland are an under-explored frontier petroleum province with proven working hydrocarbon systems. Source rock modelling, prospect evaluation and analogue basin review show a risked yet to find potential of at least 10 billion barrels of oil equivalent. The structural styles allow for the presence of giant un-drilled structures. Therefore it is not unreasonable to say that Ireland is at the beginning of the pipeline providing natural gas to mainland Europe rather than at the end of the gas pipeline importing gas from our European neighbours.

Alongside the Irish Government initiatives to promote Ireland as a place to explore for oil and gas the Petroleum Infrastructure Programme (PIP) has a critical role to play. For instance the major petroleum systems studies of 2005 and 2006 are underpinning the Department of Communications, Energy and Natural Resource's technical promotion of offshore Ireland's prospectivity. An important element of PIP is the international collaboration with government and researchers from our Atlantic Margin neighbours including the UK, Denmark, Canada and Norway, who are represented today at this conference. The recent Conjugate Margins Conference in Lisbon has highlighted the renewed interest of oil exploration companies in the deeper Atlantic Margin basins.

The challenges facing those who promote Ireland as a place to explore are many including reducing geological risk, clarifying the fiscal terms, explaining the track record of exploration, which at face value looks poor, providing baseline environmental data, counteracting the perceived risk of hostile deep water drilling west of Ireland and the higher cost of operating offshore Ireland.

The Petroleum Infrastructure Programme has focussed in on some of these challenges and has provided for example cetacean and seabird research and regional environmental baseline studies underpinning Ireland's SEA programmes; drilling downtime and field development studies demonstrating that exploration and development operations are feasible in most parts of the Irish offshore and online databases to allow easy access to data for further studies.

This conference will address the contribution of PIP to our understanding of petroleum systems and show how PIP facilitates exploration offshore Ireland. The conference will also showcase some prospects on offer offshore Ireland and finally you the delegates will have an opportunity to contribute your thoughts on future petroleum exploration research in the Conference Roundup session this afternoon.

## **A New Kinematic Plate Reconstruction between Ireland and Canada**

Ady, B.<sup>1</sup>; Whittaker, R.<sup>1</sup>; Alvey, A.<sup>2</sup>; Roberts, A.<sup>2</sup>; Kuszniir, N.<sup>3</sup>

<sup>1</sup> *GeoArctic Ltd, Calgary, AB, Canada*

<sup>2</sup> *Badley Geoscience Ltd., Spilsby, Lincolnshire, UK*

<sup>3</sup> *Department of Earth Sciences, Liverpool University, Liverpool, UK*

In comparison with other continental margins, the North Atlantic deep water basins of Ireland and Eastern Canada are very lightly explored with only a small number of wells drilled. Understanding the tectonic history of the conjugate margins of Newfoundland and Ireland is critical for evaluating their hydrocarbon potential, yet existing plate tectonic models for the North Atlantic are inadequate. Over the next two years GeoArctic Ltd., in collaboration with a team of leading researchers from academia, government, and industry on both sides of the Atlantic, will develop a Kinematic Plate Reconstruction of the North Atlantic between Ireland and Canada. The project team includes researchers from Badley Geoscience Ltd., Memorial University of Newfoundland (MUN), University College Dublin (UCD), the Dublin Institute of Advanced Studies (DIAS), the Geological Survey of Canada (GSC), and others. The project is due for completion in June 2012.

The integrated workflow developed for the project combines 4D deformable plate techniques and seismic, magnetic and geological interpretation with the analytical techniques of 2D or 3D gravity inversion, flexural backstripping, fault analysis and forward modelling. The project will use 2D and 3D structural modelling and gravity inversion to calculate crustal stretching in order to develop a new deformable plate model that will remove overlap and under-fit between plates. The new model will be useful in furthering our understanding of the major controls and mechanisms for North Atlantic basin formation and evolution.

## **Regional Tectonostratigraphy: The Irish Mesozoic Basins and Their Comparison with Atlantic Canada Counterparts**

Yang, Y.; Shannon, P.M.

*School of Geological Sciences, UCD, Dublin 4, Ireland.*

The results of a regional review of Late Jurassic to Early Cretaceous basin configurations in the North Atlantic region are presented. These show that the Atlantic Margin basins west of Ireland (Porcupine, Rockall and Slyne-Erris) lay in close proximity to the offshore Newfoundland basins (East Orphan, Flemish Pass and Jeanne d'Arc). In particular, during the Late Jurassic, the Porcupine Bank, Orphan Knoll and Flemish Cap were located closely each other and the East Orphan basin with thick Jurassic succession was the southward extension of the Rockall Basin. Some regional comparisons of Late Jurassic to Early Cretaceous lithofacies illustrate interesting trends. The Base Cretaceous Unconformity is of regional importance in virtually all the Irish basins, as well as many others along both sides of the Atlantic margin. Based on a comparison between the Irish basins, North Sea Rift, and basins between Newfoundland and Iberia, insights are provided on the nature, control and mechanisms of formation of the Late Jurassic to Early Jurassic transition along the North Atlantic

margin. This study suggests that during the Jurassic-Cretaceous transitional period, the more intense extension in the upper and middle crust beneath the Rockall Basin was balanced through brittle/ductile transition zones and a series of NW-SE trending transfer zones, resulting in compressional and transpressional folding and uplift along the NE Atlantic margin. In addition, thermal doming appears to have played a major role in the formation of the Cretaceous regional unconformity between Newfoundland and Iberia.

## **Pb isotopic composition of Feldspars from Upper Jurassic sandstones in the northern Porcupine and North Sea basins**

Mc Elhinney, Á.<sup>1</sup>; Tyrrell, S.<sup>1</sup>; Haughton, P.<sup>1</sup>; Wilkinson, M.<sup>2</sup>

<sup>1</sup> *School of Geological Sciences, UCD, Dublin 4, Ireland.*

<sup>2</sup> *Department of Geology and Geophysics, Grant Institute, Kings Building, University Edinburgh, Edinburgh.*

Provenance studies help in constraining palaeogeography and sediment dispersal to ancient basins and can have important implications for the distribution and quality of potential hydrocarbon reservoirs. The Pb isotopic composition of detrital K-feldspar has proved to be an important indicator of provenance, particularly when reconstructing regional palaeodrainage. There are significant issues in Jurassic-Cretaceous basins west of Ireland in relation to sand-entry points, routing within and between the basins, sand-source areas and palaeogeography. The Mesozoic plate configuration, links between the conjugate Atlantic margins and the regional tectonostratigraphy are also key to future exploration in the Irish offshore.

A pilot Pb isotopic study (conducted in 2006) of Porcupine detrital K-feldspar grains highlighted a bimodal distribution and suggested that the Upper Jurassic reservoir sandstones were sourced from the north from the uplifted Porcupine High (mainly Proterozoic basement rocks). This implied hinterland drainage extending a maximum of 200 km northwards and that the non-marine and deep-marine sandstones in the northern Porcupine may have lain on the same north-south dispersal path. A more detailed provenance analysis at a greatly increased resolution (including the analysis of the fine grain fraction for the first time) is currently being undertaken, initially focussing on well 35/8-2. The aim is to investigate how robust the bimodal signal is across a wider stratigraphic interval and in different facies. A parallel study of Jurassic sandstones (Fulmar Formation) in the North Sea is also underway in order to better constrain whether burial depth and progressive loss of K-feldspar can compromise the provenance signal. Feldspar abundance is known to decrease with depth in the Fulmar Formation.

Preliminary Pb results from 35/8-2 confirm the overall bimodal feldspar composition, but with larger numbers of analyses sub-populations can be defined within the main groups that may correspond to discrete basement sources. Early results from the well-drilled Fulmar Formation across a range of core depths (3-5 km) appear to show that there is no variation in Pb composition despite the loss of K-feldspar in deeper samples. This bodes well for the application of the technique in the Atlantic margin basins.

## **WARRP seismic acquisition across the conjugate North Atlantic margins: Experiment Phase 1 - southwest Ireland to Porcupine Abyssal Plain ISPSG Project IS09/06**

O'Reilly, B.M.<sup>1</sup>; Shannon, P.M.<sup>2</sup>; Readman, P.W.<sup>1</sup>; Welford, J.K.<sup>3</sup>; Hauser, F.<sup>2, 1</sup>

<sup>1</sup> *Geophysics Section, Dublin Institute for Advanced Studies*

<sup>2</sup> *UCD School of Geological Sciences, University College Dublin*

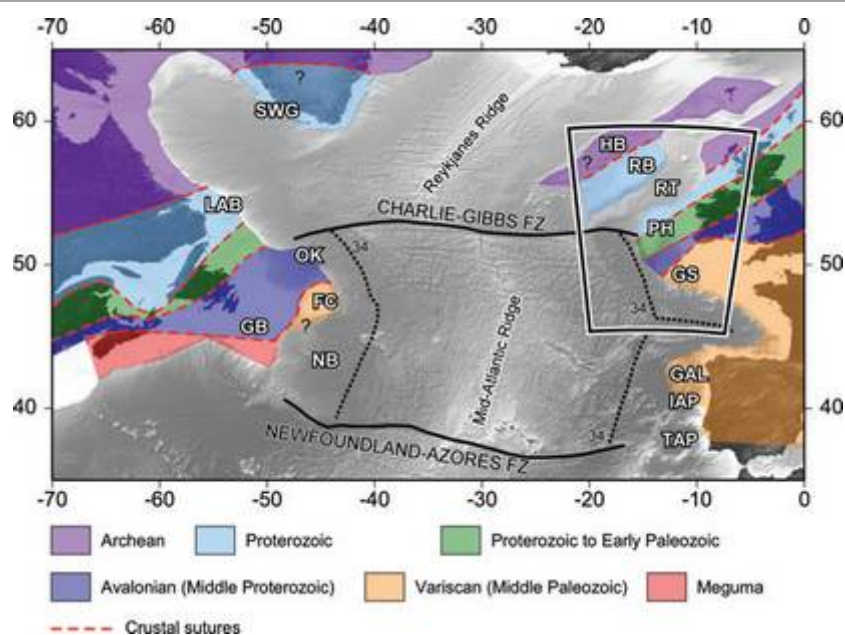
<sup>3</sup> *Department of Earth Sciences, Memorial University of Newfoundland*

The Irish and Newfoundland offshore regions (Figure 1) formed an interlinked system of Mesozoic sedimentary basins and highs, sited upon different pre-rift basement terranes, before the onset of seafloor spreading in the North Atlantic in latest Cretaceous to Early Cenozoic times (Naylor and Shannon, 2009; O'Reilly et al., 2010 and Welford et al., 2010). In the context of "plate kinematics" the development of the system at a regional trans-Atlantic scale is not well understood. Increased understanding requires additional information about the structure of the basin-fill sediments to deep levels within the subcrustal lithosphere than has hitherto been achieved (Shannon et al., 1999; Morewood et al., 2005; O'Reilly et al., 2006 and Hauser et al., 2010).

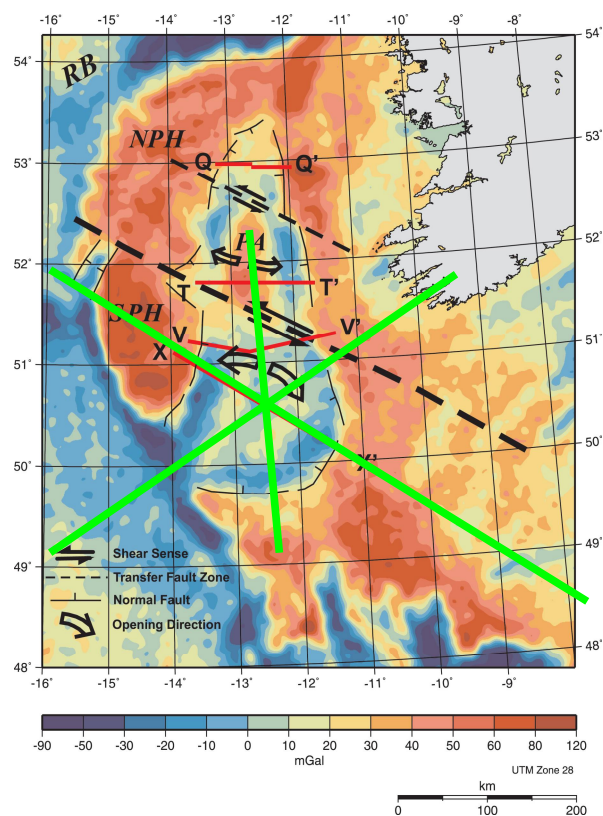
The major objective of the new proposed WARRP acquisition programme (summarised in the poster presentations) is to fill critical gaps in base-line information on the structure and physical properties of the upper lithosphere, and on the broad sedimentary succession, in key areas of the conjugate Irish and Newfoundland margins (Shannon et al., 1995). The data acquired will be of critical importance in the task of reconstructing the Late Palaeozoic to Cenozoic thermal and tectono-stratigraphic evolution of the North Atlantic region. This aspect of the proposed work is essential to understanding the relationship between the known hydrocarbon systems of both conjugate margins and "de-risking" frontier exploration, especially in the deeper water parts across the North Atlantic region.

A related project entitled "Kinematic Plate Reconstruction Project between Ireland and Canada" is being initiated to synthesise existing data sets with the ambition to establish a global North Atlantic large-scale picture (see additional Abstracts for details). This talk outlines the plan for the acquisition of new WARRP data along the Irish/Newfoundland conjugate margins, summarised in the poster session. Details of the WARRP acquisition in the Porcupine Seabight Basin (Phase 1) are given in greater detail (Figure 2) and examples of the scientific reasoning that underpins the design of Phase 1 (Figure 3) is demonstrated from synthetic seismic calculations using known seismic velocity structure across parts of basin (Figure 4).

The proposed experimental design for Phase 1 is an unprecedented opportunity to combine various seismic source types across a broad band-width (i.e. higher frequency ca. 25 Hz long streamer, ~ 20 km, seismic reflection data; low frequency, ca. 15 Hz, WARRP data and very low frequency, ca. 4 Hz, long range controlled source data). This will enable high resolution tectono-stratigraphic geometries, in the potentially petroliferous basin-fill sediments and pre-rift crust, to be directly linked to deeper physical and chemical processes within the highly extended crust that lies beneath the basin and within the sub-crustal lithosphere close to asthenospheric depths within the mantle. Some more details of the WARRP seismic acquisition programme are given in the poster session.

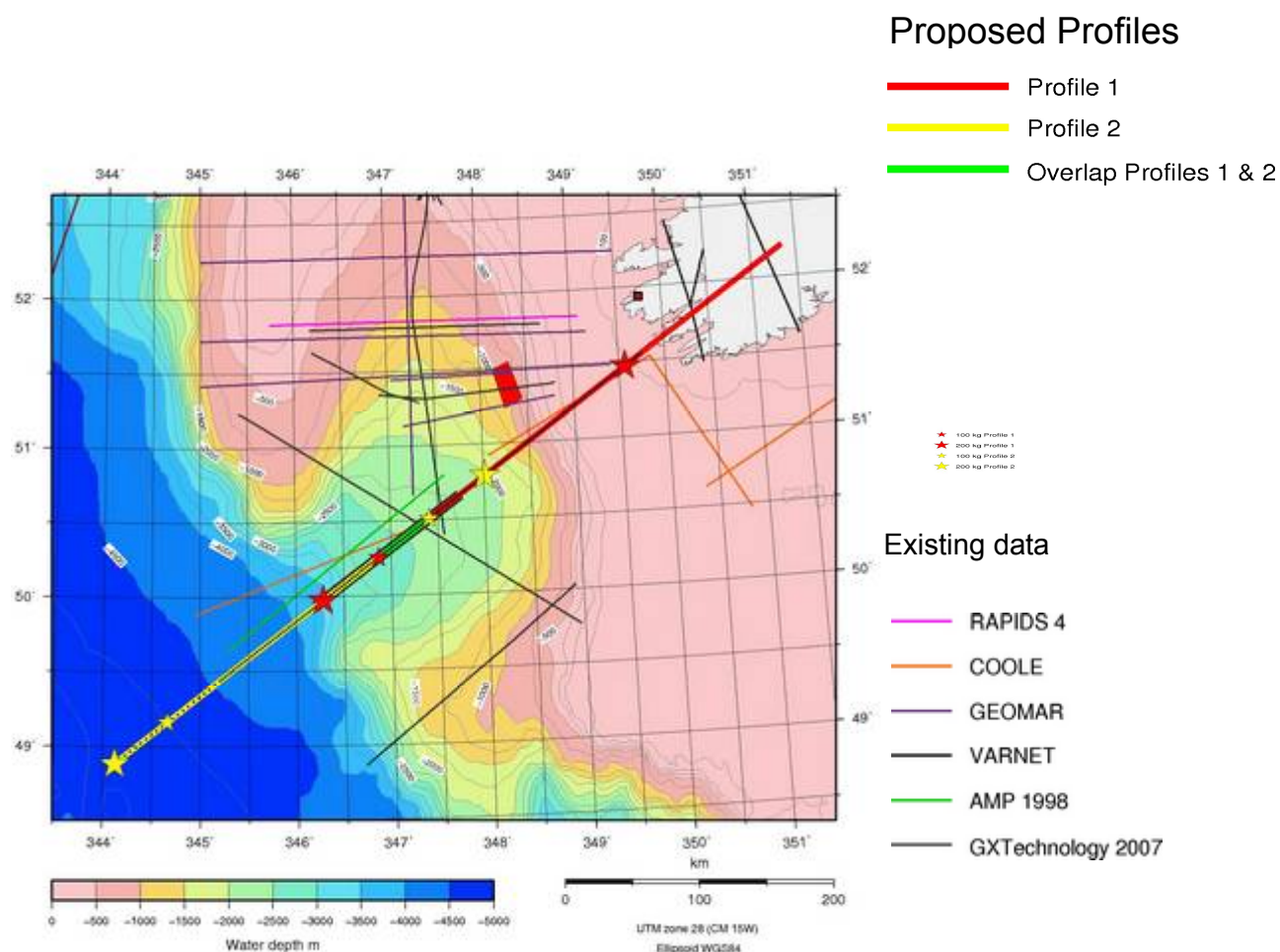


**Figure 1.** Bathymetric map of the North Atlantic region subdivided by inferred basement affinity of continental crust, adapted from Welford et al. (2010) and references therein. Location of Magnetic Anomaly (CHON 34) - dotted line segments. Bathymetric structure abbreviations: FC, Flemish Cap; FZ, Fracture Zone; GAL, Galicia Bank; GB, Grand Banks; GS, Goban Spur; HB, Hatton Bank; IAP, Iberian Abyssal Plain; LAB, Labrador; NB, Newfoundland Basin; OK, Orphan Knoll; PH, Porcupine High; RB, Rockall Bank; RT, Rockall Trough; SWG, South West Greenland; TAP, Tagus Abyssal Plain.





