PIP
Petroleum Infrastructure Programme

1st and 2nd November

Atlantic Ireland 2016

DoubleTree by Hilton Hotel Dublin - Burlington Road
Upper Leeson Street, Dublin 4

A Petroleum Conference Organised by PIP-ISPSG

A two-day conference and exhibition on Ireland's offshore hydrocarbon potential

Abstracts Volume

This annual event is organised by the Petroleum Infrastructure Programme (www.pip.ie)

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ATLANTIC IRELAND 2016

A Two Day Conference and Exhibition on Ireland's Offshore Hydrocarbon Potential Sponsored by PIP-ISPSG

PROGRAMME AND ABSTRACTS

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

Date: **1st & 2nd November 2016 – 08.00 to 19.00hrs**

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

Edited by

Martin Davies & Tom Moore

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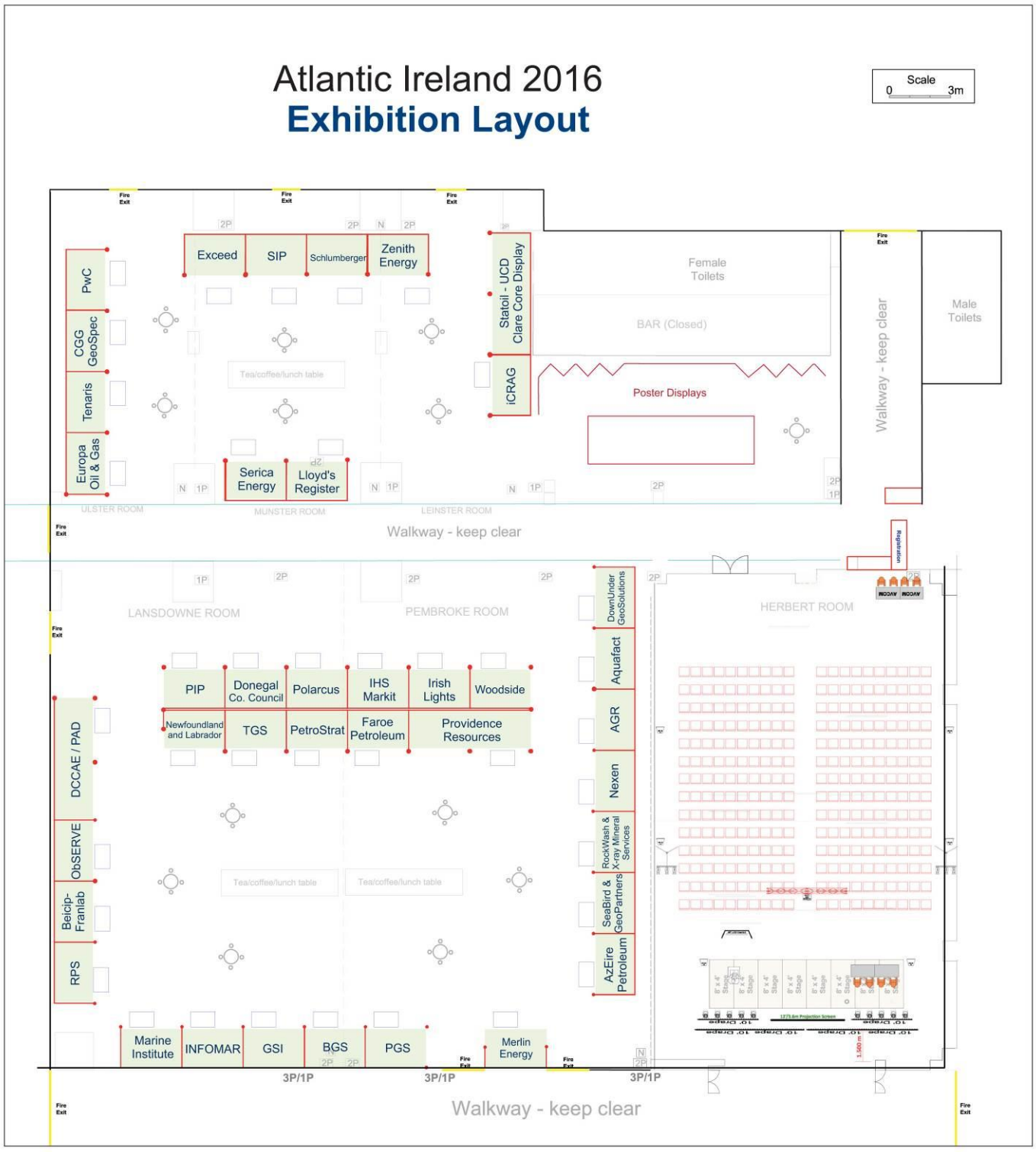
Exhibition Layout



Technical Programme

A two-day conference and exhibition on Ireland's offshore hydrocarbon potential

Technical Programme

TUESDAY 1st NOVEMBER 2016 - Morning

08.00 - 08.55	Reception – Coffee / Tea available in Exhibition Rooms
08.55 - 09.00	***Welcome to Delegates***
09.00 - 09.20	**Address by Minister of State (DCCAE) – Sean Kyne TD**
09.20 - 10.15	**Session 1 - Government Initiatives** *Chair – Matthew Collins (Assistant Secretary, DCCAE)* **Clare Morgan** (DCCAE/PAD) – "Status of exploration Offshore Ireland" **Ciarán Ó hÓbáin** (DCCAE/PAD) – "Policy and regulatory update for the Irish offshore" **Nick O'Neill** (PIP Secretariat) "PIP – key developments since 2015" Questions
10.15 - 11.00	Coffee Break and Poster Session — Kindly sponsored by: EUROPA Oil & Gas
11.00 - 12.45	**Session 2 - Regional Perspectives** — Kindly sponsored by: *Chair – Pat Shannon (IOOA)* **Andrew McCarthy** (Woodside) "The Porcupine Basin, Ireland- New Perspectives on Prospectivity for Oil and Gas" **Neil Parkinson** (Europa Oil & Gas) "Insights into the geology of the South Porcupine from 3D seismic over FEL's 2/13 and 3/13" **David Sturt** (AzEire Petroleum) "Porcupine Basin portfolio in the context of a wider Atlantic Margin exploration strategy" **Mark Attree** (Solaris Exploration) "Prospectivity of the north-east Celtic Sea: New data, new perspectives" **Graham Pritchard** (Serica Energy) "Key elements of the petroleum systems of the Rockall and Slyne-Erris basins" **Manel Prada** (DIAS) "Deep structure of the Porcupine Basin from seismic refraction data modelling" Questions

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This annual event is organised by the Petroleum Infrastructure Programme (www.pip.ie)

A two-day conference and exhibition on Ireland's offshore hydrocarbon potential

Technical Programme

TUESDAY 1st NOVEMBER 2016 - Afternoon

12.45 - 14.10 Lunch — Kindly sponsored by: Azeire Ireland, Statoil

14.10 - 15.05 **Session 3 - iCRAG Research and Innovation**
Chair – John Conroy (Shell)

John Walsh (iCRAG) – "ICRAG – Progress to date and plans for 2017"

Peter Haughton (iCRAG) "Basins on the edge – iCRAG activity in Ireland's offshore basins and their hinterland"

Shane Tyrrell (iCRAG) "Sediment tracking in the Irish offshore basins: new approaches and new insights"

Tom Manzocchi (iCRAG) "New reservoir modelling approaches for high net: gross, low amalgamation reservoir sequences"

Andrew Wheeler (iCRAG) "iCRAG marine spoke projects supporting offshore hydrocarbon activities"

Questions

15.05 - 15.50 Coffee Break and Poster Session — Kindly sponsored by: nalcor energy

15.50 - 17.00 **Session 4 - Prospects2Go / Prospects and Opportunities**
Chair – Catherine Allsop (Statoil)

Hugh Mackay (Europa Oil & Gas) "Europa Atlantic Ireland - acreage, prospects and farm-out timeline"

Paul Griffiths (Predator Oil and Gas) "Third Generation Gas Exploration Offshore Ireland - An Example from the Bantry Basin"

Alwyn Vear (Woodside) "Prospects2Go – FEL 5/13 – Ventry Prospect"

Myles Watson (Providence Resources) "Prospects2Go – LO 16/27 – Porcupine Basin – The Paleocene Avalon Oil Prospect"

Stuart Lawson (Faroe Petroleum) "Prospects2Go – LO 16/23 – Slyne-Erris Basin – The Triassic Edge Prospect"

17.00 - 19.00 Posters and Reception — Reception kindly sponsored by: nalcor energy, Newfoundland Labrador, Tullow Oil

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WEDNESDAY 2nd NOVEMBER 2016 - Morning

08.00 - 09.00 Reception – Coffee / Tea available in Exhibition Rooms

09.00 - 10.50 **Session 5 - Conjugate Margins – New Thinking**
Chair – Greg Jones (Nexen)
Kindly sponsored by:

Chris Leppard (Statoil) "The Atlantic Ireland Margin - A Super Regional Approach to Trans-Atlantic Exploration"

Ian Atkinson (Nalcor Energy) – "New research offshore Newfoundland-Labrador"

Jean-Marie Laigle (Beicip Franlab) "Atlas of source rocks, oil characteristics and oil-source correlation in Mesozoic basins offshore Newfoundland-Labrador and offshore Ireland" (Introduction by Michael Hanrahan)

Philip Copestake (Merlin Energy) "An Integrated Biostratigraphic / Lithostratigraphic Framework of Offshore Ireland" (Introduction by Kara English)

Molly de Coster (AGI) "Sea bed coring of macroseep and microseep locations for geochemical analyses and select heatflow measurements, offshore Newfoundland-Labrador"

Questions

10.50 - 11.30 Coffee Break and Poster Session

11.30 - 12.45 **Session 6 - Environment**
Chair – Andrew McCarthy (Woodside)

Orla Ryan (DCCAE/PAD) "Irish Offshore Strategic Environmental Assessment 5 IOSEA5"

Sinéad Crawford (NUI Galway) – "Acoustic noise in the Porcupine Basin"

Oliver Ó Cadhla (NPWS), **Emer Rogan** (UCC), **Simon Berrow** (GMIT) "The ObSERVE Programme"

Gareth Parry (Woodside) "Porcupine Basin Autonomous Acoustic Recorder (AAR) Cetacean Study – Results support planning for two 2016 seismic operations"