**Figure 2.** Locations of proposed WARRP profiles (green lines) in the Porcupine Basin displayed on free-air gravity map of the basin. Existing RAPIDS4 profile (T-T) (O'Reilly et al 2006) is shown in red. Labels are: RB (Rockall Basin), NPH (North Porcupine High), SPH (South Porcupine High), PA (Porcupine Arch). Solid dashed lines are inferred (postulated) transfer zones that accommodate lithospheric block extension and differential rotation (indicated by arrows). Generalised basin-bounding normal faults indicated by thin black lines in regions of high gravity gradient. Adapted from Readman et al (2005).



**Figure 3.** The new data in the Porcupine Basin will be acquired in two profile segments (**red P1 and yellow P2 lines**) with a central overlap region coincident with, recently acquired, long-streamer reflection data (**green line**). Small black dots – OBS positions, spaced at intervals of 2.5 km, stars – reversed controlled sources at extremities of each profile segment.

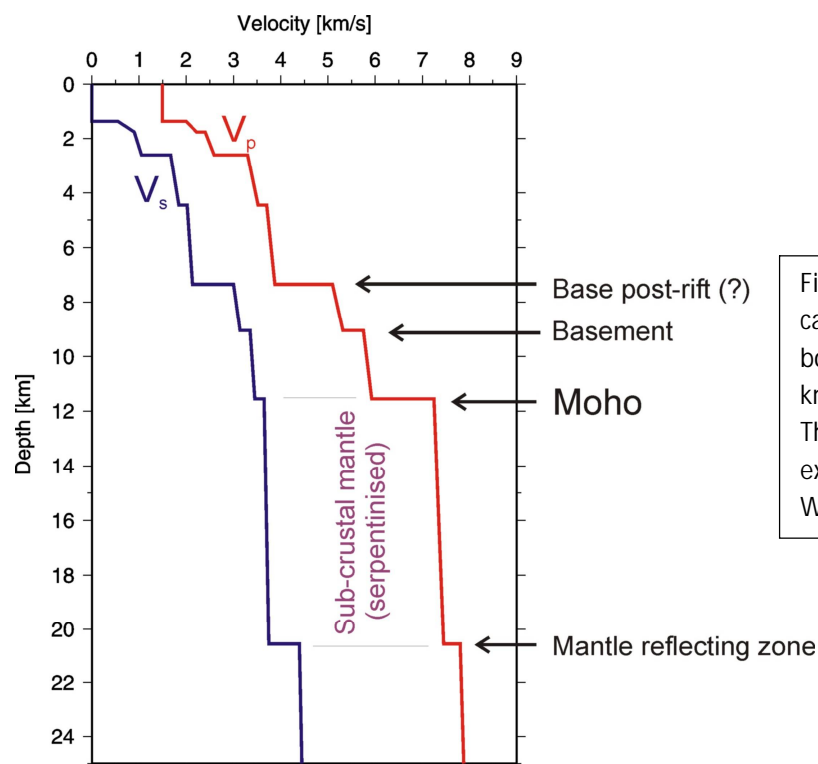


Figure 4. 1-D velocity/depth functions used to calculate full waveform synthetic seismograms for both P and S waves over various distances (30 - 300 km) and different seismic frequencies (3 - 20 Hz). These calculations underpin the design of the Phase 1 experiment and are based on recently acquired WARRP data in the Porcupine Basin across the

## An Update on Petroleum Systems Assessment West of Britain and Norway: Implications for Atlantic Ireland's Prospectivity

Mudge, D.

*Ternan*

The Northeast Atlantic depositional province extends more than 3000 km from the Rockall Trough and Porcupine Seabight Basin to the western Barents Sea margin. This province was the site of a long-lived but narrow seaway which separated Greenland and northern Europe during Jurassic to Palaeocene time. This seaway connected the North Atlantic and Arctic oceanic realms, undergoing significant widening as a result of continental extension prior to breakup and initiation of sea-floor spreading in the early Eocene. Continuous extension led to the formation of a series of fault-bounded basins separated by NW-SE lineaments that acted as transfer zones during episodes of rifting.

The discovery of widely distributed Oxfordian-Kimmeridgian and Sinemurian-Toarcian source rocks associated with reservoir sandstones of Carboniferous to early Eocene age in early wells drilled on the European margin of the Northeast Atlantic province provided the basis for a long period of exploration and field development that continues to the present day. However, despite the presence of a proven petroleum system containing the same Mesozoic and Lower Tertiary plays, nearly all the

hydrocarbon discoveries have been made in just two areas: the West of Shetlands and Norwegian Sea.

Ternan has just completed a five-year project aimed at providing a consistent view of hydrocarbon distribution and prospectivity in five contiguous segments of the Northeast Atlantic basin system: Atlantic Ireland, West of Hebrides, West of Shetlands, Norwegian Sea and Lofoten-western Barents Sea margin. Geological mapping of palaeogeography and depositional environments is based on plate reconstruction of the conjugate north European and Greenland margins. Palinspastically restored depositional environment maps for individual plays show facies distributions with the effects of later stretching and Tertiary uplift and volcanism removed. Regional sediment distribution maps, based on stratigraphic analysis of more than 500 wells and the interpretation of an extensive regional seismic dataset, have been combined with depositional environment maps to produce a present-day reservoir distribution map for each play. Similar maps display the distribution of Jurassic source rock facies.

Geological mapping of the Carboniferous-early Eocene Northeast Atlantic basin system with the Greenland and European margins restored to their pre-break up positions provides new insights into the structure, volcanism, stratigraphy and hydrocarbon plays of this major depositional province. At the same time this work has highlighted the exploration potential of the East Greenland margin, the Irish Rockall and Hatton basins, and the western margin of the Northeast Rockall and Faroe-Shetland basins.

## Sand Provenance Analysis of the North Atlantic Realm (SPANAR)

Knudsen, C.

*Geological Survey of Denmark and Greenland (GEUS)*

To facilitate interpretation of sand dispersal systems in sedimentary basins at the Atlantic margin GEUS has analysed a large number of sandstone samples on- and offshore mainly focused on East and West Greenland, Canada (Bylot Island and Cape Dyer and Labrador Sea) and the "West of Shetland" area. Further, a large number of stream sediment and till samples have been analysed to fingerprint the potential source areas for these detrital materials.

The techniques used are Computer Controlled Scanning Electron Microscopy (CCSEM), which automatically measure and store chemical compositional data for heavy minerals (a total of ca. 2000 samples have been analysed over the last 10 years) and Laser Ablation ICP-MS, where e.g. zircon ages are obtained from U/Pb isotope measurements.

Stream sediments in Central West Greenland show that ca. 85 % of the zircons have an age of ca. 2.8 Ga with minor zircon populations of ca. 3.6 Ga and 1.9 Ga. The provenance signature in the deltaic sandstones of the onshore Cretaceous Disko Bay area broadly mimics that of the entire Central West Greenland area, suggesting that the river systems depositing these sediments were draining a very large area in the interior part of Greenland. In the Paleocene there is a change in the source to a unimodal 1.9 Ga age population, indicating a very local source. In an offshore well, the

pattern is very similar but with two small but distinctive ca. 1 Ga and 1.6 Ga age peaks, indicating sediment influx from the south.

It is suggested that this work is continued in Greenland and tied together with data from sedimentary basins offshore Newfoundland and Ireland – by a consortium of Danish, Canadian and Irish researchers. Further, it is suggested that samples representing the source areas are analysed and that the methods used to fingerprint sandstones are further refined.

### **Is the Porcupine Basin a “failed” Magma-Poor Rifted Margin? Evidence from very long offset, deep penetration 2-D seismic data.**

McDermott, K.; Reston, T.

*School of Geography, Earth and Environmental Sciences, University of Birmingham, UK.*

*E-mail: [kqm876@bham.ac.uk](mailto:kqm876@bham.ac.uk)*

The Porcupine Basin is known to have accumulated very large amounts of extensional strain, with estimates calculated from subsidence data suggesting lithospheric stretching factors ( $\beta_{WL}$ ) greater than 6 for the basin's centre. Preliminary estimates of crustal thickness variations made using interpretations of ION-GXT's deep penetration 2-D (PSDM) seismic data - acquired as part of its NE Atlantic SPANTM – have enabled calculation of crustal stretching factors ( $\beta_C$ ) for the Porcupine Basin.

The data clearly show the extreme extension that has occurred in the South Porcupine Basin and demonstrate increasing extensional strain southwards, toward the Seabight Basin.  $\beta_C$  ranges from c. 13 (locally) at the Porcupine Arch to infinity further south, where crustal separation and exhumation of serpentinised mantle have occurred. As such, there are strong parallels that can be drawn between the Porcupine Basin and Magma-Poor Rifted Margins (MPRMs), such as the W. Iberian Margin, with many structural characteristics being common to both.

Here, we present some of the classic MPRM characteristics that the Porcupine Basin displays, comparing the Porcupine Basin data with published seismic data from the W. Iberian Margin. The characteristics we describe include; low volumes of syn-rift magmatism, serpentinite detachments, “peridotite” ridges, and a zone of exhumed continental mantle. We also present a map depicting the newly obtained crustal stretching factors for the Porcupine Basin, and suggest potential mechanisms for accommodating the extreme extension observed.

We suggest that the Porcupine Basin be classified as a “failed” magma-poor rifted margin. Crustal separation has occurred in the south of the basin but sea-floor spreading had not initiated.

## **Progress on Nova Scotia's OETR Project and the Moroccan Conjugate Margin**

Dehler, S.A.

*Geological Survey of Canada, Natural Resources Canada, Dartmouth, Nova Scotia, Canada  
on behalf of OETR Association*

The OETR Association (Offshore Energy Technical Research) initiated an industry standard Play Fairway Analysis and Geoscience Data Package program in 2009. This program is intended to serve a pivotal role in stimulating industry interest in exploration of Nova Scotia's offshore petroleum resources by providing explorers with critical information about prospectivity and resource potential to aid in decision making. During the 40 year petroleum exploration history of offshore Nova Scotia, more than 200 exploration, delineation and production wells have been drilled with discovered reserves in the range of 2.1 billion barrels of oil equivalent (bboe).

The remaining resource potential of Nova Scotia's offshore has been estimated by the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) to range from 12 to 39 trillion cubic feet (tcf) of natural gas and between 1.3 and 4.5 billion barrels of oil. In spite of what appears to be an attractive resource base, exploration activity has declined sharply over the last decade. The OETR Play Fairway Analysis and Geoscience Data Package Program is designed to examine the hydrocarbon potential and to demonstrate reduced risk to the industry so that the remaining hydrocarbon potential can be economically explored.

There are complex geological problems that need to be solved in order to demonstrate to the industry that there is a viable, attractive hydrocarbon region in offshore Nova Scotia. An understanding of the tectonic history is important for determining depositional environments (paleowater depths) and heat flow, which affects estimates of thermal maturation of hydrocarbons. Conjugate margin comparisons are also necessary to complete the pre-rift geometry side of the story. The tectonics interpretation is underpinned by deep wide-angle reflection/refraction data. An additional line was acquired as part of this study, to supplement the three previously interpreted profiles across the margin. The new line, located offshore eastern Nova Scotia, was acquired by GeoPro under contract to OETR, using 100 Ocean Bottom Seismographs (OBS) along a 400 km profile. These new data, and a reanalysis of existing refraction data across the conjugate Moroccan margin, are allowing the geoscience community to better understand the formation history of the basin, and to make more accurate assumptions concerning source rock and reservoir distribution.

A critical issue is to establish the degree to which volcanism was involved in the rift history of the margin. This has a profound impact on the possibility of encountering extensive restricted marine source rock systems. Related to this issue is the need to better understand the relationship between rifting and salt deposition to develop models for potential syn-rift and early post rift depositional environment. Magnetic anomaly data are being re-examined and modelled to determine the extent, both laterally and chronologically, to which rift-related volcanism may have influenced the early development of the margin. Another aspect under examination is the early plate configuration, and coast-parallel magnetic anomalies are being used to refine plate reconstruction models and predictions of paleo-environment. The tectonics component, and other projects focussing on salt modelling, biostratigraphy and reservoir quality, will be integrated into the play fairway analysis to build an industry standard evaluation of the remaining resource in the basin to support the next stage of exploration.



## Ireland's Data Policy; Importance of Quality Technical Information and The Opportunities Provided

Hanrahan, M.

*Petroleum Affairs Division, Dept. Of Communications, Energy and Natural Resources*

In order to promote and assist effective petroleum exploration in Ireland, the Department of Communications, Energy and Natural Resources makes a range of high quality technical data available to the exploration industry and the research community, as soon as the confidentiality period has expired, which is generally no more than five years from acquisition. The types of data to which access is provided includes well data/samples, seismic data and gravity & magnetic data. Access to historical licence technical studies is also facilitated. This talk will summarise Ireland's petroleum E&P data policy and will outline the mechanisms that exist for data access, including online databases. It will also highlight recent initiatives that have been taken by the Department to encourage new data acquisition and support consultant/contractor and researcher-led studies.

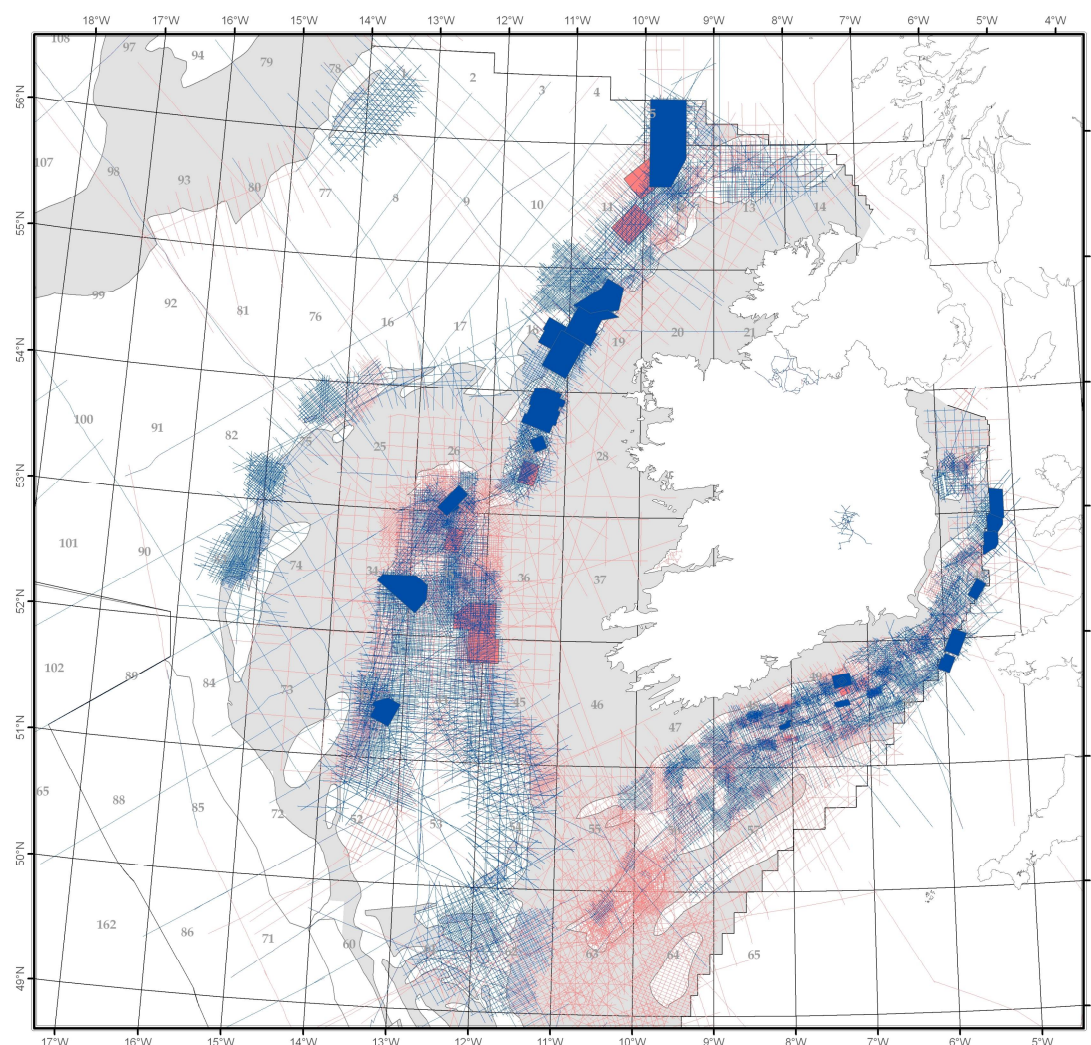


Figure 1: Seismic data coverage – the blue lines represent the large amount of released digital SEG-Y data from the Department.

## Regional Long Offset 2D Seismic Data West of Ireland

Blake, N.

*ION-GXT*

*Northeast AtlanticSPAN*

Historically, the offshore region of the Northeast Atlantic has lacked high quality and contiguous regional seismic data. In response to customer demand for improved understanding of the geologic evolution and basin architecture of the region, ION designed Northeast AtlanticSPAN (NEAtlanticSPAN).

NEAtlanticSPAN is a regional seismic and geologic program designed to address these issues with a high quality regional survey. ION worked closely with regional experts to design a survey that ties a large number of deep and deepwater wells with optimized line orientation. The program provides the industry with the only high-quality, consistent dataset for this margin and includes the longest lines ever acquired in the region.

Phase 1 of NEAtlanticSPAN contains over 7,200 km of high-quality, consistent seismic data, covering three main regions along the continental margin: Ireland, Faroe/Shetland Islands, and Norway.

ION managed the entire project to ensure the highest-quality survey design, acquisition and imaging technologies were applied. The resulting data provides new insight into the architecture of the margin and increases the effectiveness of the existing data sets with improved event identification and cross-survey correlation.

Key program components include:

Deep structural imaging, including Moho, across all the basins located offshore Ireland, the Faroes and Shetland Islands, and Norway

Definition of ocean-continent transition zone

Specifically targeted for sub-basalt imaging

Definition of sediment input points in deep-water Norway

Ties to key existing 3D surveys, and important deep exploration wells

Total planned survey length of 5,600 km in Ireland, 5,000 km in Faroes-Shetland, and 9,500 km in Norway.



## Prospectivity Review of the PGS Atlantic Margin Dataset

Botsford, A.

*Petroleum Geo-Services (PGS)*

The PGS Atlantic Margin seismic dataset incorporates over 14,000 km<sup>2</sup> of 3D data (~7,500 km<sup>2</sup> in Irish sector) and about 77,000 km of 2D data (~59,000 km in Irish sector). Interpretation of this data, tied to a comprehensive well database has revealed insights into several working hydrocarbon plays along the margin.

The Porcupine Basin to the south of the Atlantic margin has a proven oil prone source rock of mid Jurassic age, as indicated by the discoveries of Connemara, Spanish Point and Burren. Jurassic to Cretaceous sandstones within sealed fault blocks provide the major hydrocarbon reservoir in this area, although hydrocarbon shows have been detected in Eocene and Paleocene sandstones, Cretaceous chalk and Carboniferous sandstones.

Further north, in the Slyne and Erris basins, gas sourced from Carboniferous coals has been detected at the Corrib field. Oil has also been detected in Corrib reservoirs and in wells 27/4-1 (Bandon discovery) and 27/5-1. Discoveries in this region have been made in four way dip closed structures within Triassic sandstones and mid to late Jurassic sandstones. A thick layer of Zechstein salt provides detachment in this region for the Corrib and Bandon structures.

The Rockall Basin has a gas and condensate source rock, proven by the 12/2-1 Dooish well. Pre-rift sandstones of undifferentiated and Permian age provide the reservoir in a tilted fault block overlain by Cretaceous mudstones. In addition oil and gas have been detected in the UK sector of the Rockall Basin. Gas was discovered in Paleocene sandstones of the Benbecula discovery and UK well 164/28-1 encountered oil shows within Paleocene sandstones.

The petroleum systems of the Atlantic margin can be better understood through the use of a consistent regional dataset. Placing targets within an overall tectonic context allows predictions of sediment distribution to be made and assists the identification of key areas of source maturation and migration.

This regional study suggests numerous undrilled structures exist, from tilted fault blocks to large scale anticlines. Several leads have been identified. Reservoir potential is best in localised syn-rift packages from the Permian to the Lower Jurassic and the post rift infill is also a key target. Source maturity is likely in deep basinal areas of the Porcupine, Rockall and Slyne Basins and migration pathways are speculative but proven throughout the margin.

## Field Development Options in Irish Deepwater Basins

Carolan, M.<sup>1</sup>; Woodason, G.<sup>2</sup>

<sup>1</sup> *Challenge Energy*

<sup>2</sup> *Procyon Oil & Gas*

Ireland's Atlantic basins hold the potential for major oil and gas discoveries in water depths ranging from 150 to over 2,500 metres. In order to demonstrate the strong economic foundations for investment in offshore Ireland, ten field development scenarios were considered and evaluated. These cases provide analysis on each of the four Irish Atlantic basins: the Rockall Basin with challenging water depths ranging from 1,000m to over 3,000m, the 'North' Porcupine Basin with depths of up to 2,000m, the 'South' Porcupine Basin at depths of up to 2,500m and the Slyne/Erris/Donegal Basins where the water depth ranges from 150m to 1,500m.

This short talk will provide an overview of a 2009 study carried out jointly by Challenge Energy and Procyon Oil & Gas. The study included a survey and analysis of the types of production facilities suitable for use in the Atlantic Ireland Basins. The positive investment metrics determined during the study were based on an engineering study and conservative economic assumptions. As such they provide a thought-provoking insight into the attractive nature of oil and gas plays in the Irish Atlantic Basins.

## Prospects for Atlantic Ireland and Comparison with Neighbouring UKCS

Vinall, A.

*Hannon Westwood*

The Irish Atlantic Margin covers an area nearly one and a half times that of the UK equivalent yet since offshore exploration commenced the UK has enjoyed significantly more attention by the oil companies than Ireland. Of the 154 wells drilled in Irish waters over the last 38 years only 52 have been drilled in the Atlantic region and the majority of these have been restricted to the northern part of the Porcupine Basin. This compares with 200 drilled in the Atlantic sector of the UK, a fourfold difference. Since drilling in the Atlantic Margin commenced in 1972, there have been only 2 years when there has been no drilling activity in the UK, against 18 in Ireland. There have been 7 years when Atlantic drilling in Ireland exceeded or matched that of the UK. If a comparison is made between exploration success against volume of hydrocarbon resource found it can be seen that around 2.7 tcf gas and 220 mmbbls oil have been discovered in Ireland by 41 wells compared with 4 tcf gas and 2000 mmbbls oil discovered in the UK by 148 wells. A measure of success of an area can be taken as the volume of hydrocarbon discovered per well. Although the number of discoveries in Ireland lags behind that of the UK, the two areas compare favourably with Ireland returning 16.4 mmboe/well against the UK's 17.8 mmboe/well. The reason that Ireland has not enjoyed the same level of activity as the UK must be down to other factors and in part this must be a perception of risk linked to uncertainty over the potential of the various basins. One striking difference is that of the 32 UK discoveries two-thirds, containing 80% of the reserves, are in the Palaeocene, whereas all 6 of

Ireland's discoveries are in the Mesozoic and while this is a reflection of the primary objectives of the exploration wells, it is also noted that in Ireland there has been only limited encouragement from the handful of wells that have targeted the Tertiary. Both regions contain a number of mapped, but undrilled structures, which could be considered to give an indication as to the unrisks yet-to-find potential. In Ireland the mapped potential in 74 prospects is around 20 billion boe of which around 75% is pre-Tertiary, whereas in the UK it is 19 billion boe in 107 prospects of which nearly 60% is in the Tertiary. The conclusion is that there is significant remaining potential in both regions, but that with higher competition for acreage in the UK, Ireland has the potential to offer greater scope for exploration and to an extent this is supported by lower taxes on production. This, however, has to be tempered against the perception of risk in Ireland and internal company barriers to new country entry.

## Prospects 2 Go

### The Dalkey Island Prospect – Rare Shallow Water High Impact Oil Exploration Potential Offshore Ireland

O'Sullivan, J.M.

*Providence Resources plc*

The Dalkey Island exploration prospect is located in the shallow water Kish Bank Basin, offshore eastern Ireland. This preserved 'trap-door' half graben comprises the erosional remnant of a more widespread Permo-Triassic basinal system which originally extended into the Central Irish Sea, East Irish Sea and North Channel Basins to the south, east and north respectively. The basin underwent a subsequent phase of structural inversion during the late Cretaceous Alpine event with a number of tectonic elements such as the Codling fault system being tectonically active to present day. To date, four wells have been drilled in the basin, which have collectively confirmed the presence of Upper Carboniferous gas prone source rocks, Lower Triassic reservoir quality Sherwood sandstone and Upper Triassic halite bearing Mercia Mudstone cap rocks. Two of the four wells in the basin have encountered oil shows or residual pay with the main reason cited for prospect failure being late structural timing. Published hydrocarbon airborne seep detection data together with seabed core analysis indicate the presence of a liquid hydrocarbon system suggesting a potential additional Middle Carboniferous Namurian source similar to the Holywell Shale which is a proven prolific oil source in the Liverpool Bay Area.

The Dalkey Island prospect is located in the deep SW part of the basin adjacent to the Dalkey and Bray fault systems. The prospect has been mapped on reprocessed 2D seismic data and comprises two tilted fault blocks which are downthrown to the basin bounding Dalkey Fault. The potential for this fault to seal is a key element of prospect risk as it is considered to juxtapose the Sherwood Sandstone reservoir with Dalradian meta-sediments of the Bray Group on the footwall. Imaging at the target Sherwood Sandstone is good to excellent and seismic/potential field data suggest the presence of a salt pillow overlying the prospect. Seismic acoustic impedance inversion has revealed the presence of potential DHI's at the prospect level which appear to be consistent with structural closure. Fault mapping also illustrates that the bounding faults to the prospect were active up to the Late Triassic which is significantly older than other structures in the basin. The mid-case oil volumetric estimate for the prospect is 870 MMBO STOIP. Given its shallow water depth (c. 25 metres),



proximity to shore (c. 10 km) and shallow reservoir depth (1500 metres), the DHC estimate is c. \$6 MM. Providence (Operator) and partner Star Energy are seeking co-venture partners to participate in the exploration of this unique high potential oil opportunity offshore Ireland.

## **Prospects 2 Go**

### **Northeast Irish Rockall – A successful Revelation in Sub-Basalt Imaging**

Nolan, C.

*Serica Energy*

The Rockall is a deepwater Atlantic Margin Basin that covers an area ten times the size of the Central Graben. Only three wells have been drilled in the Irish Rockall, all are in the northeast and were based on the results of a 4km streamer 3D survey shot in 1998 covering 2339km<sup>2</sup>. In 2003 the second well (12/2-1) was re-entered (12/2-1z) and a 214m gas condensate column was encountered within pre-rift Middle Jurassic and Permo-Triassic sands; the Dooish gas condensate discovery (65mmboe recoverable). Imaging of the target pre-rift section is problematic, this is due to steep dips, intrusive sills and dykes and overlying extrusive basalts and volcanoclastics. With the currently processed short offset 3D data, it was often impossible to determine if a pre-rift fault blocks contained a sedimentary section or basement. In 2009 Serica Energy sponsored the acquisition of 1350km of 8km offset 2D data by TGS. Imaging of the pre-rift section was significantly improved, the 2D data revealed a prospective pre-rift sedimentary section within a number of the undrilled fault blocks including the Muckish Prospect, which is located just to the north of the Dooish discovery.

## Prospects 2 Go An Overview of San Leon Energy Atlantic Margin Prospects and Their Conjugate Margin Context

Murphy, R.; Graham, B.

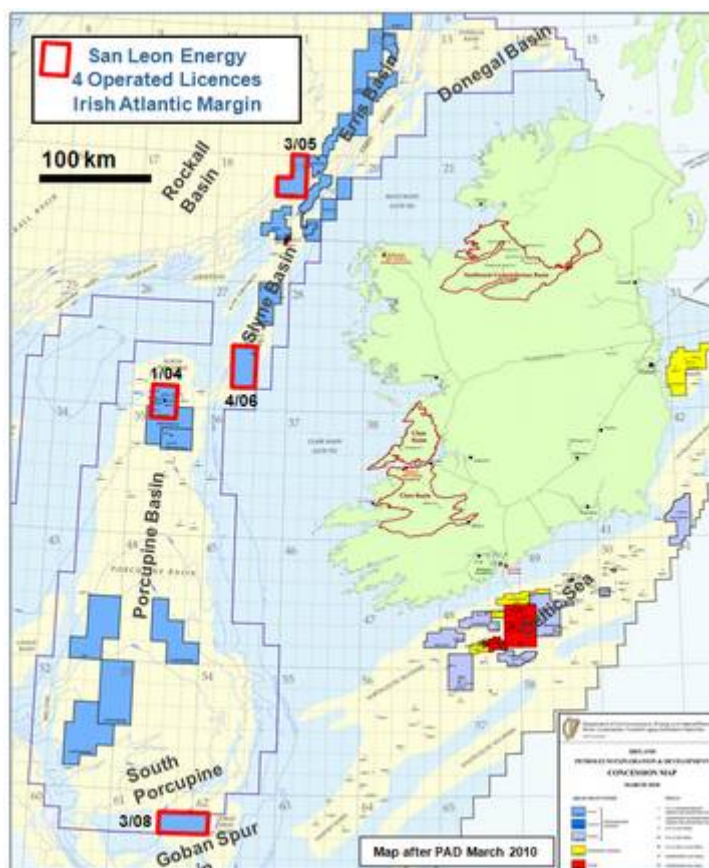
*San Leon Energy Plc*

San Leon Energy retains a large acreage holding along the Irish Atlantic Margin province, incorporating four operated licences encompassing a total area of some 2880 square kilometres. The prospect inventory ranges across the Rockall and Slyne-Erris Basin system and extends southwards into the northern Porcupine Basin and onward to the South Porcupine - Goban Basin area.

The Killala and Kingfisher prospects are located in Rockall Licence FEL 3/05. The primary target consists of the Lower Triassic Sherwood Sandstone Formation, which is also the reservoir for the Slyne Basin Corrib Field. Sourcing is from Westphalian coals. Calculated Mid Case GIIPS are 4 TCF and 4.7 TCF for Killala and Kingfisher respectively. Killala is located on the Erris Ridge, a longstanding feature separating the Slyne-Erris and Rockall basins. As such it benefits from dual sourcing potential, with hydrocarbon systems proven on both sides, by the Dooish Gas Condensate discovery on the Rockall side and the Corrib Gas Field on the Slyne-Erris side. The mapped structure at Killala has more than 1000m of closure at the Top Sherwood Sandstone level. The structure at Kingfisher consists of a large tilted fault block with 500m of closure at top Sherwood Sandstone level. In addition, Jurassic sandstones are prospective for oil at Kingfisher, a fact highlighted by the 2009 Slyne Basin 27/4-1 oil discovery. The main outstanding work programme item on the licence is for 800 km<sup>2</sup> of 3D seismic acquisition.