Questions

12.45 - 13.00 **Tony Doré** (Statoil) - Closing Speech

13.00 - 13.05 **Martin Davies** (PIP) - Closing Remarks

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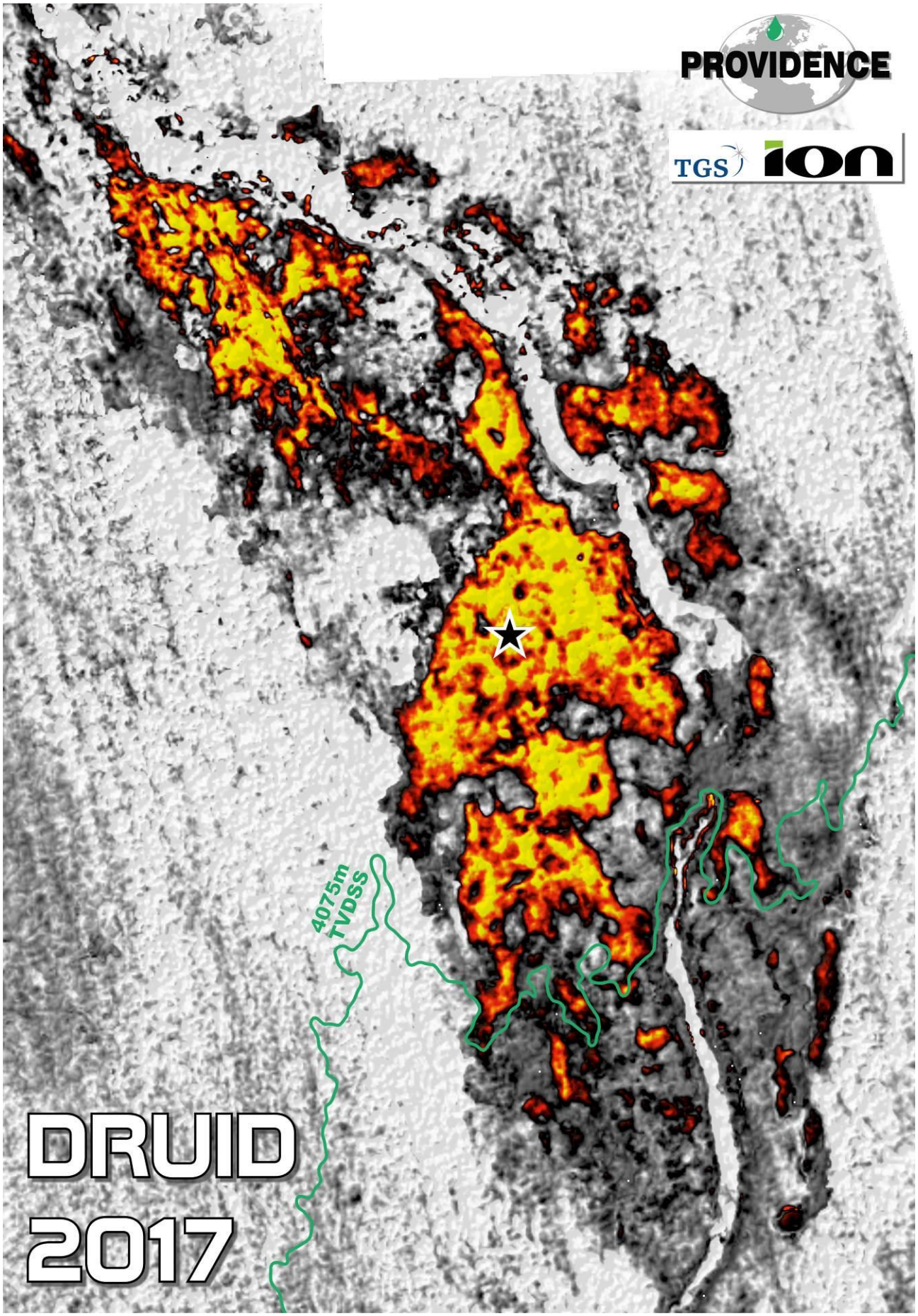
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ORAL ABSTRACTS (in order of presentation)

Speaker is underlined

Status of exploration Offshore Ireland and New Data

Morgan, C.[1]

[1]*Dept. of Communications, Climate Action and Environment, Petroleum Affairs Division, 29-31 Adelaide Road, Dublin 2 Email: Clare.Morgan@dcenr.gov.ie*

The Petroleum Affairs Division of the Irish Government has an ongoing Promotional Campaign to inform companies, contractors, governments and researchers about Exploration & Production opportunities offshore Ireland and to encourage investment in our petroleum sector. The campaign has been effective in proactively outlining the prospectivity of Ireland's offshore basins, and particularly successful in recent years where the focus was on promoting the frontier Atlantic Margin. The campaign is supported by research initiatives aimed at deepening knowledge of the petroleum potential of Ireland's offshore.

Applications for the 2015 Atlantic Margin Licensing Round closed on 16th September 2015. It was the most successful licensing round to date with 43 applications from 17 companies, across five basins in water depths from 100m to 3000m. The response from industry was extremely positive, particularly against the backdrop of a sustained low oil price. Applicants include international majors, mid capital companies and smaller players with some new exploration companies to the Irish Atlantic Margin. Furthermore, there was a substantial overlap for acreage applied for in this round, with more than 75% of the applications in the Porcupine Basin. A feature of the 2015 licensing round included applications over blocks never previously licensed. A wide variety of exploration targets are recognised including stratigraphic and structural traps. As a result of the large number of applications and the associated strong work programmes (including planned seismic acquisition in summer 2016) it was decided to have two tranches of awards, in February 2016 and June 2016. In total, 28 new Licence Options were awarded as a result of the 2015 licensing round to 14 companies. For reference, Ireland's 2011 Licensing Round resulted in 13 new authorisations being awarded compared with one following the 2009 Round and four following the 2007 Round. The number of exploration authorisations now in place is at the highest level since exploration began in the 1970s.

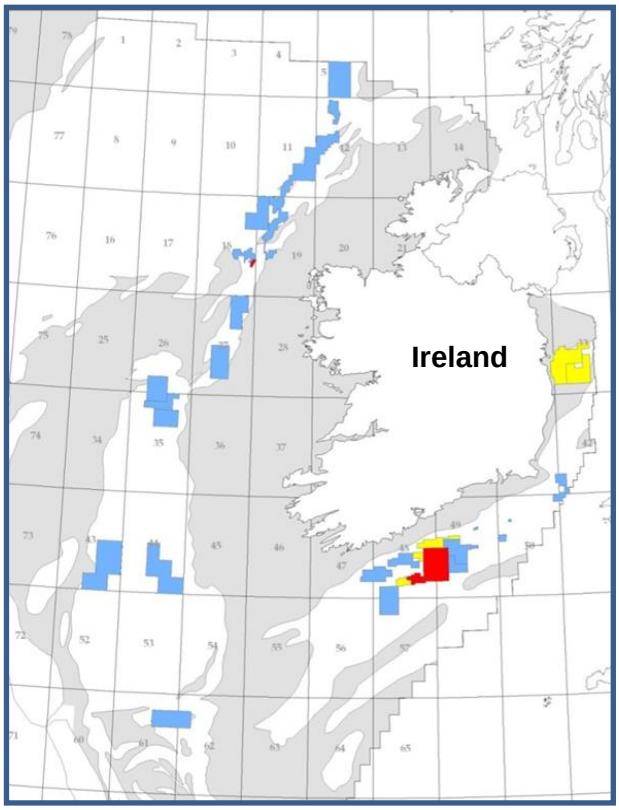
The Celtic Sea area continues to have substantial interest and a number of new Licensing Options, with associated significant work programmes, have been awarded in the basin in recent years focusing on both established and underexplored plays in the area.2016 saw a continued momentum in the level of new seismic acquisition offshore Ireland. Four separate large 3D seismic surveys were acquired in 2016, all located in the Porcupine Basin. The surveys were for the most part located across selected new licences offered to industry earlier this year, as part of the 2015 Atlantic Margin awards. More than 8,500 sq km of new long offset 3D subsurface data were acquired that should aid in assessing the prospectivity in the Porcupine Basin. Many companies are looking for analogues to the discoveries made offshore in the basins off the east coast of Canada in recent years.

No wells were drilled offshore Ireland in 2016. However, the Corrib gas field in the Slyne Basin came on stream in late December 2015 and all wells are now on production.

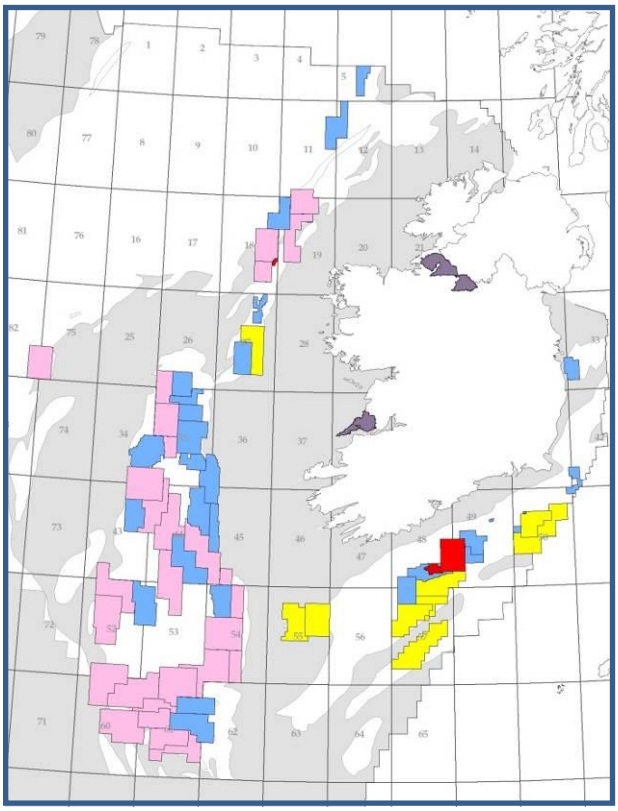
In conclusion, 2016 has been an important year for the Petroleum Affairs Division. The Department had the most successful Licensing Round to date with the Atlantic Ireland 2015 licensing Awards (Phase 1 awards in February 2016 and Phase 2 awards in June 2016); there has been significant seismic activity offshore Ireland; Department sponsored research projects have progressed substantially with new

projects initiated; technical data sales are healthy and the PAD Dataroom facility continues to be in demand. All exploration and production activities were conducted with due regard to safety, environmental impact and to other land and sea users. Overall, the exploration interest offshore Ireland continues to gain momentum. The upswing in exploration effort offshore Ireland, both in terms of the number and quality of exploration companies active in the Irish offshore and in the level of new seismic acquisition is positive. It is expected that the current exploration interest will in due course lead to increased drilling activity. The continued collaboration between government, industry and researchers in the petroleum sector offshore Ireland is undoubtedly beneficial.