The Inishmore prospects are located in Slyne Basin Licence FEL 4/06. Two large and adjacent closures have been mapped at Sherwood Sandstone level, with San Leon Energy mid case GIIP's calculated at 2 TCF and 1.4 TCF. Similar to Killala and Kingfisher, the prospects are interpreted to be sourced by Westphalian coals. As is the case for the Kingfisher Prospect in Licence FEL 3/05, on structure Jurassic sandstones are prospective for oil, again supported by the recent Slyne Basin 27/4-1 oil discovery. A 300 km<sup>2</sup> seismic survey was acquired by San Leon Energy in summer 2010, discharging the main commitment on the licence and processing results are eagerly anticipated in the fourth quarter of 2010.

The Porcupine Basin C1 Lead is located in Licence FEL 1/04 in the northern main Porcupine Basin and targets a mapped turbidite fan pinchout, considered to be analogous to the Buzzard Field in the



Moray Firth Basin offshore United Kingdom. Mounded depositional forms are clearly visible on 2D seismic above the base Cretaceous unconformity and thick Lower Cretaceous shales overly the unconformity in wells located updip to the pinchout. The hydrocarbon system at Lower Cretaceous level is proven by the Burren oil discovery to the south and the capacity of Upper Jurassic source rocks to generate large volumes of hydrocarbons is established by the adjacent full to spill Upper Jurassic Connemara Oil Field. A mid-case OIIP of 1097 MMBLS has been calculated for the C1 lead. The C1 Lead represents an untested play type in the Porcupine Basin. Licence FEL 1/04 also encompasses the H Prospect and the Connemara Field. The H Prospect consists of a tilted fault block located adjacent to the Connemara Field. The full to spill OIIP calculation for the mapped Oxfordian reservoir, the main reservoir at Connemara, is 913 MMBLS. A pilot development programme has been outlined for the Connemara Field, targeting a mid case OIIP of 67 MMBO out of a total field OIIP of 151 MMBO. Discoveries at C1 and H would benefit from existing discovered hydrocarbons at Connemara. A 3D seismic survey over the C1 Lead is considered by the operator to represent the optimum programme on Licence FEL 1/04.

The Tír Na nÓg prospect is located in Licence FEL 3/08. It targets the gas in the Sherwood Sandstone Formation and either oil or gas in overlying Paleogene turbidite sands. The Tír Na nÓg High, represents a longstanding feature separating the Goban Basin from the Southern Porcupine Basin. The Sherwood Sandstone can be mapped across the high and is interpreted to be sourced by underlying Carboniferous coals. A mid case GIIP of 5 TCF has been calculated. A large Paleogene mounded fan prospect is located above the Tír Na nÓg High. It is considered analogous to the Frigg Field in the UK Central Graben. A mid gas GIIP of 9.3 TCF or an OIIP of 5.6 billion barrels of oil has been calculated at the Paleogene level. The main outstanding work programme item on the licence is for 600 km<sup>2</sup> of 3D seismic acquisition.

The Irish Atlantic Margin basins form a conjugate pairing with Canadian Atlantic Margin basins located offshore Newfoundland. The area is currently the subject of significant international research effort aimed at reconstructing the detailed basin configuration prior to Atlantic Margin opening and ascertaining the significance of this for hydrocarbon exploration. The Charlie Gibbs Fracture zone and present day ocean floor bathymetry constitute a useful first principals determinant regarding the estimating the relative locations of basins prior to Atlantic opening. This provides a basis for more realistic comparison between the exploration results on either side of the ocean and leads to improved estimates of risk, particularly in plays and/or areas where low well density pertains. A preliminary pre-breakup positioning of the Atlantic Margin Basins of Ireland and Newfoundland is presented and the implications of this for San Leon Energy's Atlantic Margin portfolio are discussed.

## Stands (in alphabetical order)

### **ARKeX Stand**

ARKeX is a leading supplier of gravity and magnetic services to the exploration industry. As well as being a release agent for offshore PAD and DECC gravity and magnetic data, ARKeX can also supply non-exclusive data on behalf of the BGS and most of the major seismic companies. ARKeX offers processing and re-processing of gravity and magnetic data, and are able to merge overlapping data of different vintages into one contiguous data set. Drawing on nearly 25 years industry experience of international projects, ARKeX can interpret integrated potential fields and seismic data to produce geological models in areas where seismic alone is insufficient. In areas of inadequate data coverage, ARKeX is able to acquire both airborne and marine magnetic and gravity gradiometry data.

### **GeoArctic Stand**

GeoArctic has provided geoscience consulting and services since 1996. Our consultants specialise in structural geological modelling, palaeogeographic and palaeoenvironmental mapping, and geoscience software development.

Plate models developed by GeoArctic more accurately reconstruct the palaeogeography of the plate margins over geological time. Our specialized plate reconstruction methods have been successfully used for regional studies in oil and gas exploration.

Regional plate reconstructions projects have been completed for the North Atlantic, Norway-East Greenland, Labrador Sea-West Greenland, Eastern Canada-Central Atlantic, Northern Canada and the Arctic and Southeast Asia.

PIP-ISPSG has recently signed a contract to carry out the new Plate Reconstruction of the North Atlantic between Ireland and Canada. GeoArctic are the lead contractor, assisted by Badley Geoscience Ltd in the UK, GSC Atlantic in Nova Scotia and a team of academic experts in Canada, the UK and Ireland. The project will involve research collaboration between Ireland, Canada and several other countries. The work will be funded equally by the government of Newfoundland Labrador through Nalcor Energy and the Irish joint government-industry Petroleum Infrastructure Programme (PIP). The project's objective is to use newly developed software and innovative analytical techniques to define the original architecture and geological history of the North Atlantic prior to the opening of the Atlantic Ocean in much greater detail than has been hitherto possible. The project should provide a powerful new tool to support exploration and help answer questions like "Can the giant discoveries off eastern Canada be replicated on the Irish side?" It is hoped that new insights will emerge that will provide a major stimulus to exploration.

The GeoArctic stand has a series of posters whose abstracts appear in the poster abstract section.

## **IHS Stand**

Well Data & Seismic - Ireland

[Ireland Well Listing 2006](#)

[Ireland Digital Seismic Data](#)

[Ireland Paper Copy Seismic Data](#)

[Ireland Digital Wireline Data, Well Attributes and Pressure Data](#)

Following a recent agreement with the Irish government, IHS, as official agent to the Irish government, now delivers released digital SEG-Y seismic as well as hardcopy data for the Irish offshore sector. SEG-Y data is deliverable on DVD, multiple CD, 8mm Exabyte or 4mm DAT. Hardcopy data is available on paper or film sepia. Both SEG-Y and hardcopy seismic data is offered on a per line and per survey basis.

SEG-Y data will enable easier and less expensive data transfer, greater integration into technical documentation, and will reduce storage costs in comparison to hardcopy data.

For more information or to place an order, please contact [releaseddata@ihs.com](mailto:releaseddata@ihs.com).

For SubSurface Sales enquiries for Ireland please contact [ssg\\_enquiries@ihs.com](mailto:ssg_enquiries@ihs.com).

## **ION-GXT Stand**

ION Geophysical is a leading provider of geophysical technology, services, and solutions for the global oil & gas industry. ION offerings include: seismic data processing solutions, including state-of-the-art depth migration, reverse time migration, and full-wave imaging; regional basin-scale seismic programs comprising a global multi-client data library; software and services for survey design, geophysical analysis, and reservoir modeling; and seismic imaging programs encompassing survey planning, field acquisition, and final image rendering.

Additional information is available at [www.iongeo.com](http://www.iongeo.com).

ION's BasinSPANS™ (SPANS) are geologically-driven, basin-wide seismic data programs acquired and imaged using the most advanced technology available. SPANS allow geoscientists to trace the history of entire petroleum systems to determine where source rocks are most prevalent, where sediment fairways are located, and where the most promising migration paths from source to reservoir exist. Unlike conventional multi-client seismic surveys, BasinSPANS are custom designed in collaboration with ION's GX Technology (GXT), regional experts, and the O&G companies. SPANS are customized to image deep within the geologic section, cover an entire petroleum province, and overlay with areas of heightened structural or stratigraphic interest. BasinSPANS data is processed by GXT using the most advanced geophysical techniques available.

For more information on BasinSPANS visit [www.iongeo.com/SPANS](http://www.iongeo.com/SPANS). Or email us at [BasinSPAN@iongeo.com](mailto:BasinSPAN@iongeo.com).



### **Marine Institute / GSI Stand**

The Marine Institute is Ireland's national agency responsible for Marine Research, Technology Development and Innovation (RTDI). They seek to assess and realise the economic potential of Ireland's 220 million acre marine resource; promote the sustainable development of marine industry through strategic funding programmes and essential scientific services; and safeguard our marine environment through research and environmental monitoring.

The Marine Institute worked in partnership with the Geological Survey of Ireland (GSI) on the Irish National Seabed Survey (INSS), a multimillion European initiative supported by the Irish government. The survey aimed to map Ireland's 220 million acres of territorial seafloor, a natural resource that is approximately ten times the size of Ireland's land area.

Phase 1 of the Irish National Seabed Survey (INSS) is now complete, and they are currently in Phase 2: Integrated Mapping for the Sustainable Development of Ireland's Marine Resources (INFOMAR). While Phase 1 concentrated on outer deep-sea territorial waters, Phase 2 has moved inshore to coastal waters. INFOMAR aims to map the remaining 13% of the Irish territorial seafloor, concentrating on specific areas of interest such as priority bays and areas of biological interest.

A two-day conference on the Geoscience Sector will take place in Dublin Castle on the 3 and 4 November 2010. It will provide an in-depth overview of how the sector is flourishing even in these recessionary times. It will also undoubtedly be greatly welcomed by all those individuals and organisations that provided much important input into a process of evaluation of the sector that has been undertaken during the last two years. While there is no charge for attending, those interested should confirm their interest by e-mailing [michael.o'mahony@gsi.ie](mailto:michael.o'mahony@gsi.ie)

### **Nova Scotia / OETR Stand**

OETR is a not-for-profit corporation dedicated to fostering geosciences research that will enhance Nova Scotia's offshore petroleum exploration and development.

OETR's members include Dalhousie University, Saint Mary's University and the Nova Scotia Department of Energy.

OETR's mandate is to fund and encourage research that builds geoscience knowledge about Nova Scotia's offshore oil and gas potential, as well as research that reduces the technical and engineering barriers to the development of discovered reserves.

The stand displays a series of posters produced during the OETR Program and also displays posters from OETR's partners – GSC Atlantic and the Nova Scotia Department of Energy

The OETR stand has a series of posters whose abstracts appear in the poster abstract section.

## **PAD / DCENR Stand**

The role of the Petroleum Affairs Division (PAD) is to maximise the benefits to the State from exploration for and production of indigenous oil and gas resources, while ensuring that activities are conducted safely and with due regard to their impact on the environment and other land/sea users.

The functions of the Division are carried out through a number of strategies with the following objectives:

To maximise the area of Continental Shelf jurisdiction:

establish and delineate an undisputed outer limit of the continental shelf

To license private enterprise to conduct exploration and production (E&P) under terms which balance the interests of the State and of private enterprise while ensuring that:

there is effective and efficient E&P  
operations are carried out in accordance with best practices  
there is effective liaison with the E&P industry

To have the opportunities maximised for Irish business/institutions to service the needs of E&P in Ireland by:

facilitating the establishment of a mechanism whereby Irish goods and services get full opportunities to participate in exploration activities offshore of Ireland

To provide stimuli for medium and long-term exploration efforts in Ireland by:

securing Irish E&P industry assistance towards building up the local E&P-related infrastructure, and working with the Irish E&P industry to have research and joint industry research and data-gathering carried out.

The Division is responsible for the promotion, regulation and monitoring of the exploration and development of oil and gas in onshore and offshore Ireland. This involves the allocation of acreage to exploration companies under various types of licences agreeing appropriate work programmes and the promotion of acreage, either through open access or by a Round system.

Promotion

identification of areas with potential  
preparation of interpretative reports [over such areas]  
encouraging companies to acquire new data in such areas  
release of basic geological, geophysical and well data to the industry

## Regulating

agreeing with operators work programmes which are appropriate for the type of authorisation and the area to be licensed while taking account of both the operator's and the State's interests

## Monitoring

ensuring that agreed work programmes are carried out in accordance with good oilfield practice, having particular regard to safety, the environment and other land sea users.

The PAD Stand will display a series of posters covering promotion of exploration in Ireland's waters and PIP-related project posters. The abstract for the Petroleum Systems Analysis posters can be found under Ternan in the poster abstracts section.

## **Petroleum Geo-Services Stand**

Petroleum Geo-Services (PGS) possesses the world's most extensive 3D MultiClient data library comprising over 400,000 km<sup>2</sup> worldwide. Additionally the developing MultiClient 2D portfolio (200,000 km) is available in frontier and developing hydrocarbon areas and includes a growing proportion of GeoStreamer® data that demonstrates excellent imaging qualities.

PGS flagship MultiClient products include the MegaSurvey, MegaSurveyPlus and MegaProject data packages which provide contiguous 2D and 3D coverage across vast areas.

Recent work by PGS in Ireland has focused on the Atlantic Margin MegaProject. A large database of 2D and 3D seismic data has been assembled from released datasets and PGS MultiClient surveys. All the data has been matched, merged and balanced to provide a regionally consistent, coherent seismic dataset.

The Atlantic Margin MegaProject is being offered for licensing in time for the 2011 Atlantic Margin Licensing Round and includes 4,700 km<sup>2</sup> of high end 3D MultiClient data, a comprehensive 2D data package and four regional gridded horizons.

PGS Reservoir has provided a regional interpretation and high level prospectivity review of this dataset and will be presenting this with a poster summary at the Atlantic Ireland 2010 Conference.

## **PIP Stand**

The Petroleum Infrastructure Programme (PIP) was set up by the Petroleum Affairs Division (PAD) in 1997. PIP presently comprises two sub-programmes:- the active Petroleum Exploration and Production Promotion and Support (PEPPS) and the now completed PIP (1997 - 2002) sub-programmes.

The overall aim of PIP is to promote hydrocarbon exploration and development activities by:

- Strengthening of local support structures
- Funding of research data gathering and 'land-based' research in Irish offshore areas
- Providing a forum for co-operation amongst explorationists and researchers

Research under the Programme goes beyond normal licence area-specific work and is designed so as not to duplicate the efforts of other groups or of commercial contractors. It is also considered essential that local researchers should be given an opportunity to participate in the research projects. PIP is funded by oil companies with licences offshore Ireland and the PAD.

The abstracts for these posters can be found under Davies, Shannon and Vaughan in the poster abstracts section.

### **Providence Resources Stand**

#### **The Dalkey Island Prospect – Rare Shallow Water High Impact Oil Exploration Potential Offshore Ireland**

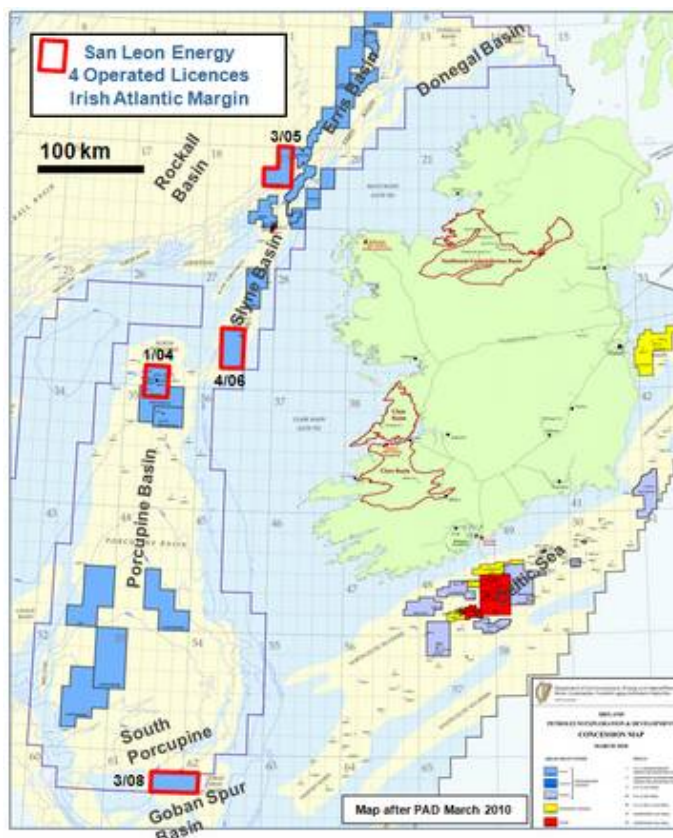
The Dalkey Island exploration prospect is located in the shallow water Kish Bank Basin, offshore eastern Ireland. This preserved 'trap-door' half graben comprises the erosional remnant of a more widespread Permo-Triassic basinal system which originally extended into the Central Irish Sea, East Irish Sea and North Channel Basins to the south, east and north respectively. The basin underwent a subsequent phase of structural inversion during the late Cretaceous Alpine event with a number of tectonic elements such as the Codling fault system being tectonically active to present day. To date, four wells have been drilled in the basin, which have collectively confirmed the presence of Upper Carboniferous gas prone source rocks, Lower Triassic reservoir quality Sherwood sandstone and Upper Triassic halite bearing Mercia Mudstone cap rocks. Two of the four wells in the basin have encountered oil shows or residual pay with the main reason cited for prospect failure being late structural timing. Published hydrocarbon airborne seep detection data together with seabed core analysis indicate the presence of a liquid hydrocarbon system suggesting a potential additional Middle Carboniferous Namurian source similar to the Holywell Shale which is a proven prolific oil source in the Liverpool Bay Area.

## San Leon Energy Stand

### **An Overview of San Leon Energy Atlantic Margin Prospects and Their Conjugate Margin Context**

San Leon Energy retains a large acreage holding along the Irish Atlantic Margin province, incorporating four operated licences encompassing a total area of some 2880 square kilometres. The prospect inventory ranges across the Rockall and Slyne-Erris Basin system and extends southwards into the northern Porcupine Basin and onward to the South Porcupine - Goban Basin area.

The Killala and Kingfisher prospects are located in Rockall Licence FEL 3/05. The primary target consists of the Lower Triassic Sherwood Sandstone Formation, which is also the reservoir for the Slyne Basin Corrib Field. Sourcing is from Westphalian coals. Calculated Mid Case GIIPS are 4 TCF and 4.7 TCF for Killala and Kingfisher respectively. Killala is located on the Erris Ridge, a longstanding feature separating the Slyne-Erris and Rockall basins. As such it benefits from dual sourcing potential, with hydrocarbon systems proven on both sides, by the Dooish Gas Condensate discovery on the Rockall side and the Corrib Gas Field on the Slyne-Erris side. The mapped structure at Killala has more than 1000m of closure at the Top Sherwood Sandstone level. The structure at Kingfisher consists of a large titled fault block with 500m of closure at top Sherwood Sandstone level. In addition, Jurassic sandstones are prospective for oil at Kingfisher, a fact highlighted by the 2009 Slyne Basin 27/4-1 oil discovery. The main outstanding work programme item on the licence is for 800 km<sup>2</sup> of 3D seismic acquisition.





## **TGS Stand**

TGS provides multi-client geoscience data and services to oil and gas Exploration and Production companies around the globe. TGS' geophysical and geological data products include multi-client seismic libraries, extensive magnetic and gravity data, the industry's largest global database of digital well logs and regional interpretive products. TGS also provides high-end depth imaging services to help resolve complex seismic imaging problems.

### Geophysical

- 2D & 3D Seismic
- Depth imaging products
- Wide Azimuth Seismic
- Aeromagnetics
- Gravity
- Electromag (CSEM)
- Multi-beam

### Geological

- Digital well data
- Directional surveys
- Production data
- Core data
- Regional geologic
- Interpretations
- Facies Map Browser
- Interpretive Services

### Imaging

- Seismic processing
- High end depth imaging
- Proprietary technology
- Ongoing R&D investment
- Contract business model

TGS specializes in planning, acquiring and processing multi-client geophysical data in major and emerging offshore exploration plays worldwide. Resources are centered on a core collection of multi-client exploration data products. These data sets are diverse in location, acquisition technique and specifications and are united by a common approach to quality assurance, advanced processing and expertise. TGS' 2D and 3D seismic library is among the strongest, most diverse and highest quality in the marketplace. The company also offers value-added gravity and magnetic data products to complement regional interpretations and seismic data packages.

TGS has a large geophysical database in Ireland including:

- Over 20,000 km of multi-client seismic data
- Facies Map Browser
- Seep data

These data provide the exploration tools for evaluating open acreage. Examples from the TGS' long offset database are on display in the booth.

## POSTER ABSTRACTS (in alphabetical order)

### A New Kinematic Plate Reconstruction between Ireland and Canada

Ady, B.<sup>1</sup>; Whittaker, R.<sup>1</sup>; Alvey, A.<sup>2</sup>; Roberts, A.<sup>2</sup>; Kuszniir, N.<sup>3</sup>

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In comparison with other continental margins, the North Atlantic deep water basins of Ireland and Eastern Canada are very lightly explored with only a small number of wells drilled. Understanding the tectonic history of the conjugate margins of Newfoundland and Ireland is critical for evaluating their hydrocarbon potential, yet existing plate tectonic models for the North Atlantic are inadequate. Over the next two years GeoArctic Ltd., in collaboration with a team of leading researchers from academia, government, and industry on both sides of the Atlantic, will develop a *Kinematic Plate Reconstruction of the North Atlantic between Ireland and Canada*. The project team includes researchers from Badley Geoscience Ltd., Memorial University of Newfoundland (MUN), University College Dublin (UCD), the Dublin Institute of Advanced Studies (DIAS), the Geological Survey of Canada (GSC), and others. The project is due for completion in June 2012.

The integrated workflow developed for the project combines 4D deformable plate techniques and seismic, magnetic and geological interpretation with the analytical techniques of 2D or 3D gravity inversion, flexural backstripping, fault analysis and forward modelling. The project will use 2D and 3D structural modelling and gravity inversion to calculate crustal stretching in order to develop a new deformable plate model that will remove overlap and under-fit between plates. The new model will be useful in furthering our understanding of the major controls and mechanisms for North Atlantic basin formation and evolution.

### Deformable Plate Reconstruction for the North Atlantic: Calculation and Removal of Plate Overlap

Ady, B. E.<sup>1</sup>; Whittaker, R.C.<sup>1</sup>; Alvey, A.<sup>2</sup>

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A present day tectonic elements map for the North Atlantic has been interpreted and compiled as part of the *New Kinematic Plate Reconstruction between Ireland and Canada* project. As part of the initial phase of the project the tectonic elements map has been used in a series of rigid plate reconstructions corresponding to the main breakup ages along the North Atlantic margin. The main purpose of these reconstructions is to define the pre-breakup location of major tectonic elements, regional seismic lines, and published profiles on the conjugate margins. Using these reconstructions, regional profiles will be selected and modelled using Badleys' FlexDecomp software to establish the timing and amount of pre-breakup extension that has occurred. Modelling results will be incorporated

into regional Beta Factor grids derived from 3D gravity inversion, refraction seismic data, and deep reflection seismic data.

Pre-breakup lithosphere extension appears as Continent-Ocean Boundary (COB) overlap in the rigid plate reconstruction models (shown in yellow). The rigid body reconstructions clearly show that the amount of overlap is considerable. This overlap will be removed using deformable plate reconstruction methods in order to restore plates, tectonic elements, and palaeogeographies, etc. to their pre-extensional location and geometry and to produce meaningful plate reconstructions.

## Crustal Thickness and Continental Lithosphere Thinning Factors from Gravity Inversion for the North Atlantic

Alvey, A.<sup>1</sup>; Kusznir, N.<sup>2</sup>; Whittaker, R.<sup>3</sup>; Ady, B.<sup>3</sup>; Welford, K.<sup>4</sup>

<sup>1</sup> *Badley Geoscience Ltd., Spilsby, Lincolnshire, UK*

<sup>2</sup> *Department of Earth Sciences, Liverpool University, Liverpool, UK*

<sup>3</sup> *GeoArctic Ltd, Calgary, AB, Canada*

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Globally available free-air gravity data can be used to predict continental lithosphere extension, refine plate reconstruction models, and provide a prediction for the continent-ocean boundary location independent from the magnetic anomaly data. Crustal thickness, continental lithosphere thinning factor and residual continental crustal thickness have been determined for the North Atlantic conjugate rifted margins and adjacent oceanic regions using gravity inversion incorporating a lithosphere thermal gravity anomaly correction. Satellite derived gravity anomaly data, bathymetry data, and sediment thickness data have been used to derive the mantle residual gravity anomaly which is then inverted in the 3D spectral domain to give Moho depth.

Thinning factor estimates determined from crustal thinning from gravity inversion require a volcanic addition correction. To encompass all margin types within the study area the gravity inversion has been corrected for three volcanic addition predictions – magma starved (0km), normal (7km), and volcanic (10km). The results of the gravity inversion have also been provided with sensitivity to five breakup ages (33, 55, 80, 135m and 180 Ma) applicable to the main breakup events of the North Atlantic. The oldest isochrons used within the inversion are 25, 45, 55, 100, and 150 Ma respectively. By ignoring the oldest isochrons against the ocean-continent transition, which may prejudice the determination of ocean-continent transition using gravity inversion, the continent-ocean boundary can be independently determined. Reference crustal thickness for the gravity inversion depends on many factors; ideally it is calibrated against seismic refraction estimates of Moho depth. As this is a regional study, a sensitivity of the gravity inversion to reference crustal thickness has been provided for crustal thicknesses values of 30 km, 35 km & 40 km. Sensitivity tests for sediment density and crustal basement density have also been carried out.

Continental lithosphere extension calculated from gravity anomaly inversion is useful in areas where seismic refraction data is sparse or non-existent. The North Atlantic results will be compared to seismic refraction estimates in selected locations and integrated with detailed local studies around the

margin. The resultant dataset will be used to remove the effects of pre-breakup extension on North Atlantic margin using deformable plate techniques.

## **The Irish Porcupine Basin Hydrocarbons A Detailed Geochemical Characterisation of Provenance and Quality**

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As exploration and exploitation of hydrocarbons on the North West European continental margin continues, interest is inevitably turning to the Porcupine Basin, one of the least well understood and under explored basins along the Frontier North Atlantic margins.

To date only 26 exploration wells have been drilled in this large basin most (21) being drilled in the period 1977-1982 with a few additions (5) in the period 1985-2001. Hydrocarbons have been found in the presently non-commercial Connemara Field and significant flow encountered in three other prospects including the Spanish Point (35/8-2) and the 35/8-1 and 35/6-1 wells. A total of 18 of the 27 wells exploration wells encountered good shows of oil in potential reservoirs of variously Carboniferous, Jurassic, Cretaceous and Tertiary age.

The key issues to address the uncertainties in understanding of the petroleum system are to determine:

How many effective source rocks there are in the basin. This is readily assessed using high quality geochemical data derived from the known hydrocarbon evidence in the basin. As already outlined above many of the exploration wells drilled have encountered hydrocarbons throughout the stratigraphic column.

The likely quality of hydrocarbons that will be encountered in future drilling. This can also be addressed by detailed analyses of the fluids.

These reasons lie behind the decision by APT UK to carry out this project with the support and active contribution of the Petroleum Affairs Department of the Irish Department of Communications, Energy and Natural Resources, which is gratefully acknowledged.

This project addresses one of the outstanding issues by providing a high quality analytical database which characterises 76 different shows from 18 wells spread across the drilled portion of the basin. In addition 9 flowed oil samples have been analysed in detail (see map overleaf and table listing below for details of wells studied). The shows have been extracted from core or cuttings samples and analysed in the world class APT AS laboratories in Oslo. The report contains the raw data and an interpretation of the detailed biomarkers and carbon isotopes.

## OETR – Who we are

Barrett, W.

*Offshore Energy Research Associations OEEER and OETR*  
*Halifax, Nova Scotia. Email: [w.barrett@offshoreenergyresearch.ca](mailto:w.barrett@offshoreenergyresearch.ca)*

This poster explains purpose and membership of The OETR Association (OETR). OETR is a not-for-profit corporation dedicated to fostering geosciences research that will enhance Nova Scotia's offshore petroleum exploration and development.

OETR's members include Dalhousie University, Saint Mary's University and the Nova Scotia Department of Energy.

## The new fission track laboratory in Trinity College Dublin

Chew, D.

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The fission track laboratory in Trinity College Dublin Geology Department was installed in autumn 2007. It was funded by Science Foundation Ireland (SFI) and the Petroleum Infrastructure Programme (PIP) of the Petroleum Affairs Division (PAD). All sample preparation material has been installed and several irradiation packages of samples and standards are now being processed.

The system in TCD is based on a state-of-the-art Carl Zeiss AxioImager Z1m microscope, using an Autoscan AS3000i/f stage system in conjunction with Sony linear sensors for improved positioning accuracy, and an Olympus/SIS CView 3 high-resolution digital colour camera. The system is controlled by Autoscan Trakscan software, which also has an automated track counting module. The data produced by the automated track counting module can be reviewed (and modified, if necessary) by the operator.

Projects utilizing the laboratory include assessing the utility of low temperature thermochronometers (apatite fission track, (U-Th)-He apatite) in quantifying the timing of exhumation in various tectonic settings. These include crystalline basement samples obtained by the MeBo seabed drilling rig from the northern Porcupine high, along with projects investigating the timing of exhumation in the Tanzanian sector of the East African Rift, the Peruvian Andes and the Isthmus of Panama. A major project in conjunction with the University of the Algarve has also just commenced, with a Ph.D. student using the facility to reconstruct the burial and exhumations histories of the South Portuguese Zone and Algarve Basin on the southern Iberian margin.



## Seismic interpretation and inversion of the Galway Bay high frequency datasets.

C. Clarke, G. Duffy and K.C. Leurer

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The spatial distribution of the thickness of shallow sedimentary layers in Galway Bay have been produced from the 2007 INFOMAR 4-kHz shallow seismic dataset together with an Earth and Ocean Sciences (NUIG) acquired chirp sub-bottom profiler data set. This ongoing study aims to address the gap in understanding of the shallow succession in Galway Bay using modern seismic interpretation techniques. Three significant surfaces (Bedrock, Till and an upper acoustic unit) have been tagged in a seismic interpretation package and exported to a GIS platform to map the spatial variation of depth-to-bedrock and the thickness of sediment packages.

Initial results of the bedrock surface redefine the position of the Galway Bay (GB) Fault north of its current inference, reveal 6 - 7 km jointing in the limestone pavement northeast of Inis Oírr and show the southern extensions of Galway granites along the north of the bay. The sedimentary surfaces delineate an inner sediment filled basin, track the course of a proposed proto-River Corrib channel constrained by the GB Fault, the data also show the extension of a till surface west of Tawin Island.

Further objectives of this research;

- Application of the innovative SOFTSEDS seismic trace inversion method has been used to extract sound velocity of layers and enable the conversion of the isochron (milliseconds) to isopach (metres) maps.
- Develop a palaeo-environmental reconstruction to aid the understanding of past sea level change in the bay.
- Form recommendations for future coring to target near surface unconformities.
- Assimilate the isopach with an onshore Digital Elevation Model (DEM) to derive an ice flow model for Inner Galway Bay.

## **MarineTT: European Marine Research Knowledge Transfer and Uptake of Results**

Cregg, F.

*Aqua TT*

The challenge for MarineTT; the support action co-ordinated by AquaTT, is to unlock the full potential of EC funded marine research results. The European Commission has funded almost 600 marine research projects through FP6 and FP7, worth €1.1billion as it is recognised that marine research plays a pivotal role in the sustainable development and governance of our seas and oceans. To date little post-analysis has been done of the “knowledge outputs” generated from this significant body of research and thus it is difficult to measure the transfer, uptake and impact of the research investment. The objective of MarineTT is to analyse past EC funded research in order to identify high potential knowledge and then carry out customised knowledge transfer to targeted end users for uptake and application. MarineTT will assess the impact of its transfer activities in order to measurably demonstrate the return on investment of its work.

There are three distinct project phases; collect and understand research outcomes from the marine FP6 and FP7 projects, analyse the outcomes and consult with key stakeholder groups and transfer high potential knowledge outputs to the appropriate end users.

MarineTT has the potential to both improve the accessibility of valuable knowledge generated from marine projects and to transform how the knowledge transfer process is approached.

## **Petroleum Infrastructure Project (PIP)**

Davies, M.; O'Neill, N.

*PIP Secretariat*

The Petroleum Infrastructure Programme (PIP) was set up by the Petroleum Affairs Division (PAD) in 1997. PIP presently comprises two sub-programmes:- the active Petroleum Exploration and Production Promotion and Support (PEPPS) and the now completed PIP (1997 - 2002) sub-programmes.

The overall aim of PIP is to promote hydrocarbon exploration and development activities by:

- Strengthening of local support structures
- Funding of research data gathering and 'land-based' research in Irish offshore areas
- Providing a forum for co-operation amongst explorationists and researchers

Research under the Programme goes beyond normal licence area-specific work and is designed so as not to duplicate the efforts of other groups or of commercial contractors. It is also considered essential that local researchers should be given an opportunity to participate in the research projects. PIP is funded by oil companies with licences offshore Ireland and the PAD.