2015 Atlantic Margin Licensing Round
Awards illustrated in pink

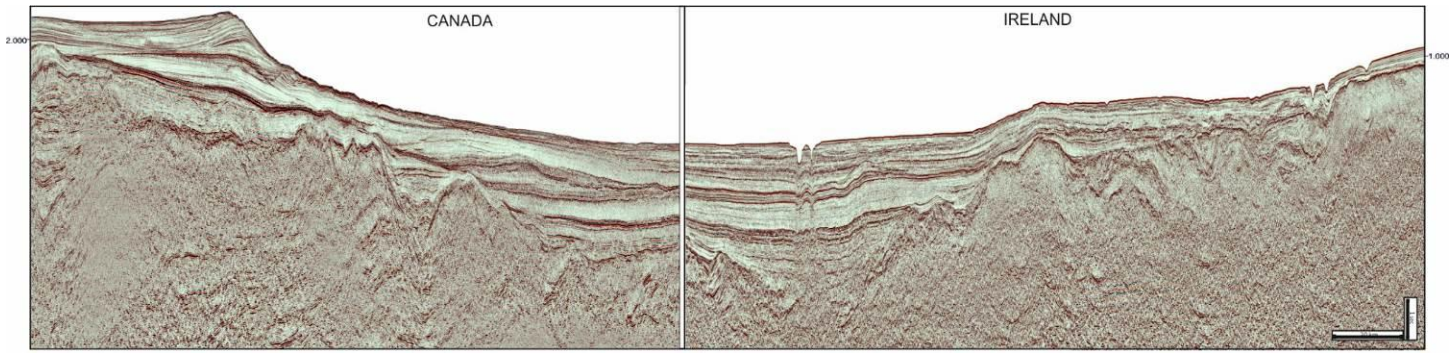


Ireland Concession Map
January 2011



Ireland Concession Map
September 2016

Increased exploration interest offshore Ireland is demonstrated by the dramatic increase in Authorisations issued in the past 5 years



Uninterpreted composite seismic line:
left -Flemish Pass and Orphan Basin (ORO-129) East Canada, right - Porcupine and Goban Spur Basin (PAD14-040S1 and PAD13-045) West of Ireland, illustrating similarity.

The Irish Petroleum Infrastructure Programme (PIP): Key Developments since 2015

O'Neill, N.[1]

[1]*PIP Secretariat Email: noneill@pip.ie*

The Irish Petroleum Infrastructure Programme has funded research that enhances Ireland's offshore hydrocarbon prospectivity since it was first established by the Petroleum Affairs Division in June 1997. The research topics are not license specific but address barriers to successful hydrocarbon exploration shared by all license operators. The results of this research assist the Petroleum Affairs Division in their role promoting the opportunity to invest in exploration in the Irish offshore.

To achieve its research objectives PIP periodically conducts workshops with its oil company members to identify gaps in our understanding of the petroleum system offshore Ireland and barriers to efficient exploration operations and; with the Petroleum Affairs Division; with researchers to understand the research capacity and infrastructure available to address the research topics identified. The five year research programmes are guided by the Petroleum Affairs Division objective of initiating and supporting research directed at deepening knowledge of the oil and gas potential of the Irish offshore.

Among the topics identified by our workshops with industry was the need for a source rock/oil correlation study of the North Atlantic conjugate margins. At last year's conference we announced that we were negotiating a contract for the delivery of an Atlas of Source Rocks, Oil Characteristics and Oil Source Rock Correlation in Mesozoic Basins of the North Atlantic Conjugate Margins Offshore Newfoundland and Labrador and Offshore Ireland. I am pleased to report that the project, jointly funded with our research partners Nalcor Energy from Newfoundland and Labrador, is well advanced and Beicip-Franlab are due to deliver the final product before the end of the year. They will present on the project in tomorrow's session.

Another barrier to progress that was identified by the workshops is the lack of an Integrated Biostratigraphic & Lithostratigraphic Framework of Offshore Ireland. Following a tendering exercise a consortium led by Merlin Energy Resources Ltd was awarded a contract to carry out this work which has now commenced.

The commitment of oil companies to address societal issues around climate change and the transition to a low carbon renewable energy system is reflected in PIPs support for research in applied geoscience. Last year we announced PIPs intention to contribute €2.4m in cash and benefit in kind value in the form of data to the new SFI Irish Centre for Research in Applied Geoscience (iCRAG) which had just been approved by SFI. The Centre will address issues around the security of supply of clean water, raw materials and energy. This afternoon we will hear about iCRAG's progress to date and plans for 2017 from John Walsh and his team of principal investigators.

PIP's continued success depends on the people involved, the drivers in Government and Industry with vision and energy who manage PIP, those committed oil company representatives who mentor PIP projects and the academics who continue to generate the creative ideas that are turned into practical solutions.

The Porcupine Basin, Ireland- New Perspectives on Prospectivity for Oil and Gas

McCarthy, A.[1]

[1]*Woodside Energy* *Email: andrew.mccarthy@woodside.com.au*

Introduction

Woodside Energy (Ireland) Pty Ltd has been exploring in the Porcupine Basin since late 2013, and is currently operator of four Frontier Exploration Licences (FELs 5/13, 3/14, 4/14 and 5/14) and one Licensing Option (LO 16/14) – see ***Figure 1***. Upon entering the basin, Woodside reprocessed to pre-stack depth migration two 1998-2000 vintage 3D seismic surveys. This resulted in a much clearer image of the pre-Chalk structure and stratigraphy, and the identification of a number of robust leads and prospects. In summer 2016 two new surveys were acquired, totalling more than 4000km^2. The Woodside Porcupine Basin portfolio therefore has almost complete 3D seismic coverage. A first exploration well will be drilled in the 2018-2020 period.

Woodside's London-based Ireland team continues also to thoroughly examine existing well, seismic, and other data as it evaluates the basin and the assets. This presentation reviews certain data, with a view to addressing and challenging some fundamental aspects of prospectivity and exploration in the Porcupine Basin.

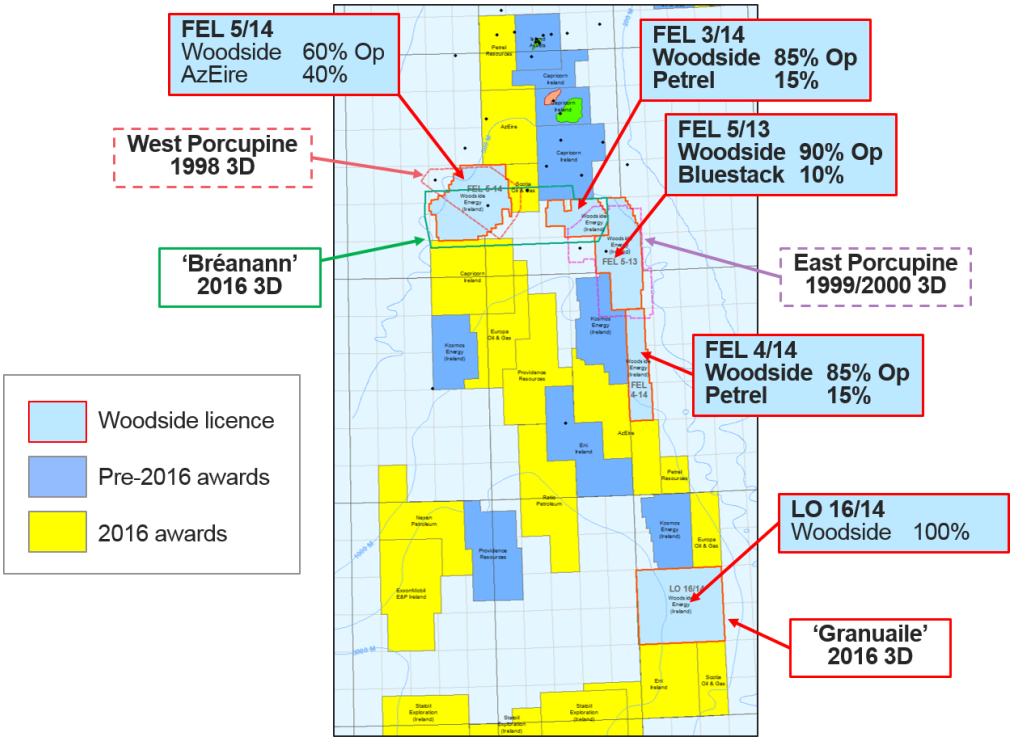


Figure 1 *Woodside Porcupine Basin licence holding and 3D seismic coverage*

Exploration History

An examination of the history of exploration drilling in the Porcupine Basin, and comparison with the history of discoveries in the North Sea, West of Shetlands, and offshore Eastern Canada, reveals how truly underexplored the basin remains – see ***Figure 2***. The majority of discoveries in the latter two provinces post-date the 1977-1982 burst of drilling activity which accounts for 19 out of 26 wildcats drilled in the Porcupine Basin. Just as significantly, there was limited 3D seismic coverage in the basin until

recently. Remarkably only one wildcat of 26 was drilled on 3D seismic. Despite this, three discoveries have been made, with shows in a further 14 wells. These statistics offer great encouragement for renewed exploration of the basin using all the techniques and knowledge now available to the industry.

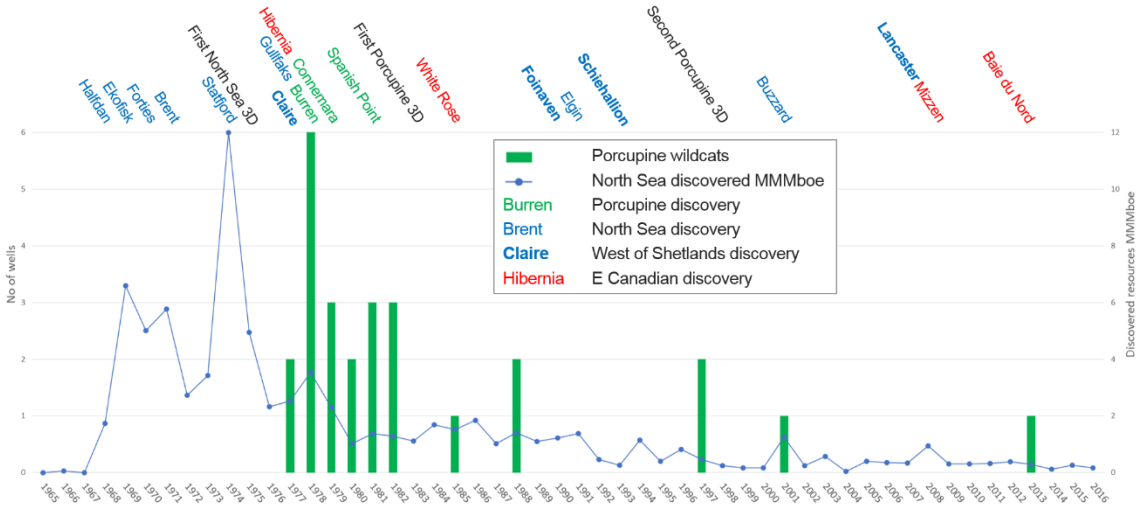


Figure 2 *Porcupine Basin exploration drilling history in context*

Oil versus Gas

It is commonly held that the Porcupine Basin is gas-prone, possibly due to the present depth of burial at the Base Cretaceous Unconformity (BCU) in the axis of the basin, below which the primary Jurassic source rocks are thought to lie. This perception, however, is at odds with the overwhelming evidence from drilling. Oil accounts for two of three discoveries made in the basin, while the fluid phase of the third is ambiguous. The majority of shows in wells were of oil. There are numerous known and potential source rocks, and all have liquids potential. The concept of the 'Kimmeridgian source rock super-highway' is misleading and discounts widespread source rocks at other levels. While Middle to Upper Jurassic organic-rich intervals show mixed oil- and gas-prone properties, Lower Jurassic and Cretaceous potential source rocks are much more oil-prone in nature. Woodside considers the primary fluid type generated in most Porcupine Basin depocentres to have been oil.