The ISPSG Group, the successor to the joint industry Rockall Studies Group and Porcupine Studies Group, was set up by the Petroleum Affairs Division (PAD) in 2002 and concentrates on the regional exploration elements of the PIP objectives with an aim to address common industry problems anywhere in the Irish Offshore. Specific work themes include:

- regional geological and geophysical data gathering and studies aimed at improving knowledge of petroleum systems and exploration potential;
- special engineering studies to improve E&P cost effectiveness and recommendations on better procedures and practices;
- environmental baseline studies and monitoring with a view to developing regional impact assessment frameworks;
- other project areas to be agreed with the PAD.

There are four technical committees covering the various work strands of the ISPSG as follows:

- Geology & Geophysics
- Environment
- Engineering
- Data Management & Support Services

## North Atlantic Petroleum Systems Assessment (NAPSA)

Davies, M.; O'Neill, N.

*PIP Secretariat*

The objective of NAPSA is to foster research collaboration between Irish and Atlantic Canadian researchers that will lead to the establishment of funded scientific projects to enhance our understanding of the petroleum geology of the North Atlantic basins. The long term goal is to promote research that leads to increased petroleum exploration and development, with projects also fostering basic research to enhance growth of scientific knowledge.

NAPSA was formalised with the signing of a Letter of Intent at the first NAPSA Executive Committee in Dublin on 28 February 2007. The main areas for collaboration are: Basin studies; Data acquisition and processing; Data access for researchers and Human & Capital Resources. The signatories were the Oil & Gas Development Partnership in Newfoundland and Labrador (OGDP – see [www.mun.ca/ogdp/about/](http://www.mun.ca/ogdp/about/)) and by the Petroleum Infrastructure Programme in Ireland (PIP - see [www.pip.ie](http://www.pip.ie)).

The NAPSA initiative was developed from contacts established between Irish, Newfoundland and other European researchers in hydrocarbon exploration at a two day workshop in Ireland in October 2005. The workshop considered future research objectives to enhance the hydrocarbon prospectivity of the Atlantic Margin Basins of Western Ireland and Eastern Canada. This was followed by a conference in Dublin in November 2006 “Exploring Atlantic Ireland” where delegates from Ireland and

Newfoundland presented their research results. A broad research programme for NAPSA was established at a workshop during the conference and this was developed further by PIP and the OGDG.

The work programme has begun and includes collaborative research between Memorial University of Newfoundland (MUN) and National University of Ireland, Galway (NUIG) on fluid inclusion studies, Trinity College Dublin (TCD) on Carboniferous geology and University College Dublin (UCD) on reservoir provenance studies.

### **Initial rifting and break-up between Nova Scotia and Morocco: An examination of new geophysical data and models**

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The margins off Nova Scotia and Morocco began forming during Late Triassic rifting and Middle Jurassic separation of the North American and African plates. Initial rifting formed small rift basins bounded by long, sinuous faults. Thick salt deposits accumulated in these early rift basins, later deforming younger sequences as the margins evolved. Images of deeper crustal structure show that faulting style and basin geometry vary along the margin, and beneath the central and north-eastern Scotian margin the continental crust was thinned by up to 50% over 150 to 200 km distance prior to breakup and initiation of sea floor spreading. Thermal subsidence of the Scotian margin was also greater to the northeast, resulting in a thick (in excess of 10 km) post-rift succession and numerous salt structures that obscure basement and deeper structure.

Determining the nature and timing of rifting between Morocco and Nova Scotia has proved challenging. The margin to the south of Nova Scotia has clearly recognized characteristics of a volcanic-style rifted margin, including seaward dipping reflector (SDR) sequences that are interpreted as rift-related volcanic flows overlying basement. These SDRs are coincident with a strong linear magnetic anomaly, the East Coast Magnetic Anomaly (ECMA), which shares many characteristics with the West African Coast Magnetic Anomaly (WACMA). Seismic evidence for these reflector sequences is absent along most of the Scotian margin, and the magnetic anomalies on the Nova Scotia and Moroccan margins change character and fade in amplitude midway along the margins. The nature of the ECMA and WACMA is regarded as being critical to understanding the nature of rifting. Modelling of a new compilation of magnetic data is one approach being used to explain the source of the anomalies and the variations in rifting character along the margin. Other evidence, ranging from geophysical (gravity, magnetics, reflection and refraction studies) to geological (volcanic age dating, salt deposition, and Triassic/Jurassic stratigraphy) is also being evaluated to garner insight into the early stages of rifting and break-up.

The new interpretations and supporting evidence are being used to develop revised models for the early rifting between Nova Scotia and Morocco in order to provide a better framework for predicting palaeo environments and heat flow during the rifting process, both critical to understanding the hydrocarbon prospectivity.

## Waveform tomography applied to long streamer MCS data from the Scotian Slope, offshore Eastern Canada

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Conventional seismic imaging of complex margin structures such as salt diapirs, mass transport deposits and sequence boundaries at the edge of the shelf is often challenging even using the most advanced techniques. Determining the nature of sediment reflectors is also of great importance for exploration purposes and requires imaging beyond reflection. Waveform tomography, which uses both phase and amplitude of the seismic wavefield, is a method that can produce high resolution velocity fields if refracted waves propagating through the target structures are recorded. Modern marine acquisition with long streamers now offers the ability to record far offset arriving refracted waves at great density using uniform sources. We use 2D MCS data acquired with a 9-km-long streamer over the Nova Scotia Slope in water depths of ~1600 m. Using a frequency domain acoustic code over frequencies from 10-25 Hz on two crossing profiles (45 and 30 km long), we detail how the limited refracted waves can constrain the velocity field above the depth of the turning waves (~1.5 km below seafloor).

Velocity inversions are particularly well resolved above the 1500 mbsf limit, where the high resolution velocity field also matches the lithology very closely and velocity models are consistent at the crossing point between the two tested profiles. Several important features are resolved by the waveform velocity model, which are not present in the initial travel-time model. In particular, a small increased velocity layer (<100 km/s) due to gas hydrates is imaged along the entire profile even where a characteristic BSR (Bottom Simulating Reflector, marking the thermal stability of hydrates) is not visible. Imaging gas hydrates continuously where the BSR cannot be identified by reflection imaging allows better estimates of the total volume of hydrates, important for their potential impact on climate. The depth of the BSR can also be used to estimate heat flow, information of potential importance for estimating petroleum system maturation in frontier areas.

This abstract was presented at the Conjugate Margins conference in Lisbon on 29<sup>th</sup> September 2010.



## Salt Tectonics Offshore Nova Scotia

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The poster displays a series of 3D seismic models of the Nova Scotia salt basin. The basin is:

- Under-explored salt basin with proven hydrocarbon system
- Wide range of Jurassic to Tertiary structures associated with autochthonous and allochthonous salt
- Numerous untested deepwater plays outboard major Jurassic and Cretaceous deltaic systems
- Possible Early Jurassic restricted marine depositional setting immediately above the autochthonous salt layer

## The 'slope detachment zone' on the western Scotian Slope, offshore Nova Scotia: structural style and implications for margin evolution

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Regional 2D and 3D seismic mapping efforts reveal a ca. 350 km long structurally distinct region that runs parallel to, and outboard of, the Jurassic carbonate bank on the central and western parts of the Scotian Slope, offshore Nova Scotia. This region, defined here as the „slope detachment zone“ (SDZ), covers an area greater than 13 000 km<sup>2</sup>, is ca. 35 to 55 km wide, and is characterized by the distinct absence of allochthonous salt diapirs in present day water depths generally between 500 to 2500 m. Because it encompasses roughly 30% of the total area of the Scotian Slope in water shallower than 2500 m, improved understanding of this structural domain is of significant economic and academic interest (in terms of understanding deep water petroleum systems and margin evolution). The landward edge of the SDZ corresponds to the structural hingeline that parallels the Jurassic carbonate bank, separating a relatively stable platform to the north from significantly attenuated continental crust to the south; its distal limit, as defined here, corresponds to the landward edge of the „slope diapiric province“ comprised dominantly of allochthonous salt diapirs. Within the SDZ, strong decoupling is recognized between the structural styles above and below a seismically amorphous interval interpreted as a thin autochthonous salt layer. The deformation style above this layer (and its associated primary weld) is dominated by raft tectonics and associated thin-skinned detachment. Jurassic strata are commonly offset along low-angle listric growth faults that sole out in autochthonous salt. These faults define the headward parts of detached „slabs“ of Jurassic strata, and can be correlated laterally into distinct shear zones that define the edges of rafted blocks. Parts of the Jurassic carbonate bank foundered in a similar manner. In the southern parts of the SDZ, there is

an increased tendency toward contractional structures, including detachment folds, reverse faults and thrust faults. Such structures continue into the „slope diapiric province“ to the south. Several scenarios could explain the distinct lack of allochthonous salt diapirs in the SDZ. However, there is little evidence to suggest that much salt moved seaward from the SDZ during sediment loading and detachment. Rather, significant sediment down-building took place along the southern boundary of the SDZ in the Jurassic and Cretaceous, accommodated by salt withdrawal along the landward edge of the „slope diapiric province“. Hence the transition from the SDZ to the „slope diapiric province“ probably corresponds to a seaward increase in the original thickness of autochthonous salt in present day water depths >2000 m. The SDZ is therefore interpreted to coincide with the onlap edge of the original autochthonous salt basin and development of extensional and contractional structures is believed to have been prompted by tilting of autochthonous salt layer during Jurassic thermal or mechanical subsidence after continental break-up.

This abstract was presented at the Conjugate Margins conference in Lisbon on 29<sup>th</sup> September 2010.

## Observations on Irish sills and comparison between sills imaged using 2D and 3D seismic data

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The Porcupine, Hatton, and Slyne-Erris basins, offshore western Ireland, are part of the NE Atlantic volcanic continental margin. Igneous sills intruded into the upper crust account for a significant portion of the volcanic content of such margins. Sills in these basins have been identified, catalogued and mapped using 2D and 3D seismic data. 285 individual sills have been recognized. Intrusions are unevenly distributed across the area, with sill density increasing towards the east. The dearth of sills in Hatton may be attributed to sparse seismic coverage across this basin. The majority, if not all, intrusions are saucer-shaped, a geometry which may be fundamental to sills. The sills display a preference for intruding the sand and mud succession below the Cretaceous chalk. With an average lateral extent of 3.4 km, Irish sector sills cover an area of approximately 12,500 km<sup>2</sup>. Though poorly constrained, average sill thickness is thought to lie between 50 and 150 m. It has been estimated that Irish sills represent a volume of  $6.3 \times 10^5$  to  $1.9 \times 10^6$  km<sup>3</sup> of igneous intrusive material. A comparison study of 2D and 3D data with regard to sills has found that, unsurprisingly, 3D data is of superior quality to 2D data. Sills are imaged in far greater detail on 3D data. 3D seismic data also facilitates the identification of steeply dipping intrusions, or sills that are located deep in the crust or toward the bottom of multi-layered sill complexes. While 2D data is useful for gauging the quantity and extent of sills over a wide area, it is evident that many deeper sills may not be imaged. As most of the Irish sector is covered by 2D data, a significant proportion of sills in this area may not have been accounted for. Current area and volume estimations for the intrusive component of the North Atlantic Igneous Province in this area are therefore, most likely, underestimates. The “missing” sill volume can be estimated by comparing sills imaged on co-located 2D and 3D surveys.

## Hatton-Rockall Sites for the New BGS 40m Rockdrill

Hitchen, K.

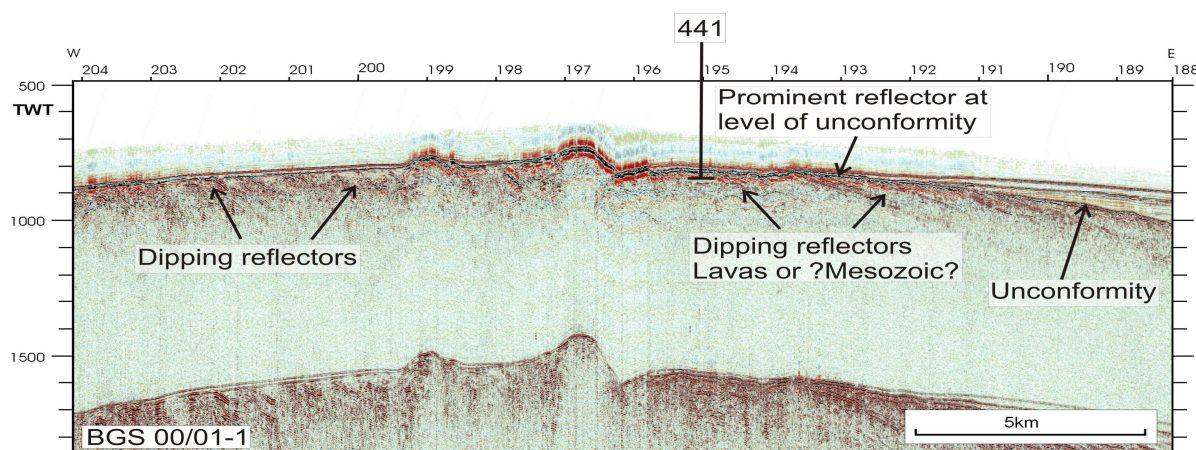
BGS, Murchison House, West Mains Road, Edinburgh, EH9 3LA. E-mail: [khi@bgs.ac.uk](mailto:khi@bgs.ac.uk)

In 2012 the British Geological Survey (BGS) will be taking the *RRS James Cook* to the Hatton-Rockall area of the NE Atlantic Margin to collect rock cores, up to 40m below the sea bed, using the modified BGS 'RD2' rockdrill. The drill is completely portable, has its own dedicated launch and recovery system and can be deployed from any suitable vessel equipped with dynamic positioning and sufficient deck space. Its specification allows cores to be recovered in up to 3000m water depth without the requirement to hire an expensive drillship.

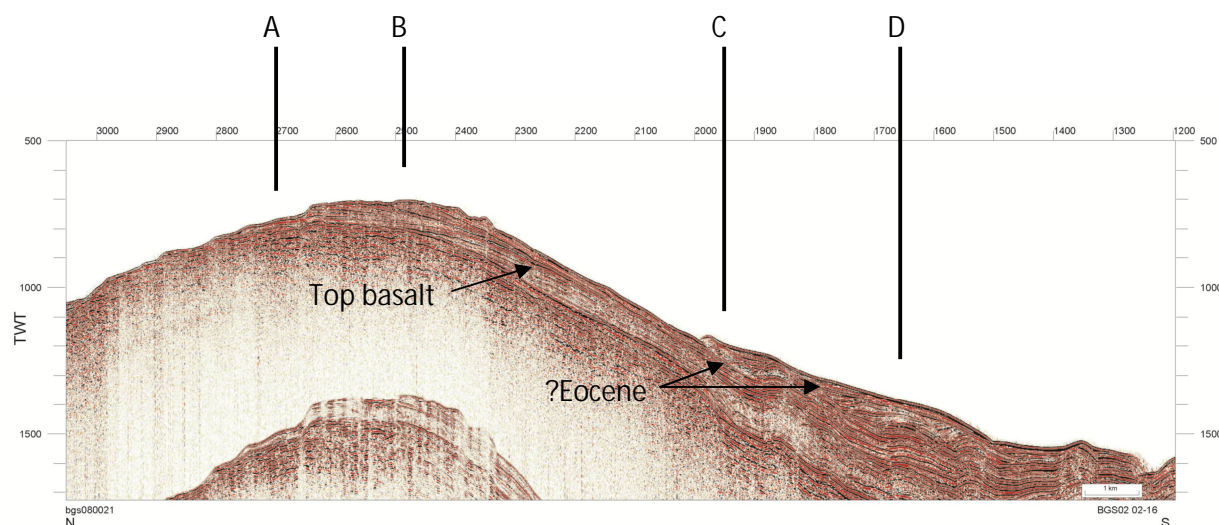
The principal aims of the 2012 cruise are:

- 1) To investigate the Mesozoic rocks of Hatton Bank
- 2) To use offset drilling strategy to determine the detailed post-basalt Cenozoic stratigraphy, especially of the Eocene which was a period of multiphase tectonic activity
- 3) To drill previously unsampled major volcanic centres and lava flows and undertake analyses to elucidate the temporal and geochemical igneous evolution of the area.

Various geological sites and targets have already been selected using existing BGS, and other, high-resolution seismic data. Examples are shown below.



Drill site (441) to identify nature of dipping reflectors



Offset drill sites (A, B, C and D) to determine Cenozoic stratigraphy

## GEUS Geophysical Research Project

Hopper, J.R

*Geological Survey of Denmark and Greenland (GEUS)*

Poster on a joint research project involving eight geological surveys.

## Mesozoic Tectonic and Stratigraphic Evolution of the Orphan Basin, with Special Emphasis on Regional Correlations with Flemish Pass and Northern Jeanne d'Arc Basins

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The tectonic framework and depositional settings of the Orphan Basin are studied by using approximately 25,000 km of 2-D seismic reflection profiles and stratigraphic data from nine exploration wells. The evolution of the region is recorded in five seismic distinct seismic stratigraphic units (denoted Z, A, B, C, X), separated by widespread regional markers (U1 to U4), representing prominent unconformities. Exploration well data showed that seismic units Z, A, B, C and X correlate to the Precambrian/Paleozoic (prerift) basement, Triassic?/Jurassic, Early Cretaceous, Late Cretaceous and Tertiary successions, respectively. The well data show that U1, U2, U3 and U4 markers can be correlated with the Top Precambrian or Paleozoic (prerift), Top Jurassic, Mid-Cretaceous and Base Tertiary unconformities, respectively. The well data further show that the seismic Units A, B+C and X are broadly correlated with three regional tectonic phases, where each

phase includes a period of extension, followed by a period of protracted uplift associated with sectoral break-up, and a period of sustained thermally-driven subsidence.

On the basis of stratigraphic and structural architecture of the successions imaged between the Prerift Unconformity and the Base Tertiary Unconformity, the large Orphan Basin is divided into five distinct tectonic provinces: the Western and Southwestern Basin Margin, the Eastern Basin Margin, the White Sail Fault Zone, the West Orphan Basin and Ridge Province, and the East Orphan Basin.

This abstract was presented at the Conjugate Margins conference in Lisbon on 29<sup>th</sup> September 2010.

### **Variations in crustal structure across the Nova Scotia continental margin and its conjugate**

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The Nova Scotia rifted continental margin lies in a transitional segment between the volcanic US East Coast margin to the south and the non-volcanic Newfoundland margin to the north. The East Coast Magnetic Anomaly (ECMA) and the associated seaward dipping reflectors (SDR), both well-known volcanic margin phenomena, are observed off Georges Bank on the south-western part of the margin but quickly reduce in magnitude to the northeast. A comparison of seismic observations across different parts of the margin also shows a parallel decrease in syn-rift volcanism as defined by three previous cross-margin refraction profiles (SMART-1,2,3). The margin changes from volcanic to non-volcanic between the southern line (SMART-3) and the central line (SMART-2). Existing data between the central and the northern line show a wide continent-ocean-transition (COT) zone characterized by a pervasive layer with velocities of 7.3-7.9 km/s, intermediate between crust and mantle, that we interpret as partially serpentinized mantle. The nature of the crust overlying the partially serpentinized layer was, however, difficult to define as it was under-sampled due to sparse receiver spacing.

In November 2009, a new refraction profile was acquired by the Offshore Energy and Technical Research (OETR) Association of Nova Scotia along a coincident deep reflection profile (NovaSPAN line 2000) to the northeast of SMART-1. The profile was obtained using 100 ocean-bottom seismometers and with particularly dense spacing (2.5 km) within the COT that gives greatly improved resolution in this region. It also extends 125 km seaward of the reflection profile to better constrain the oceanic crust. Data were analysed using the same modelling technique as for the SMART survey. Preliminary results show very similar structures to those determined for SMART-1. Therefore, all the profiles in the central and the northern margin are consistent with the lack of volcanism and the presence of thin oceanic crust. These results aid in determining a detailed kinematic reconstruction of the rifting and breakup of the complete Nova Scotia-Morocco conjugate margins. Asymmetry in oceanic crustal thickness is, however, observed across a near conjugate to NovaSPAN 2000 on the Moroccan margin (SISMAR-4) after plate reconstruction. Either a ridge jump or post-spreading volcanism may be required to explain such asymmetry.

This abstract was presented at the Conjugate Margins conference in Lisbon on 29<sup>th</sup> September 2010.



## **Gross Depositional Environment offshore Nova Scotia: Methodologies and preliminary results**

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The Play Fairway Analysis (PFA) programme initiated by OETR (Offshore Energy Technical Research Association of Nova Scotia) is fundamentally based on the creation of Gross Depositional Environment (GDE) maps for key intervals. These maps are created through a thorough integration of paleo-environment data from wells with seismic facies analysis.

The methodology is essentially based on a rigorous sequence stratigraphic approach. The major innovation in this PFA study was the creation of a systematic sequence stratigraphic framework offshore Nova Scotia. This analysis was based on 20 key wells of which 6 had new biostratigraphic analyses.

The information from these key wells was extrapolated using seismic stratigraphy. Accurate well to seismic ties were established through careful calibration of sonic and density data together with well established well/seismic correlations methods. In order to ensure the highest possible resolution for calibration to the wells, key seismic lines were reprocessed to improve bandwidth and imaging. These well data were extrapolated using a large seismic database (~70,000 km of 2D and ~30,000 sq km of 3D).

The PFA workflow imposes a rigorous and disciplined integration process. This is designed to ensure that the various input elements of the study are internally consistent. The integration process is continual throughout the programme and is tested fully during the creation of the GDE maps. These maps necessarily have to honour all the data and interpretation that feeds into the process (from the most basic tectonic history, through biostratigraphy, depositional processes as evidenced by sedimentological studies, seismic stratigraphy and, in this instance, salt kinematics).

The PFA project included some 14 horizons that were mapped seismically for structural and stratigraphic control. Of these, 9 surfaces have significance for understanding the most prospective Cretaceous and Jurassic plays. The GDE maps for the most important intervals are interrogated for predictions of distribution of reservoirs, sources and seals.

This paper presents the overall methodology and illustrates the workflow with an example of source rock distribution.

This abstract was presented at the Conjugate Margins conference in Lisbon on 29<sup>th</sup> September 2010.

## Is the Porcupine Basin a “failed” Magma-Poor Rifted Margin? Evidence from very long offset, deep penetration 2-D seismic data.

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The Porcupine Basin is known to have accumulated very large amounts of extensional strain, with estimates calculated from subsidence data suggesting lithospheric stretching factors ( $\beta_{WL}$ ) greater than 6 for the basin's centre. Preliminary estimates of crustal thickness variations made using interpretations of ION-GXT's deep penetration 2-D (PSDM) seismic data - acquired as part of its NE AtlanticSPAN™ – have enabled calculation of crustal stretching factors ( $\beta_C$ ) for the Porcupine Basin.

The data clearly show the extreme extension that has occurred in the South Porcupine Basin and demonstrate increasing extensional strain southwards, toward the Seabight Basin.  $\beta_C$  ranges from c. 13 (locally) at the Porcupine Arch to infinity further south, where crustal separation and exhumation of serpentinised mantle have occurred. As such, there are strong parallels that can be drawn between the Porcupine Basin and Magma-Poor Rifted Margins (MPRMs), such as the W. Iberian Margin, with many structural characteristics being common to both.

Here, we present some of the classic MPRM characteristics that the Porcupine Basin displays, comparing the Porcupine Basin data with published seismic data from the W. Iberian Margin. The characteristics we describe include; low volumes of syn-rift magmatism, serpentinite detachments, “peridotite” ridges, and a zone of exhumed continental mantle. We also present a map depicting the newly obtained crustal stretching factors for the Porcupine Basin, and suggest potential mechanisms for accommodating the extreme extension observed.

We suggest that the Porcupine Basin be classified as a “failed” magma-poor rifted margin. Crustal separation has occurred in the south of the basin but sea-floor spreading had not initiated.

## **A revised biostratigraphic and well-log sequence stratigraphic framework of the offshore Nova Scotia Margin, Canada**

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<sup>4</sup> *Biostratigraphic Associates (UK) Ltd. Stoke-on-Trent, UK*

As part of a Play Fairway Analysis (PFA) of the Scotian Margin, offshore eastern Canada, we have conducted quantitative multi-disciplinary biostratigraphic studies of the Upper Triassic-Cenozoic sections in 6 wells: Bonnet P-23, Chebucto K-90, Cohasset L-97, Glenelg J-48, Glooscap C-63 and South Griffin J-13.

These wells were chosen to provide good spatial coverage and stratigraphic penetration, plus correlation with the seismic grid.

Using the results from these new wells as calibration, we have also evaluated pre-existing biostratigraphic data and interpreted the well-log sequence-stratigraphy of 14 additional wells using a consistent event scheme. Our study provides accurate ties and clarifies the origin of seismic horizons mapped across the area within the PFA project. Key to the dating of some horizons has been integration of the palynology and micropalaeontology (most commonly used for biostratigraphy on the Scotian Margin) with available nannofossil and calpionellid data. By integrating the biostratigraphic, lithofacies, well log and seismic data, we have enhanced resolution over previous efforts and thus have a better understanding of unconformities and major flooding events in the region. As part of the PFA, this work will help generate new momentum in the search for hydrocarbons on the underexplored Scotian Margin, especially in deeper water.

This abstract was presented at the Conjugate Margins conference in Lisbon on 29<sup>th</sup> September 2010.

## **A crust and basin study of the Nova Scotia margin and its ocean transition based on densely spaced ocean bottom seismic observations**

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A crustal and basin seismic study of the Nova Scotia shelf/slope and its transition to the oceanic crust of West Atlantic was performed in November 2009. One 400 km long NW-SE oriented seismic profile was observed by 100 Ocean Bottom Seismographs (OBSs) spaced at 2.5 to 10 Km intervals. Inline shots were spaced at 120 m and fired by a tuned air gun array of 50 l volume. By using a first-break tomography an initial velocity model was obtained limited at depth due to the penetration of diving waves. This was improved by layered tomography. Reflected arrivals were picked and assigned to specific layers in a top to bottom procedure by a list-square approximation, thus defining thickness of layers and optimizing the velocity distribution. The final velocity model was obtained by forward modelling, computing synthetic travel times and amplitudes. Upon completion of this procedure, the velocity model was used to depth-migrate the diving waves and reflected phases.

Four different geological sections have been recognized. The first, starting at the north western end of the profile and extending for its first 70 km, consists of a continental crust of 33 to 27 km thickness. An upper, middle and lower crust, very similar in structure and velocities to those observed further south across the Canadian continental margin, were resolved. Sediments in this part of the profile have a maximum thickness of about 4.5 km. The second section, of 100 Km width, consists of a stretched continental crust thinning from 27 to 19 km, including more than 9 km thick sediments. Here the continental crust is terminated. For the following 90 km the crust consists of an igneous intrusion with Vp-velocity ranging between 7.2 and 7.3 Km/s. This intrusive body is covered by a layer with Vp-velocities of 5.1 to 5.4 Km/s. The irregularity of the velocity distribution within this layer indicates that this also consists of igneous intrusions that have experienced intense serpentinization. The next 140 km of the profile are floored by thin oceanic crust of about 4 km thickness, which is covered by 4 to 5 km thick sediments.

Several salt bodies were identified within the sedimentary sequence and cover most parts of the stretched continental crust up to the edge of the igneous intrusions. This part of the basin belongs to the salt province that strikes parallel to the Canadian continental shelf.

The conjugate margin of Nova Scotia, which is the Moroccan margin north of Agadir, differs from that of the Canadian side since the stretched continental crust of the Moroccan margin is followed by seafloor spreaded oceanic crust without any igneous intrusions and serpentinized units.

This project was financed by OETR, Canada.

This abstract was presented at the Conjugate Margins conference in Lisbon on 29<sup>th</sup> September 2010.

## Continental slope sediment distribution and characterization: case studies from the Scotian and Suriname margins

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The Scotian margin endured a number of unsuccessful hydrocarbon exploration attempts because of insufficient understanding of continental shelf-to-slope and slope geologic processes. The Shubenacadie H-100 and Shelburne G-29 wells were drilled on mounded seismic morphologies, interpreted as depositional fans. In post-drill analysis, it is apparent that these structures are erosional remnants of canyons cutting across the slope. More recently, the Torbrook C-15 well was drilled into a presumed Tertiary fan; a mass transport deposit was encountered.

The above examples highlight a global need to recognize and understand continental shelf-to-slope and slope sedimentary processes. This investigation addresses this issue through study of Cenozoic analogues on the Scotian and Suriname margins wherein there is sufficient data resolution and fewer complicating factors such as sediment compaction, structural faulting and mobile salt deformation. For the Scotian margin, application of conventional sequence stratigraphic methods has proven difficult to apply; the margin is largely aggradational with dominance of erosive processes. Such processes include numerous episodes of canyon cut and fill, mass transport reworking and re-deposition, and along-slope sediment erosion and transport by deepwater contour currents. These poorly understood processes dominate over sediment input and sea level controls and greatly impact the preserved stratigraphic record with significant spatial and temporal variations.

By contrast, the Suriname margin is relatively simple in its Cenozoic depositional architecture. This margin is the last vestige of the proto-Atlantic, forming in the mid-Cretaceous. As such, its modern latitudinal position and post-rift history are equivalent to Nova Scotia's in the Jurassic. In the case of Suriname, off-shelf sediment transport driven by an interplay of sediment supply and sea level position dominates control of Cenozoic sedimentation, leading to rapid margin progradation and construction of a well developed sequence stratigraphy.

Despite these distinctions between margins, there are consistencies in depositional patterns that provide the basis for a stratigraphic framework. For example, a major Oligocene canyon cutting period and a mid-Miocene bottom current intensification period are recognized along both margins. Control events such as these provide stratigraphic markers that permit broad age control and a degree of correlation.

This abstract was presented at the Conjugate Margins conference in Lisbon on 29<sup>th</sup> September 2010.

## Combined rigid/deformable plate tectonic reconstructions for the Central Atlantic margins

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The Iberian and Newfoundland conjugate margins are zones which record anomalously large amounts of crustal extension. Within this segment of the Atlantic margins, the formation of continental 'rafts', comprising highly attenuated continental crust, poorly defined oceanic crust and exhumed mantle, is characteristic. The reconstruction of plate boundaries to their pre-extended configurations assuming 'rigid' plate geometries results in large misfits across plate boundaries (e.g., by restoring North America, Iberia, Greenland and Europe Plates, including the Hatton Bank to the Late Jurassic). In order to solve these problems and utilise the information on the amounts of continental extension along passive margins, a new combined rigid/deformable plate kinematic model has been developed, consisting of a complex global chain of rigid plates rotating around a fixed hotspot frame and deformable plates defined along continental margins and within cratonic interiors.

To model the continental deformation in the reconstructions, an ArcMap<sup>TM</sup> extension has been developed (Plate Wizard<sup>TM</sup>). The program creates displacement vector maps that allow restoration of the plate margins by 'warping' the mapped extended regions. The program also allows the restoration of the geometries of geo-referenced datasets that can be intersected with the plates defined by the model.

To date, a self-consistent global, plate tectonic model has been achieved, that incorporates stretching factors and scales deformation for the Cenozoic and Mesozoic for the entire Atlantic margin. Restoration to the pre-rift geometries of the margin in these areas can be refined further by detailed modelling of tectonic evolution and the extent of crustal deformation.

## Thermal modelling of the central Scotian Slope, offshore Eastern Canada: Seafloor heat flow data, hydrocarbon maturation potential and the effects of salt on heat flow

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Six of the twelve deepwater Scotian Slope explorations wells were drilled between 2002 and 2004 as a result of the global push towards deeper water exploration. The Jurassic-Cretaceous Verrill Canyon Formation has been inferred as the prominent source rock for the entire Scotian Basin based on



previous wells on the shelf. However, the maturation of these shales through standard vitrinite reflectance analysis is largely unknown for the outer slope basins, as few of the deeper water wells penetrate the Verrill Canyon Formation and none reach beneath the upper Jurassic sediments. In an attempt to provide additional constraints on the thermal structure of the central Scotian Slope 48 seafloor heat flow measurements were acquired in July 2008. The data show significant lateral variations in seafloor heat flow associated with the presence of large salt diapiric structure with high thermal conductivity. However, measurements in regions unaffected by salt record relatively uniform seafloor heat flow values of  $\sim 42\text{--}45 \text{ mWm}^{-2}$ . The crustal heat flux history of the basin consistent with these values is calculated using uniform and depth dependant extensional models. Crustal stretching factors ( $\beta$ ) across the rifted continental crust underlying the Scotian Slope, which are required for extensional modelling, are constrained from previous seismic refraction velocity models (Wu et al. 2006).

To further define the maturation potential of sedimentary sequences within the slope basins, dynamic 3D thermal models are produced as constrained by available seismic data, well data, seafloor heat flow data, and crustal rift models. Initial results assuming no radiogenic heat production, or radiogenic heating in only within the sediments, predict that the inferred Late Jurassic source rocks occur within the wet gas or late oil window, depending on whether the models are matched to the landward or seaward measured heat flow data. To match all observed seafloor heat flow, requires increasing radiogenic heat production associated with thickening crust in the landward direction. These models predict that the maturation of the inferred Late Jurassic source rocks increases from the late oil to wet gas window in the landward direction.

This abstract was presented at the Conjugate Margins conference in Lisbon on 29<sup>th</sup> September 2010.