Reservoir Quality

Early exploration efforts in the basin were largely concentrated in northern areas. The lack of commerciality to date of the three discoveries there is popularly regarded to be due to the poor quality of Late Jurassic and Early Cretaceous reservoirs. In fact the historical well data include numerous penetrations of good reservoirs in the Late Jurassic in particular. The reservoir in the Connemara discovery well was highly productive on test, but subsequent appraisal revealed the accumulation to be restricted and compartmentalised. The reservoirs in the northern Porcupine Basin are generally fine-grained, lithic sandstones that are significantly buried beneath thick, southerly-prograding Cretaceous and Tertiary deltaic sections. Potential hinterlands include the offshore extensions of the Carboniferous Clare Basin and Irish metamorphic terranes, as well as high-grade metamorphic terranes previously lying to the north.

While northern Porcupine Basin reservoirs are unfairly maligned, those to the south of Spanish Point offer different provenance, depositional systems, facies and burial histories. Seismic data in Woodside's eastern Porcupine licences unequivocally indicate derivation from the adjacent rift flank, rather than axially from the north, and the strong probability of coarser clastic reservoirs. The offshore extension of the boundary between the mixed clastic Carboniferous of the Clare Basin and the Devonian Old Red Sandstone of the Munster Basin is unknown, however southerly areas have an increased probability of

cleaner, better-sorted clastic reservoirs sourced from the latter. Stratigraphic and combination trap plays that have proven so prolific in the eastern Atlantic basins further south, such as Mauritania and Ghana, are well developed in Woodside's basin margin licences.

AVO, DHI's and geophysical exploration techniques

Such techniques as amplitude-versus-offset (AVO) and other direct hydrocarbon indicators (DHI's) are used when screening acreage, and when risking prospects and plays. Rock physics modelling of Jurassic sands encountered in well 35/30-01 indicates that no significant AVO effect is to be expected for differing fluids or enhanced porosity. Full stack responses tend to be lithology- and possibly porosity-controlled. AVO-screening of 3D seismic volumes in areas of known hydrocarbon occurrence confirm the view that the pre-Chalk of the Porcupine Basin is unlikely to be a quantitative interpretation (QI) play in the near future. Major non-AVO discoveries e.g. Buzzard, have been made in excellent reservoirs of similar age and setting. Geophysical advances since previous exploration activity in the Porcupine include the 'silent revolution' of greatly improved seismic acquisition and processing, and desktop processing interpretation and multi-attribute interpretation.

Tectonic framework

Tectonic fundamentals in the Porcupine Basin are not fully understood. It appears however to be an example of an amagmatic aulacogen, in which extreme stretching occurred before extension on the eastern side of the proto-North Atlantic apparently relocated. The rapid change in structural style, degree of extension, and crustal configuration from north to south in the basin is noteworthy. How these rapid changes are accommodated by the surrounding crustal blocks is far from clear, but the roles of poorly mapped pre-existing lineaments are likely to have been critical. Evidence from potential field, seismic refraction and seismic reflection data supports hyperextension, and even an absence of continental basement in the southern Porcupine Basin. This is backed up by such fundamental observations as the current bathymetry and the long-lived underfilling of the basin. The implications for ages of sediments and their burial and thermal histories are critical. The Woodside team considers that the Porcupine Median 'Volcanic' Ridge is unlikely to be of volcanic origin.

Prospectivity of the Woodside portfolio

Woodside's licences lie at the margins of the Porcupine Basin to the west, east and southeast.

To the east, the Moling Sub-basin behind the Ruadhan High hosts a thick Middle Jurassic section including a potential major source kitchen, and set up a ready depocentre for clastic deposition off the basin flank in the Late Jurassic. Major incision in the Early Cretaceous set up a highly prospective canyon fill play. These two plays appear better represented here than in any other part of the basin, and have never been tested. Structural / stratigraphic combination traps are mapped at both levels.

To the west in FEL 5/14, reprocessing of 3D seismic data to PreSDM has greatly improved imaging of particularly well developed Jurassic tilted fault blocks which are expected to contain both source rocks and reservoirs. These are overlain in the Early Cretaceous by thick onlapping fan systems. This area is well situated for charge from source rocks of any age from Jurassic to Palaeogene.

This pattern is repeated in LO 16/14 in the southeast, where 2D seismic depicts major tilted fault blocks, probable Late Jurassic ponded basins, and Lower Cretaceous onlap at stratigraphic levels where fans are imaged on 3D seismic in adjacent acreage. It is expected that processing of the 2016 3D seismic will reveal major prospects.

In all of these areas, to the Early Cretaceous and Jurassic targets can be added the Chalk and the Palaeogene. A recent study commissioned by Woodside has found the Chalk to be highly variable in lithological make-up, as evidenced in wells and on the reprocessed 3D seismic data. Offsetting faults

commonly break the Chalk blanket, especially on the western and eastern flanks of the basin. Oil shows are frequently evidenced in wells within and immediately above the Chalk, and potential fluid escape features or chimneys are also observed.

Targets from late Jurassic, through Cretaceous to Tertiary in age, together with a number of conventional paradigms, will be tested by the exploration programme conducted by Woodside and Joint Venture partners in the coming years.

Acknowledgements

While the primary authors of this paper are cited herein, many others at Woodside, its JV partners and third party organisations have made significant contributions during the past three years. Specifically we wish to thank Ciaran Lavin, Evan Faris, Glen Bowman, Vashti Singh, Chris Falconer, Sarah Grain, André Gerhardt, and Ranald Kelly at Woodside; David Horgan at Petrel; Donal O'Driscoll and John Robbins at Bluestack; Ken McDermott at ION; and Pat Shannon and numerous other interlocutors at Irish institutions.

Insights into the geology of the South Porcupine from 3D seismic over FEL's 2/13 and 3/13

Parkinson, N.[1], Thomas, R.[1]

[1]*Europa Oil & Gas (Holdings) PLC* *Email: neil.parkinson@europaoil.com*

Europa acquired Licensing Options over what were to become FEL's 2/13 and 3/13 in November 2011. Proprietary 3D seismic was acquired over these licences by Polarcus in 2013 (Figure 1). Shooting continuing until October in a benign summer. Our interpretation of this data, combined with our ongoing regional work, has transformed our view of the pre-, syn- and post-rift geology of the Southern Porcupine and we want to share some of these insights in this presentation.

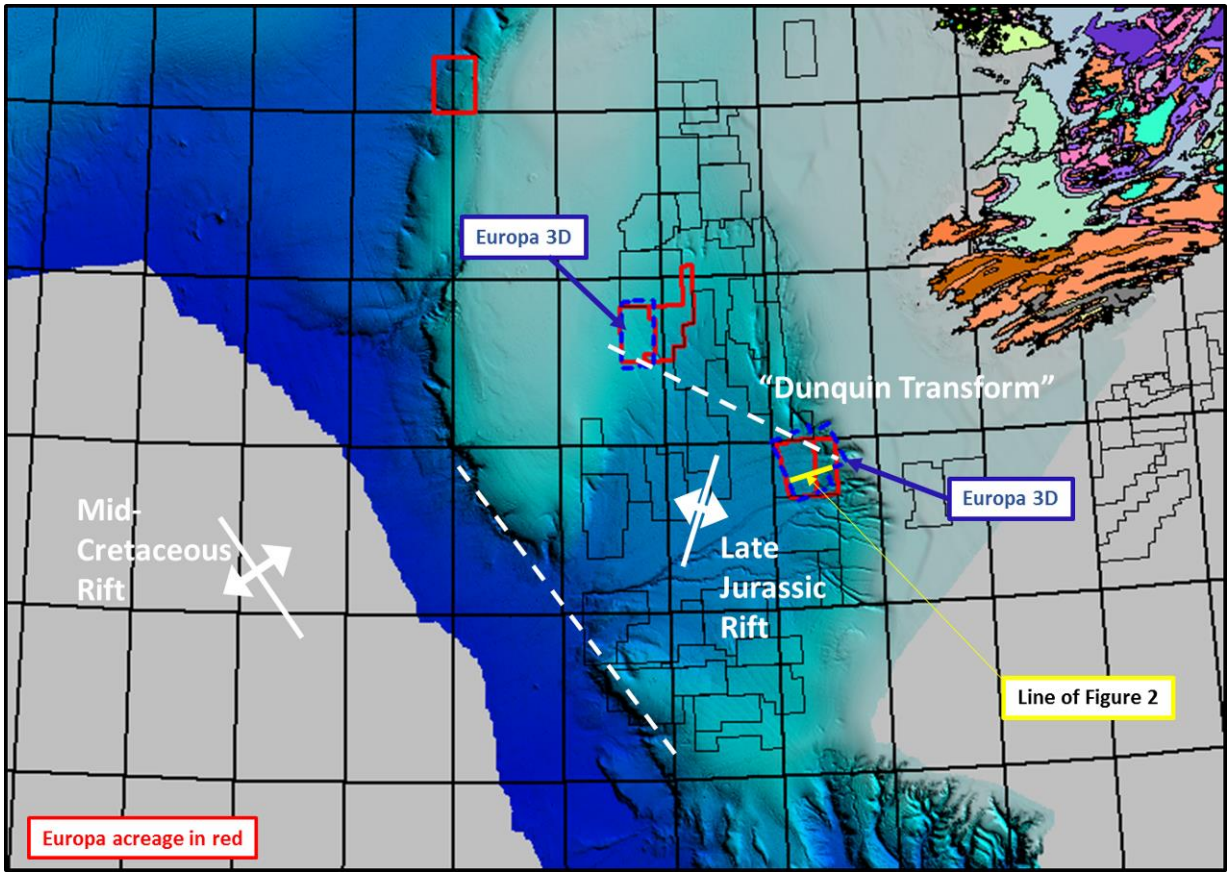


Figure 1 Porcupine Basin bathymetry, Europa acreage and some features discussed

"Top Pre-Rift" is defined on the crests of many, but not all, basement blocks by some 300msec of high amplitude reflectors over a transparent interval (Figure 2). Our working assumption, based on regional experience and the tie at BP 43/13-1, is that this is the Middle Jurassic on the Lower Jurassic. The Lower Jurassic is largely absent from the North Porcupine area and we suggest that the North Porcupine was an Aalenian high, comparable with time-equivalent unconformities in the North Sea area. North of this high, the Lower Jurassic appears to be of Hebridean character. South of the high, it may have more in common with the Celtic Sea and southern English Lias. The Lias may contain petroleum source rocks which supplement the likely Late Jurassic-Early Cretaceous source rocks in the Porcupine area. A key question for reservoir quality is the development of shallow marine facies within the Middle Jurassic. Given the paleogeography (and 150km to the nearest well control) it is easy to postulate this development, but difficult to substantiate it.