## **Proposed Atlantic margin WARRP seismic acquisition offshore Ireland and Newfoundland**

### **ISPSG Project IS09/06**

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<sup>2</sup> *UCD School of Geological Sciences, University College Dublin*

<sup>3</sup> *Department of Earth Sciences, Memorial University of Newfoundland*

The sedimentary basins located along the Atlantic continental margins of offshore Ireland and Newfoundland comprise of a conjugate system with a shared but still poorly constrained geological history. To understand the petroleum geology of individual large basins within the Irish and Newfoundland parts of the system (e.g. Rockall/Porcupine and Orphan/Flemish Cap basins) requires knowledge of the regional deep structural architecture of the entire basin system. Well constrained models of the pre-rift crust; mantle lithosphere and basin-fill sediments are needed. Understanding of the processes and controls on basins in hyper-extended passive margin settings is critical in the assessment and de-risking of the petroleum systems along both the Newfoundland and Irish margins. A set of up to eight new seismic wide-angle reflection/refraction profiles (WARRP) in the Porcupine, Rockall and Orphan regions are proposed to address specific scientific questions and to improve

predictive modelling of petroleum systems. The data acquired will be a fundamental ingredient in reconstructing the late Palaeozoic to early Mesozoic thermal and tectono-stratigraphic evolution of the North Atlantic region. The results will be complemented by, and will also guide, other studies (e.g. basement isotopic provinces, Triassic and Jurassic sediment transport patterns and provenience studies, and also high-resolution biostratigraphy/chronostratigraphy). Some details for Phase 1 of data acquisition are given in the "Phase 1 of WARRP seismic acquisition: southwest Ireland to Porcupine Abyssal Plain, O'Reilly et al." poster.

### **Phase 1 of WARRP Seismic Acquisition: Southwest Ireland to Porcupine Abyssal Plain**

#### **ISPSG Project IS09/06 (PHASE1)**

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The target for Phase 1 of the proposed new seismic acquisition experiment is a 600 km long profile extending from onshore southwest Ireland to the very deep water (ca. 4700 metres depth) in the Porcupine Abyssal Plain. In terms of geological development this profile encompasses a long time span (~ 400 Ma) - from the time the Irish crust was accreted by Caledonian subduction-related processes in the late Silurian/early Devonian to the much later onset of seafloor spreading in the late Cretaceous (~ 82 Ma). The profile transects the proximal region of Mesozoic tectonic extension across the Irish shelf break region and crosses the Porcupine Seabight Basin (PSB) into the distal deep-water hyper-extended regions of crust at the mouth of the PSB, before terminating in oceanic crust (Magnetic Anomaly CHRON 34). Little is known about the details of this frontier region of the Irish Continental Margin. Phase 1 will address key scientific questions about geological development and related hydrocarbon potential. Significant advances in our geological and geophysical understanding are anticipated with the use of proven seismic acquisition parameters. A novelty of the experiment is the combination of various seismic source types (i.e. high frequency long streamer seismic reflection data, lower frequency WARRP data and very low frequency long range controlled source data). The information collectively provided by this data is expected to resolve lithospheric structure over a broad range of seismic frequencies. This information will permit the development of new integrated tectono-stratigraphic models (that incorporate lithospheric-scale processes) across this complex and poorly understood region of the Irish Margins.

## Oil Based Mud Cuttings: Treatment Solutions for Ireland

The management of oil based mud (OBM) contaminated cuttings generated by offshore hydrocarbon exploration in Ireland involves transfrontier shipment (TFS) of the cuttings to the UK for treatment. Some companies find that the process is logistically complicated. Furthermore the EU Landfill Directive 1999/31/EC may cause difficulties for the export of OBM contaminated waste. There is a need for exploration companies operating in Ireland to find alternative solutions to TFS. This study was commissioned by the Irish Shelf Petroleum Studies Group of the Petroleum Infrastructure Programme to examine the options.

## Glacial Meltwater and the Continental Margin of NW Europe: initial results from the IPY GLAMAR campaign to the Irish-UK Celtic Sea

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The seaward extent of the British-Irish Ice Sheet (BIIS) in the Celtic Sea remains uncertain. A BIIS grounding line has been postulated on the Irish-UK mid-shelf, based on the extent of cored tills, but no morphological evidence of an ice margin is recognised. Instead, the Celtic Sea contains a vast system of shelf-crossing seabed ridges, interpreted as palaeo-tidal sand banks formed by reworking of glacial outwash during post-glacial marine transgression. An alternative interpretation is that the ridges are glaciofluvial features, formed by meltwater drainage beneath a more extensive ice sheet. This hypothesis was explored by the GLAMAR campaign of the OGS Explora in 2009, which targeted a mid-shelf study area that crosses the grounding line postulated from cored tills. The first multibeam imagery of the Celtic Sea ridges reveals remarkable bedforms: en echelon ridges are flanked by and give way to transverse 'ribs' up to 10 m high, some including smaller 'crenellations' <1 m high. Subbottom profiles allow stratigraphic ties to vibrocores, showing the ridges to be mantled by subglacial till and glaciomarine sediments. The ribs and ridges are interpreted as subglacial bedforms, which extend at least 65 km seaward beyond the proposed ice grounding line. These initial results support a glaciofluvial origin of the seabed ridges and have broad implications for the seaward extent and dynamics of the BIIS, being explored within the INFOMAR project RIDGES.

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The GLAMAR campaign was an Italian-led contribution to the International Polar Year; RIDGES (Regionally Integrated **D** **G**EOlogical Mapping of the Celtic **S**ea) is an INFOMAR-funded collaboration of NUIM, OGS & BGS. Poster originally presented at IPY Oslo Science Conference, 8-12 June 2010.

## Combined Structural Elements Map

Shannon, P.M.<sup>1</sup>; Naylor, D.<sup>2</sup>

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<sup>2</sup> *ERA-Maptec*

This map was prepared by combining the maps published in PAD Special Publications 1/99 and 1/02 on the Slyne-Erris, Donegal, Porcupine, Rockall and Goban Spur Basins. These reports on a Standard Structural Nomenclature System for the Irish Offshore basins were funded by the PIP Programme.

The Structural Nomenclature Reports with geoseismic sections across the basins and the structural elements maps are available for purchase from the PIP Secretariat – see [www.pip.ie/page/230](http://www.pip.ie/page/230)

## Petroleum Systems Analysis of Atlantic Ireland - A Fresh Approach to Prospectivity Evaluation

*Ternan Ltd, Ternan House, North Deeside Road, Banchory, Aberdeen, AB31 5YR, Scotland  
& the Petroleum Affairs Division, Department of Communications, Energy and Natural Resources, Adelaide Road, Dublin 2*

A series of posters from this project will be on display including.

- Interpretation and reconstruction of the tectonic and structural evolution of the North Atlantic from rift to drift.
- New regional play fairway analysis of the offshore Ireland area, including integration of play trends with the more mature petroleum provinces on the Canadian conjugate passive margin.
- Regional depositional environment interpretation at key stages in the structural evolution of the North Atlantic used to predict reservoir potential in the Rockall and Porcupine basins.
- Gravity data interpretation indicates pre-Cretaceous sediments in the Rockall Basin with likely presence of source rocks and potential hydrocarbon generation.
- Basin modelling and DHIs predict active petroleum systems throughout the Ireland offshore area

## Tracking Sand Grains from Source to Sink Using the Pb-in-K-feldspar Provenance Tool: Examples from Sedimentary Basins on the NW European Margin.

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Evaluating sand dispersal and provenance is an important element in basin analysis, particularly in source-to-sink modelling of sedimentary systems and in assessing the role of up-dip sediment supply on stratigraphic development. *In-situ* analysis of Pb isotopes in detrital K-feldspar provides a powerful means of constraining provenance. K-feldspar grains buried in sedimentary basins retain the Pb signature of their original basement source. Basement Pb isotopic domains with distinctive compositions vary on a broad (>100 km) scale, hence this technique can help to determine the size and geometry of ancient depositional systems. As detrital K-feldspar is generally first-cycle in origin, determining its source can provide complimentary insight alongside provenance methods which utilise signals in more robust, potentially recycled, grains such as zircon.

The Pb-in-K-feldspar tool has been applied to Late Palaeozoic to Mesozoic sandstone intervals, including regionally important hydrocarbon reservoirs, in a range of sedimentary basins on the NW European margin. In Upper Carboniferous sandstones of the Pennine Basin, onshore northern England, the integration of the Pb-in-K-feldspar data with detrital U-Pb zircon geochronological constraints has identified likely recycled grain populations. These datasets suggest that a specific zircon age population, though ultimately derived from a southern source, was recycled from older sedimentary rocks to the north of the basin. The results of Pb analysis of K-feldspars from Triassic sandstones from basins onshore and offshore England (the East Irish Sea and Wessex basins) suggest that the depositional system in these areas was controlled by the Variscan Uplands to the south, with external drainage threading together separate basins at scales in excess of 500 km. However, data from Triassic basins farther to the north and west (the Slyne, Rockall and Faroe-Shetland basins) imply that sediment dispersal was controlled by uplifted Archean and Proterozoic basement blocks, with no discernable Variscan influence. On the scale of individual sedimentary systems, isotopically distinct K-feldspar populations vary with stratigraphy on the margins of the Rockall Basin, implying switching between fluvial systems over time and suggesting that the technique could potentially be used as a correlation tool in barren strata.

## PIP Map

Vaughan, E.

*ERA-Maptec*

The PIP Map shows various sets of data available in the Irish Offshore in one map at either 1:2million scale or 1:1million scale. The datasets are generally non-commercial data acquired by academic researchers, governments or government institutes or under EU research programmes. Shapefiles are available for all the datasets on a PIP Map CD issued to Members of PIP and various researchers working on the Irish offshore.

## Hydrocarbon potential of Mass Transport Deposits on the Central Atlantic Conjugate Margins- An Evolving Play Concept

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Mass transport deposits (MTDs) form a significant portion of the sedimentary section of most continental margins. For example, MTDs comprise up to 40% of the Cenozoic section along the eastern Canadian margin. MTDs are commonly recognised as a geohazard in offshore hydrocarbon exploration, documenting evidence of seafloor instability. However, MTDs are now becoming recognised as potential hydrocarbon exploration targets. Drilled MTDs have contained gas (Shipp & Gibson, 2009) and while these are often geohazards to deeper drilling, they do prove petroleum systems with effective reservoir, trap and seal facies.

The lack of recognition of MTDs as potential hydrocarbon targets was in part due to their deposition in deep water, with large run-out distances down slope onto the abyssal plain, the heterogeneity of these deposits, and their typical chaotic seismic character. There was also the belief that MTDs would have poor reservoir quality with the assumption of very fine grained sediment.

There are potential risks associated with the exploration of MTDs. Reservoir heterogeneity can create baffles and barriers to effective fluid flow contributing to reservoir risk. In drilling and production operations MTDs are a risk where top seal, and internal baffles and barriers can create zones of overpressure that are difficult to predict, particularly in gas-charged systems that are difficult to image seismically. Sand deposited by high density turbidites can act as a “thief” zone, bleeding off production.

MTDs follows the ever evolving concepts of new exploration plays; from the novel idea of sediment bypass across the shelf and slope to deeper waters; drilling through overpressure zones to find new zones of hydrocarbons; and sub-salt plays along passive margins. The potential of MTDs will continue to grow as exploration expands along the slope systems of continental margins.

This abstract was presented at the Conjugate Margins conference in Lisbon on 29<sup>th</sup> September 2010.



## **Cenozoic reactivation of faults, onshore and offshore Ireland**

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Previous work suggests that the 3 principal controls on the Cenozoic deformation in offshore and onshore Ireland are: (i) the Icelandic plume, (ii) Alpine compression and (iii) Atlantic spreading. The relative importance of each of these factors is uncertain and will, in any case, vary both spatially and temporally. This poster briefly outlines ongoing and recent research on the Cenozoic reactivation of faults within the Irish Sea and NE Ireland, on the one hand, and within the Porcupine Basin, on the other. It is suggested that Paleocene faulting in the east of Ireland mainly comprises sinistral and dextral strike-slip faulting, with the former reactivating earlier Carboniferous/Caledonian structures, which is punctuated by pulsed igneous activity associated with the Iceland plume. Further west within the Porcupine Basin, the most significant phase of Cenozoic faulting involves Eocene extensional reactivation of older Jurassic faults. Since Tertiary faults examined in onshore Ireland are highly conductive structures, we speculate that fault reactivation could be responsible for leakage of deeper hydrocarbon traps (in a manner very analogous to that observed in the Timor Sea, within NW shelf of Australia). This scenario could be tested by research combining the analysis of fault kinematics with migration modelling incorporating fault trapping and up-fault leakage.

## **Nova Scotia Play Fairway Analysis Why and What For**

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The OETR (Offshore Energy Technical Research) Association has initiated an industry standard Play Fairway Analysis program. This program serves as a pivotal role in stimulating industry interest in exploration of Nova Scotia's offshore petroleum resources by providing explorers with critical information about prospectivity and resource potential to aid in decision making.

The play fairway program addresses three key issues:

1. Plate tectonic reconstruction: Establishing the relationship between rifting and salt deposition has developed models for potential syn-rift and early post rift depositional environments and the development of source rocks.
2. Forensic Geochemistry: The program has undertaken a systematic evaluation of geochemical source rock and hydrocarbon typing data. An important component of this work includes fluid inclusion studies from hydrocarbon traces found in the salt. This analysis, combined with the reconstruction work provides evidence for a restricted marine Lower Jurassic source rock covering much of the margin.

3. Sequence stratigraphic framework: The program of work has re-evaluated the biostratigraphy of 20 key wells which were then integrated with the seismic interpretation, and tectonic models. A comprehensive sequence framework for the basins has been established

Leading academic researchers based in Halifax have contributed substantial elements to the overall program. Of particular note are the plate tectonic and salt modelling projects being done at Dalhousie University; and the biostratigraphy and reservoir quality projects being done at St Mary's University. All projects will also build on the extensive high quality thinking and knowledge that exists in the Geological Survey of Canada (GSC) and the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB).

The Play Fairway Program has integrated the results of these individual projects to develop an industry standard play fairway analysis and atlas. This includes Gross Depositional Environment (GDE), and Common Risk Segment (CRS) maps on each key sequence.

This technical program is being accompanied by a marketing campaign focussed on attracting leading exploration companies to explore in Nova Scotia.

This abstract was presented at the Conjugate Margins conference in Lisbon 29<sup>th</sup> September 2010. We thank RPS Energy for permission to publish.

## **Evolution of the northern Porcupine Basin during the Late Jurassic-Early Cretaceous**

Yang, Y.; Shannon, P.M.

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A data base of 15 key wells and approximately 4,000 km of seismic reflection data were examined in the northern Porcupine Basin. During the Late Jurassic (possibly the Oxfordian and Kimmeridgian stages), the basin experienced extension and syn-sedimentation. A series of NNE-trending compressional-driven structural highs and lows developed during the latest Jurassic (Tithonian stage). During the earliest Cretaceous, with exception of synclinal depocentres, extensive areas in the northern Porcupine Basin experienced uplift and became erosional areas. Evidence from the study suggests that compression, uplift and erosion played an important role in the shaping of the depositional and structural architecture of the basin. It is suggested that the differential stretching of the crust beneath the Rockall Basin during the latest Jurassic caused southeast-directed compression and transpression to the northern Porcupine Basin, which modified the original geometry of the Late Jurassic rift basin and gave rise to flexure and folding.

## **Regional Tectonostratigraphy: the Irish Mesozoic Basins and Their Comparison with Atlantic Canada Counterparts**

Yang, Y.; Shannon, P.M.

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The results of a regional review of Late Jurassic to Early Cretaceous basin configurations in the North Atlantic region are presented. These show that the Atlantic Margin basins west of Ireland (Porcupine, Rockall and Slyne-Erris) lay in close proximity to the offshore Newfoundland basins (East Orphan, Flemish Pass and Jeanne d'Arc). In particular, during the Late Jurassic, the Porcupine Bank, Orphan Knoll and Flemish Cap were located closely each other and the East Orphan basin with thick Jurassic succession was the southward extension of the Rockall Basin. Some regional comparisons of Late Jurassic to Early Cretaceous lithofacies illustrate interesting trends. The Base Cretaceous Unconformity is of regional importance in virtually all the Irish basins, as well as many others along both sides of the Atlantic margin. Based on a comparison between the Irish basins, North Sea Rift, and basins between Newfoundland and Iberia, insights are provided on the nature, control and mechanisms of formation of the Late Jurassic to Early Jurassic transition along the North Atlantic margin. This study suggests that during the Jurassic-Cretaceous transitional period, the more intense extension in the upper and middle crust beneath the Rockall Basin was balanced through brittle/ductile transition zones and a series of NW-SE trending transfer zones, resulting in compressional and transpressional folding and uplift along the NE Atlantic margin. In addition, thermal doming appears to have played a major role in the formation of the Cretaceous regional unconformity between Newfoundland and Iberia.