3D fault correlation within the pre-rift suggests a series of narrow tilted blocks defined by NNE-SSW trending normal faults and WNW-ESE trending relays, consistent with WNW-ESE extension in the Upper Jurassic. These faults are commonly (at least locally) down-to-the-east. Regionally, we suggest a "Dunquin Transform"' broadly parallel to the extension direction and separating the high-subsidence South Porcupine Basin from the low-subsidence North Porcupine Basin. This lineament would have a more north-westerly orientation than the Clare Lineament of Tate (1992) and we make no suggestion of a linkage to the onshore, or to the much younger Charlie Gibbs Fracture Zone.

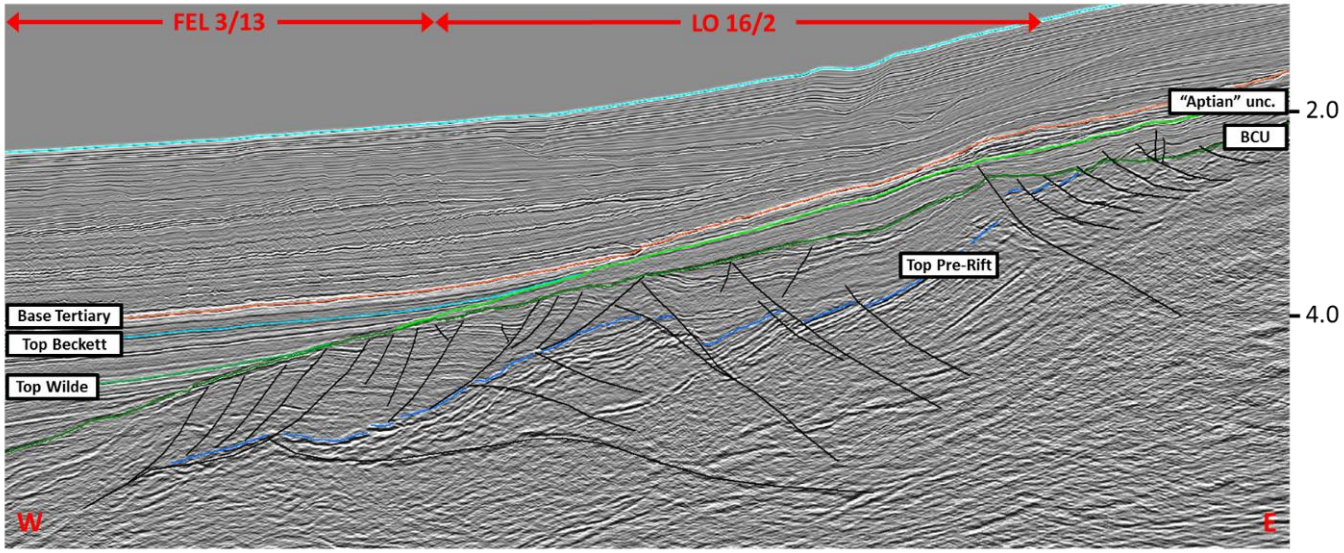


Figure 2 Example seismic line (see Figure 1 for location)
Full offset PSTM. Line length ~32km

Syn-rift growth is modest and local high amplitude reflectors suggest that at least some of the growing half-graben were kept full to base level. We postulate Tithonian and Berriasian shallow marine sandstones comparable to those on the conjugate margin in the North Flemish Pass. Significant and rapid earliest Cretaceous subsidence has locally given rise to down-to-basin listric faulting. These faults are slightly rotated (striking North) with respect to the earlier rift faults, presumably indicative of the subsidence axis. They commonly sole on the top of the pre-rift structures. The additional fault phase generates structural traps within the syn-rift, which also contains the most likely source interval.

Our initial applications for South Porcupine acreage were based on Lower Cretaceous submarine fan plays mapped on historic 2D seismic data. None of the fans subsequently mapped on our 2013 3D seismic coincided with those mapped on 2D. Our eastern 3D defines a steep Lower Cretaceous canyon set up by the Jurassic fault system. This persists as a major sediment entry point to the present day (the Gollum Channel system). Sand-rich fans (i.e. those with clear seismic attribute and/or isopach expression) are the exception rather than the rule in what appears to be a mud-dominated basin, but we have an early (Valanginian?) fan system, which is confined by residual rift topography, and a later (Aptian?) fan system which is unconfined as the pre-rift topography has by this time been overlapped and largely extinguished. Our western 3D suggests a gentler post-rift slope with sinuous slope channel systems, pushing the locus of fan deposition out into the basin.

Obviously our understanding is still developing, but one clear lesson is that "no 2D interpretation survives contact with modern 3D".

Porcupine Basin portfolio in the context of a wider Atlantic Margin exploration strategy

Strut, D. C.[1], McGreevy, J.[1], Murphy, R.[1]

[1]*AzEire Petroleum* *Email:* *david.sturt@azimuth.bm*

AzEire is a wholly owned subsidiary of Azimuth Ltd. a company which owns six regionally focused exploration vehicles in: Indonesia, Norway, UK, Namibia, Brazil and Ireland.

In Ireland, the company owns interests in FEL 5/14, LO 16/16 and LO 16/17 which are all located within the Porcupine Basin along the north western and eastern margins the Basin.

In 2012 the company acquired its initial 40% interest in FEL 5/14 after seeing similarities with other Atlantic Margin Lower Cretaceous deep water clastic plays within its portfolio. After successfully reprocessing existing 3D seismic which covered the northern half of the licence, with our partner Woodside, we acquired a 3D broadband seismic survey covering mainly the southern half of the licence and also partially over shooting the existing survey.

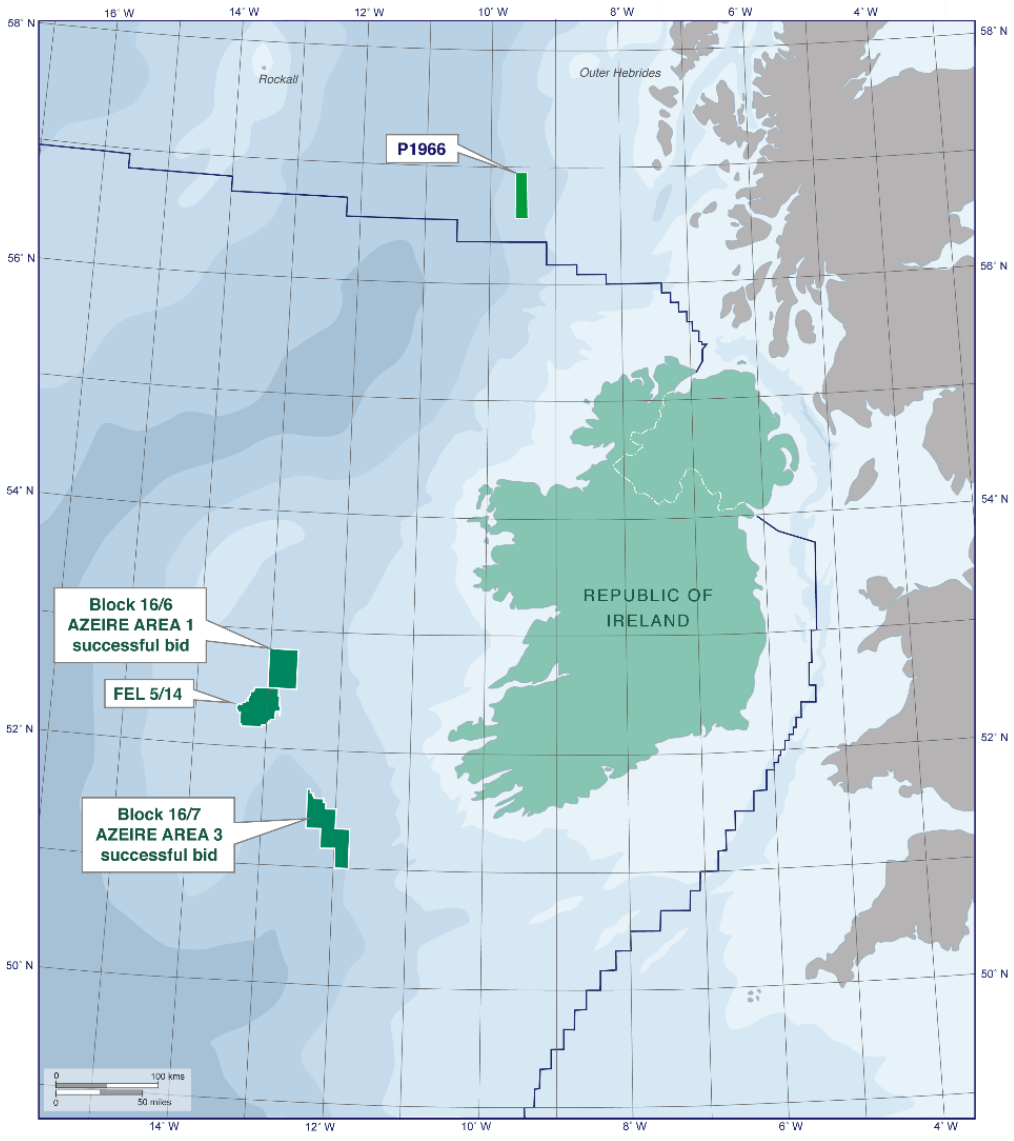


Figure 1.

In 2016 we were successfully awarded Licence Options 16/6 & 16/17 (Figure 1) which lie along the north western and eastern margins of the Porcupine Basin respectively. Although we see potential with the Jurassic and overlying Tertiary sections, our main targets are located within the Lower Cretaceous deep water clastic plays.

In our northern Porcupine Licence Option LO 16/16, we see substantial potential for Lower Cretaceous detached fan lobes overlying an excellent quality mature oil source rock. The fan lobes were deposited seaward of a large deltaic sequence feeding axially southwards from the northern part of the Porcupine Basin. A Lower Cretaceous isopach across the basin shows a regional tilt with preferential deposition of a clastic system on the western margin. A distinct southward directed funnel trend, with the northernmost apex passing directly through LO16/16 is interpreted. Good evidence for the presence of detached sand bodies is present in the seismic dataset. This setting is very analogous to the North Falkland Basin where the Sea Lion discovery was made in similar Lower Cretaceous fan lobes resulting from the building our of a substantial delta from the north.

Within our other two licences – FEL 5/14 and LO 16/17, we see deep water Lower Cretaceous clastic fans building out from the Basin margins.

Looking at our broader Atlantic Margin portfolio, we see similarities within the Ceara and Potiguar Basins offshore Brazil and the Walvis Basin offshore Namibia.

In Brazil we have interests in two licences which span the Ceara and Potiguar Basins. We have access to three different regional 3D seismic surveys over these Basins with the most recent covering 7,000km2 over the Ceara Basins which was acquired in 2015. The play types within these Basins is essentially Lower Cretaceous deep water clastic systems building out from the shelf in a similar manner to the Lower Cretaceous fan plays with FEL 5/14 and LO 16/17 in the Porcupine Basin. The challenges within the Basin are similar to the Porcupine, the prospects and leads are dominantly stratigraphic and whilst the reservoirs stand out clearly on the seismic data, due to geology it is not possible to be able to differentiate fluid content within the reservoir from seismic.

In Namibia, we have interests in six licences (one as operator) within the Walvis Basin. There are two main deep water clastic systems which are the main target, firstly Aptian-Albian base of slope fan complexes like the Osprey prospect and then in the shallower section significant Cenomanian-Turonian deep water channel complex's which form a variety of play types including canyon heads, channels and distal fan lobes.

Accumulating a large and knowledgeable position along the Atlantic Margin enables AzEire to draw on conclusions from elsewhere to improve understanding of the regional geology and prospectivity of Porcupine Basin.

Prospectivity of the north-east Celtic Sea: New data, new perspectives

Attree, M.[1], Sarnowski, Z.[2], Byrne, K.[3]

[1]*Solaris Exploration Limited* *Email: attreemark0@gmail.com*

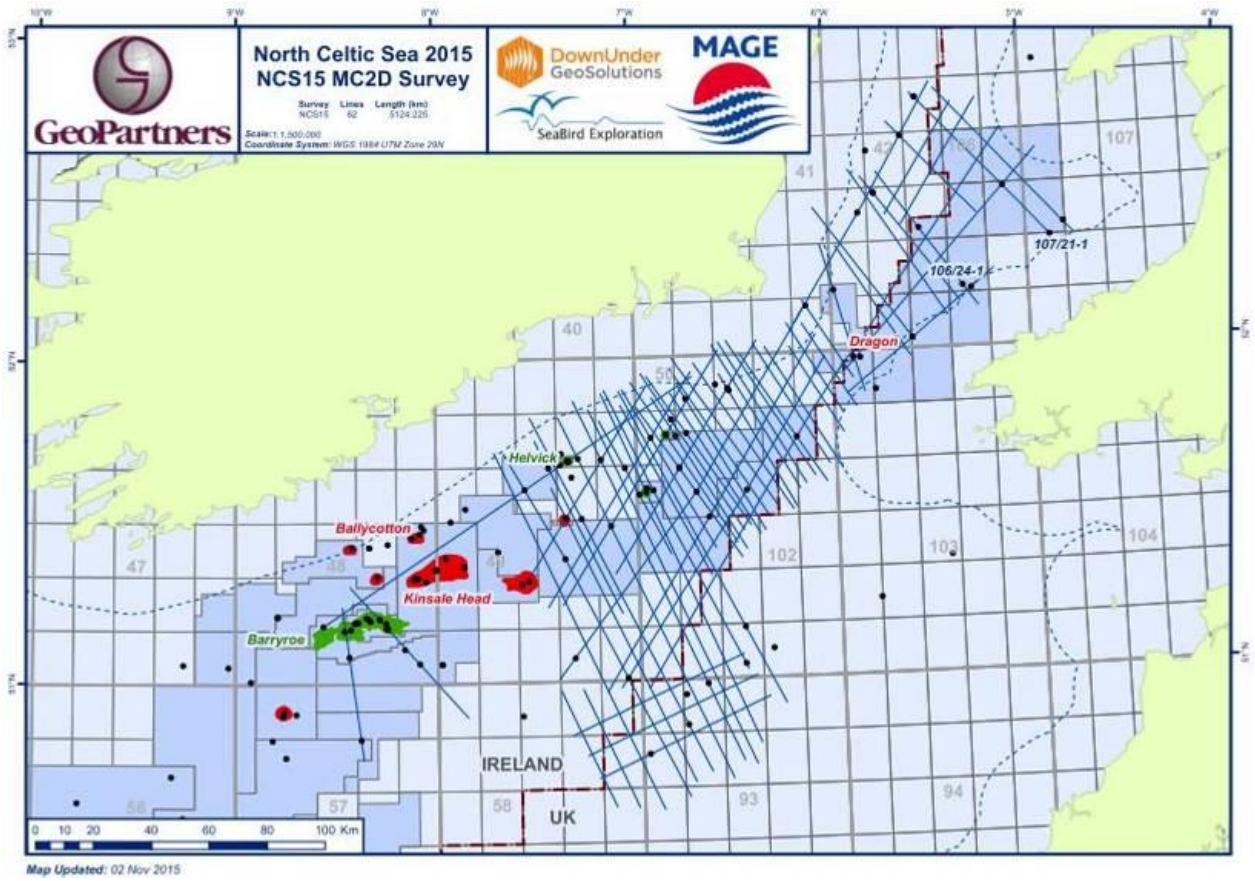
[2]*GeoPartners Ltd*

[3]*Providence Resources*

During the summer of 2015 a consortium headed by GeoPartners acquired a new regional long offset broadband survey in the North Celtic Sea and St Georges Channel.

This Ireland/UK cross border survey comprising a total of 5124 km has been fully processed at Down Under GeoSolutions and now interpreted.

The imaging problems in this area due largely to outcrop of chalk at sea bed are well known and partially explain why this area is so underexplored. The new data however could prove to be a "Basin Opener" as they provide for the first time a truly regional view and a step change in data quality to take a fresh look at the basin.



The petroleum geology of the North Celtic Sea and St Georges Channel shares many similarities with regard to basin development, structural style, inversion history and sedimentology, including key source and reservoir intervals with other petroliferous basins in the North Atlantic whilst also exhibiting an individual character. This is due to the position adjacent to the underlying Variscan Thrust and also being situated between two long lived high areas, leading to a relatively narrow, silled basin intermittently open to the sea. An extremely thick Jurassic sequence is present, particularly in the St Georges Channel Basin (itself north of the Variscan Front), giving significant potential for the generation and expulsion of hydrocarbons from the Lower Jurassic. The North Celtic Sea Basin, though with a thinner Jurassic section also contains the same sequence, culminating in a thick Upper Jurassic lacustrine sequence that

also has proven oil generative capacity. Reservoirs are proven not only in the producing Lower Cretaceous but also in the Upper and Middle Jurassic. The possibility exists for turbiditic reservoirs in the deeper parts of the basin. The Triassic, with few well penetrations, although thinner than in the Irish Sea to the north has demonstrated reservoir potential and juxtaposition against the Lower Jurassic source rock can be seen and inferred in a number of places. Although by no means the only interesting potential objective in the area it captures the romance of the opportunity and this presentation utilises the new data to illustrate aspects of the regional geology and shows how the new data can put the petroleum exploration potential of this area into regional context, utilising analogues and extending these ideas. Particularly, the deep penetration achieved, combined with the retention of shallow detail allows the possibility of predicting new areas for exploration based on both regional and local context.

Key Elements of the Petroleum Systems of the Slyne-Erris and Rockall Basins

Pritchard, G.[1]

[1]*Serica Energy* *Email: graham.pritchard@serica-energy.com*

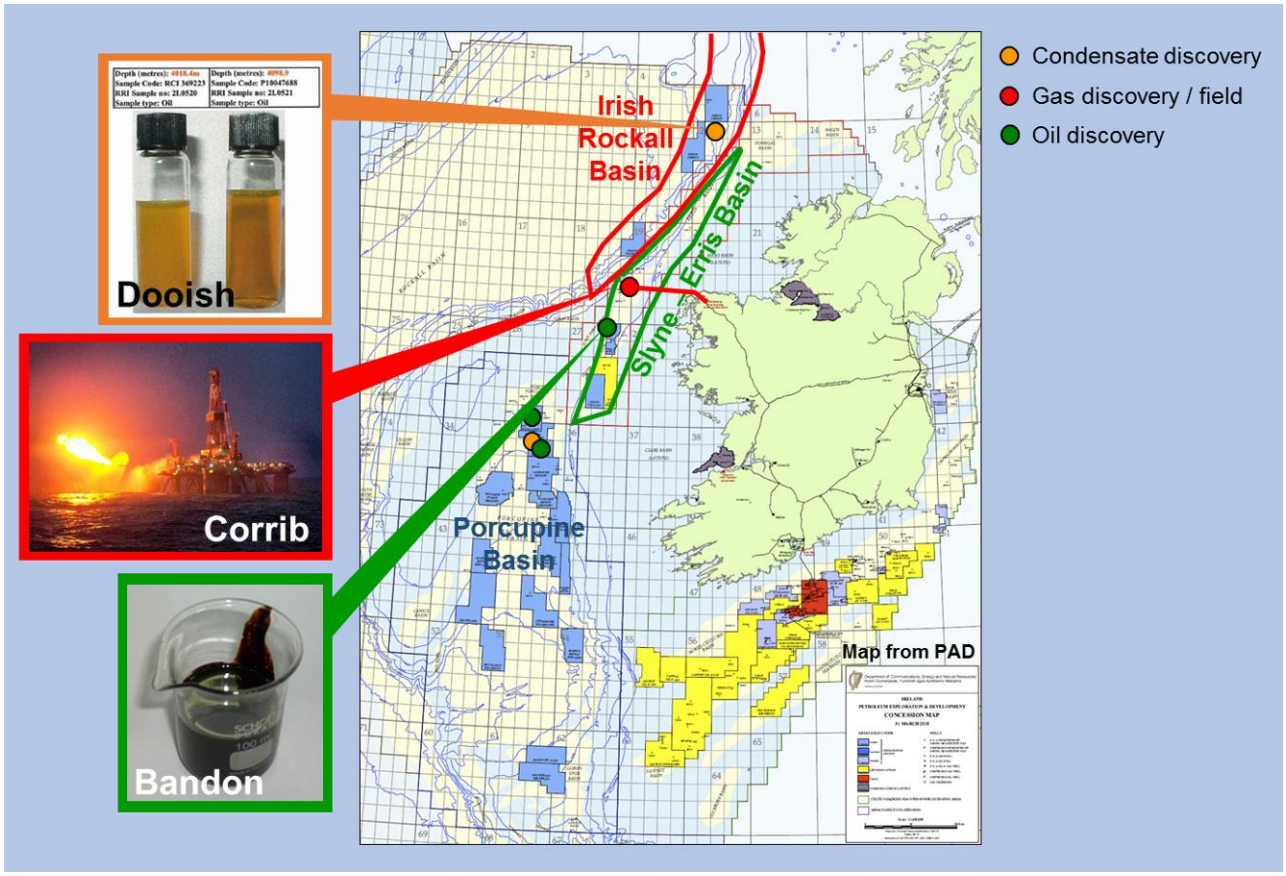
The Slyne-Erris and Irish Rockall Basins boast excellent quality sandstone reservoirs and rich, thick extensive source rocks at numerous stratigraphic levels; all the elements required for a working hydrocarbon system. This offers the perfect setting for the identification of high quality exploration prospects.

Reservoirs rocks have been proven within the Carboniferous, Permian, Triassic, Jurassic and Cretaceous periods and source rocks in the Carboniferous, Lower Jurassic and Upper Jurassic. The eight exploration wells drilled to date have resulted in three hydrocarbon discoveries, Dooish, Corrib and Bandon, which encountered gas condensate, dry gas and oil respectively.

The Slyne-Erris Basin contains two proven hydrocarbon systems: (1) the now-producing Corrib gas field with Carboniferous-sourced gas and a Triassic Sherwood Sandstone reservoir, as well as (2) the Bandon oil discovery, with Lower Jurassic “Liassic” sourced oils and sandstone reservoirs.

To the north, the Rockall Basin contains a third hydrocarbon system, as proven by the Dooish gas-condensate discovery. Here, a substantial column of rich gas-condensate is present within sandstones of both Middle Jurassic and Permian age. Regarding source rock, recent drilling suggests that Upper Jurassic organic rich shales of “Kimmeridge Clay” affinity are in play, as well as a possible contribution from deeper Carboniferous coals.

This analysis clearly demonstrates that with existing hydrocarbon discoveries, proven reservoirs and source rocks, the Slyne-Erris and Rockall Basins have the potential to emerge as the next Atlantic Ireland play. With extensive 3D seismic coverage, spectacular improvements in seismic data quality, a variety of well-defined structural and stratigraphic prospects, and drilling costs at an historical low, there is here a genuine opportunity for exploration companies to add material assets to their portfolios.


Dooish
Corrib
Bandon
Irish
Rockall
Basin
Slyne
Erris Basin
Porcupine
Basin
Map from PAD
Condensate discovery
Gas discovery / field
Oil discovery

Deep structure of the Porcupine Basin from active source seismic refraction data

Prada, M.[1], Watremez, L.[2], Chen, C.[2,3], O'Reilly, B.[1], Minshull, T.[2], Reston, T.[4], Wagner, G.[5], Gaw, V.[5], Kläschen, D.[5], Shannon, P.[6]

[1]*DIAS* *Email: mprada@cp.dias.ie*

[2]*University of Southampton*

[3]*National Oceanography Centre, Southampton*

[4]*School of Geography, University of Birmingham*

[5]*Geomar Helmholtz, Centre of Ocean Research, Kiel, Germany*

[6]*University College Dublin*

The Porcupine Basin is a north-south, tongue-shaped basin located in the Atlantic margin southwest of Ireland (Figure1). Its formation is the result of several rifting and subsidence phases during Late Palaeozoic and Cenozoic, with the most pronounced rift phase occurring in Late Jurassic–Early Cretaceous times. The sedimentary succession and tectonic structure is reasonably well constrained by a large amount of reflection seismic and borehole data, particularly in the northern part of the basin. However, little is known on the deep structure of the basin, which results in a large uncertainty of the formation processes that governed lithospheric stretching and thermal evolution of the sedimentary blanket.

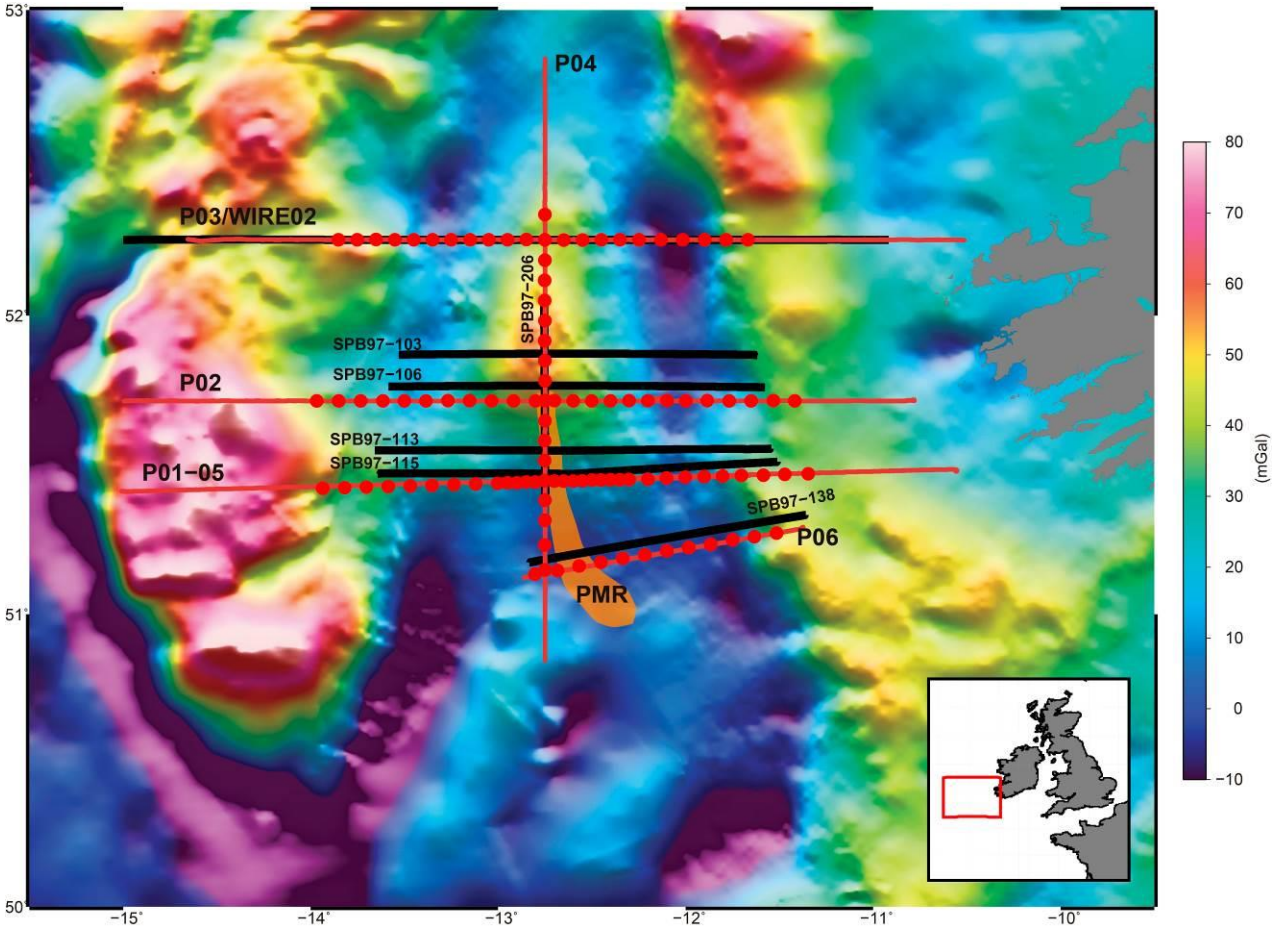


Figure 1. Free air gravity anomaly map of the Porcupine Basin region showing the location of seismic refraction (red lines) and reflection (thick black lines) lines used in this work. Red dots show the location of ocean bottom receivers used to record the wide-angle seismic data used to obtain velocity models in this study. PMR: Porcupine Median Ridge

The occurrence of crustal hyperextension and mantle serpentinisation has been proposed by several authors [Reston et al., 2004; Readman et al., 2005; O'Reilly et al., 2006], but the extent of these processes, and particularly the degree of mantle serpentinisation, are still poorly constrained by geophysical data. Likewise, the presence and extent of rift-related magmatism in the basin is still uncertain as witnessed by the ongoing debate on the petrological nature of the Porcupine Median Ridge (PMR) [Reston et al., 2004; Calves et al., 2012]. Further uncertainty concerns crustal thickness variations along the basin axis, which in turn, hinders the assessment of deep processes such as serpentinisation.

The nature of the PMR, along-axis crustal thickness variations and mantle serpentinisation are critical questions that need to be addressed to constrain rift kinematics and thermal evolution of the basin. Here, we present a set of 2D P-wave seismic velocity (V_p) models obtained from wide-angle seismic data modelling, which reveal important across- and along-axis variations in crustal structure and upper mantle petrology in the Porcupine Basin.

The V_p structure of these models together with the tectonic structure from coincident seismic reflection lines show important crustal thickness variations across- and along- the basin axis. The seismic structure of the upper mantle suggests that serpentinisation occurred and that the degree of mantle hydration increases southwards consistently with the amount of extension. The PMR is imaged with V_p of 5.0-5.7 km/s in a region where crustal break up is imminent. Our results show that crustal thickness increases southwards from Line P01-05 as evidenced by P04 and P06, suggesting a dramatic change in the extension regime. Such drastic variation in lithospheric extension is difficult to reconcile without the presence of major transform zones. Further data is needed to constrain this hypothesis in the central Porcupine.

This project is funded by Petroleum Infrastructure Programme (PIP).

Irish Centre for Research in Applied Geosciences (iCRAG) - Progress to date and plans for 2017

Walsh, J.[1]

[1]*Irish Centre for Research in Applied Geosciences, UCD School of Earth Sciences, University College Dublin*
Email: john.walsh@ucd.ie

iCRAG is a newly formed national research centre which will transform applied geoscience research in Ireland, performing research which is designed to deliver economic impact for a broad range of application areas and industries. The Centre brings together Ireland's leading geoscience experts focusing on a range of issues all of which underpin economic development - from safe and secure groundwater supplies through to the discovery of mineral/aggregate deposits, and from the de-risking of oil and gas exploration to ensuring that the Irish public is educated and informed on these issues. Supported by Science Foundation Ireland and industry partners for the next six years, iCRAG is one of only 12 SFI Research centres, and the first national geosciences initiative to be supported by SFI's flagship funding scheme. iCRAG is collaboration between 150 researchers within UCD, TCD, NUIG, UCC, NUIM and DIAS and more than 50 industry partners who will work in partnership with government agencies involved in the geosciences sector.

iCRAG's research programme consists of four cohesive topics or 'spokes' in the areas of raw materials, marine geoscience, groundwater and hydrocarbons which are built around four enabling technology and equipment based 'platforms' which focus on geophysical sensing and imaging, geochemistry, 3D geological modelling and public perception and understanding. It will capitalise on Ireland's unique geological resources, including its world-class base metal deposits, its unusually extensive and highly prospective offshore basins and its world-class lowland karst and fractured bedrock aquifers. The principal goal is to embed the outcomes of high quality research within industry practice in Ireland and overseas.

This talk briefly describes our progress over the past year on a range of issues. This presentation also complements other iCRAG talks on different aspects of our hydrocarbons and marine research, by briefly presenting some examples of ongoing and forthcoming research from our other spokes/platforms which have relevance to the hydrocarbon sector in particular. These studies range from the analysis and modelling of the impact of faults on dolomitisation, Zn-Pb mineralisation and groundwater flow within Irish Carboniferous limestones and its implications for hydrocarbon flow, to the significance of Alpine deformation in onshore Ireland and its potential impact on associated shale gas basins. Other studies involve the application of geological and geophysical techniques to the subsurface modelling of onshore Ireland from regional to reservoir scale. Our research suggests that the geology of onshore Ireland highlights generic issues which have important potential implications for hydrocarbon exploration/production.

This presentation has emanated from research supported in part by a research grant from Science Foundation Ireland (SFI) under Grant Number 13/RC/2092 and is co-funded under the European Regional Development Fund and by PIPCO RSG and its member companies.

Basins on the edge – iCRAG activity in Ireland's offshore basins and their hinterland

Haughton, P.D.W.[1]

[1]*Irish Centre for Research in Applied Geosciences, UCD School of Earth Sciences, University College Dublin*
Email: Peter.Haughton@ucd.ie

Ireland has a wide and variably extended continental shelf that is underlain by an array of basins and structural highs. A protracted history of stress-re-orientation, areas of both narrow and wide extension and hyperextension, vertical axis rotations, strong lateral strain gradients, and reactivation and inversion of earlier structures all make for complex geology. The Hydrocarbons Spoke of the Irish Centre for Research in Applied Geosciences (iCRAG) seeks to address issues that are critical to future resource evaluation in the basins. When fully staffed up, the Centre will bring together over 35 researchers spread across all the main Irish institutions and tackling topics ranging from pore to lithosphere scale. In developing the programme, attention has focused on developing existing in-country expertise, much of it acquired in other parts of the world, and bringing it to bear on the Irish basins. The overriding goal is to help de-risk exploration through novel geoscience exploiting all available datasets, new technology and fresh ideas. Some of the work builds on tools, insights and collaborations fostered previously by the Petroleum Infrastructure Programme (PIP). Work specifically on the basins is running alongside other work packages dealing with sediment tracking, reservoir modelling, the development of new seismic imaging tools (passive seismology and diffraction imaging) and enhancing the subsurface training potential in Ireland. A core function of the Centre is to promote collaboration across disciplines, shared technology, academic-industry partnerships and outreach activities. The work tackles issues specific to the Irish basins but also generic themes and the use of better characterised analogues and numerical modelling as large parts of the Irish basins remain very lightly explored.

At the largest scale, iCRAG researchers are investigating the lithospheric and deep-crustal structure beneath the basins and linking this to basin evolution and thermal history. Keys issues here are crustal-scale stretching mechanisms, the development of basin asymmetry, the impact of cross-rift discontinuities, the origin of intra-basinal ridges and arches, and the implications for basin filling, particularly along hyperextended sectors of the Atlantic margin. Links to conjugate and along-strike sectors of the North Atlantic will form an important part of the analysis. The emphasis is on understanding both subsidence and phases of uplift, both within the basins and across the hinterland (including the offshore highs and onshore Ireland). The latter will underpin quantitative estimates of sediment volumes and help constrain source areas and drainage pathways. Combined structural-stratigraphic analysis focusing on the individual basins (Celtic Sea, Porcupine, Slyne-Erris, Rockall, Hatton) will feed into a better understanding of the petroleum system(s). Fault analysis using the latest software and generic models is addressing the structure and evolution of rift-boundary fault systems, the controls on rift polarity switching, the formation of hanging wall traps and the inversion of both local faults and whole basins on a larger scale. Basin filling is being addressed via seismic stratigraphy, analogue investigations and parallel work in extant rift systems (Albertine rift system); key issues are onlap configurations, up-dip seal in deep-water systems and the high resolution stratigraphy of rift axial deltas. The fault structure and the interplay between fault system development and stratigraphy are also being addressed through DEM modelling of faults and forward stratigraphic modelling. At the smallest scale, application of cutting-edge technology will see synchrotron imaging applied to multiphase cement stratigraphy, fluid tracing using fluid inclusions, and XRF core scanning and QEMSCAN to better understand bed-scale clay distribution; both issues are key to better understanding reservoir quality degradation in some of the more deeply buried basins.

This presentation has emanated from research supported in part by a research grant from Science Foundation Ireland (SFI) under Grant Number 13/RC/2092 and is co-funded under the European Regional Development Fund and by PIPCO RSG and its member companies.

Sediment tracking in the Irish offshore basins: new approaches and new insights

Tyrrell, S.[1,4], Haughton, P.D.W.[2,4], Shannon, P.M.[2,4], Chew, D.[3,4], Franklin, J.[1,4], Barry, A.[1], Kerryming, S.[1], Cogné, N.[3]

[1]*Earth and Ocean Sciences, School of Natural Sciences, National University of Ireland Galway*
Email: shane.tyrrell@nuigalway.ie

[2]*UCD School of Earth Sciences, University College Dublin, Belfield, Dublin 4*

[3]*Department of Geology, Trinity College Dublin, Dublin 1*

[4]*Irish Centre for Research in Applied Geosciences (iCRAG)*

Sediment tracking (or provenance analysis) is a key tool in petroleum exploration and has proven especially useful in frontier basins. The traditional aim of provenance analysis is to identify the source of sediment or sedimentary rock deposited in a basin by directly linking a signal (petrographic or geochemical) in detrital grains with signals from rocks in a modern hinterland. By adopting this overly-simple approach, many additional insights, which may have important implications for the economic resource potential of a sedimentary rock, are overlooked. For example, conventional approaches can fail to reconcile or identify factors such as prolonged storage phases, recycling, mixing, climatic effects and post-depositional perturbation of critical geochemical signals. A move toward first-order quantitative modelling of sedimentary systems and their detrital products can be achieved through development and rigorous testing of integrated, multi-proxy, provenance approaches in parallel with identifying and quantifying the various factors which may modify sand during and after transport. These types of new approaches should ultimately help in achieving the desired output of any provenance study – ***a predictive tool for both reservoir sandstone distribution and quality.***

The Sediment Tracking targeted project within the Hydrocarbons spoke of iCRAG aims to address outstanding issues in provenance research by 1) tapping into Irish and international expertise in this area; and 2) utilising sedimentary basins offshore Ireland as a test bed for new techniques. The work builds on recent PIP-funded and Griffith Geoscience-funded research developing/applying new provenance proxies, new thermogeochronological approaches, and new geochemical data on regional economic basement, and should ultimately help de-risk exploration in the Irish offshore basins.

For example, there is currently little clarity on the relationship between provenance and reservoir quality, and questions remain as to the extent to which cementation and porosity/permeability evolution can be controlled by the primary detrital mineralogy. These types of questions are being investigated through high resolution sampling and multi-proxy provenance analysis of Triassic sandstones (Sherwood Sandstone Group (SSG) and equivalents) in the Slyne Basins and beyond. These sandstones are an ideal target as their bulk reservoir characteristics are well understood (they host the Corrib Gasfield) yet on smaller scales they comprise heterogeneities (e.g. chloritised zones) which directly impact reservoir quality. These sequences, therefore, allow links between these bed-scale heterogeneities, and changes in sediment supply, to be interrogated.

Other on-going or planned research is targeted at Mesozoic and Cenozoic intervals in the Irish offshore, and includes projects which aim to better understand the connection between onshore structure, uplift history and supply pathways to the offshore basins. In addition, the targeted project aims to constrain sediment transport processes and the potential impact of prolonged hinterland storage. These types of

processes could significantly modify sediment delivered to the basin and could be especially important in the Irish passive margin basins, particularly during the early Cretaceous and Cenozoic, when, potentially, there is a wide hinterland and shelf area which may have to be traversed prior to ultimate deposition in the Porcupine and Rockall basins.

The aim of this presentation is to provide an overview of work in the Sediment Tracking targeted project, focusing on some of the issues related to sediment supply to the Irish offshore basins, highlighting how these issues are being resolved and showcasing some of the new insights being generated through this research. The work also dovetails with other research in the Hydrocarbons spoke and links to elements within the iCRAG platform.

This presentation has emanated from research supported in part by a research grant from Science Foundation Ireland (SFI) under Grant Number 13/RC/2092 and is co-funded under the European Regional Development Fund and by PIPCO RSG and its member companies.

New reservoir modelling approaches for high net: gross, low amalgamation reservoir sequences

Manzocchi, T.[1,2], Zhang L.[2,3], Walsh, D. A.[1,2], Soni, K.[1,2], Haughton, P.D.W. [1,4].

[1]*Irish Centre from Research in Applied Geoscience (iCRAG)* *Email: Tom.Manzocchi@ucd.ie*

[2]*Fault Analysis Group, UCD School of Earth Sciences, University College Dublin*

[3]*Current Address: School of Earth and Space Sciences, Peking University, Beijing, China*

[4]*Marine and Petroleum Geology Group, UCD School of Earth Sciences, University College Dublin*

Maximising oil recovery relies in part on decisions made on the basis of results obtained from numerical flow models of reservoirs, which depend on the modelled representation of reservoir heterogeneities at a variety of scales. Appropriate representations of heterogeneity in flow models, as well as robust means of testing uncertainties in the geological parameterisation underlying these representations, are therefore important factors in achieving reliable modelling results. Deep marine reservoir sequences often comprise hierarchical depositional elements which can be poorly interconnected despite occupying a large proportion of the volume at each scale of interest (Figure 1). Traditional object-based models are unable to reproduce the low amalgamation ratios at high net:gross ratios characteristics of many deep marine systems, but a novel geometrical transformation (the compression algorithm) can be applied to honour independently both parameters. A hierarchical modelling workflow centred on the compression algorithm allows the creation of full-field reservoir flow models containing sedimentological elements at scales from beds to lobes and with appropriate hierarchical amalgamation ratio and volume fractions (e.g. Figure 2). The method and underlying geological characterisation is being extended to consider also submarine channelised reservoirs. A drawback of the object-based method is that it cannot honour hard data recorded at wells, but encouraging results in this area have been achieved by combining the compression method with multiple point statistics (MPS) methods. A significant ongoing research effort aims to develop and streamline these modelling algorithms and workflows as plugins within industrial reservoir modelling software, with the ultimate aim of delivering a mainstream implementation of these improved methods for modelling deep marine reservoir systems.

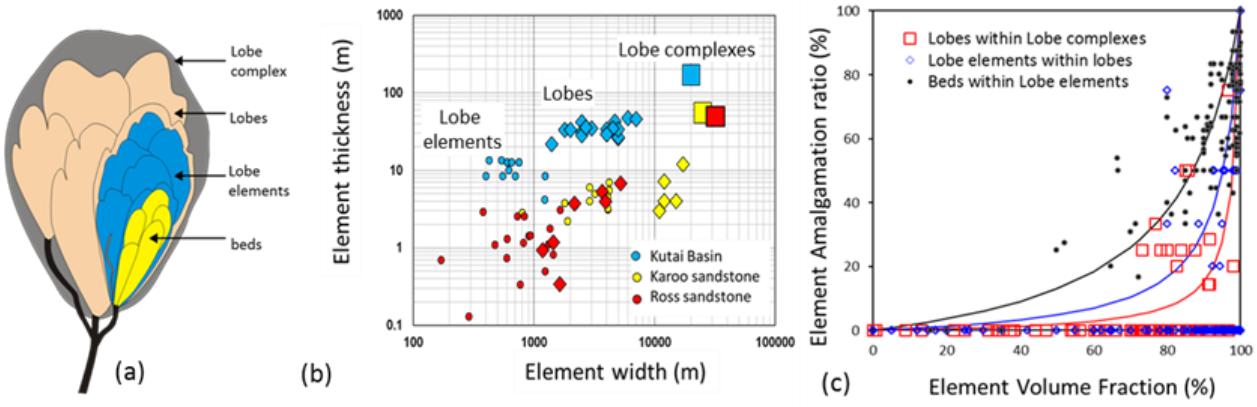


Figure 1. (a) Lobe hierarchy modified from Prelat et al. (2009). (b) Compilation of size data for hierarchical elements in three well characterised lobe systems. (c) Volume fraction vs. amalgamation ratio for three hierarchical levels, compiled from all available outcrop data. The curves show representative compression factors (Manzocchi et al. 2007) for the different hierarchical levels. (b & c from Zhang 2015).

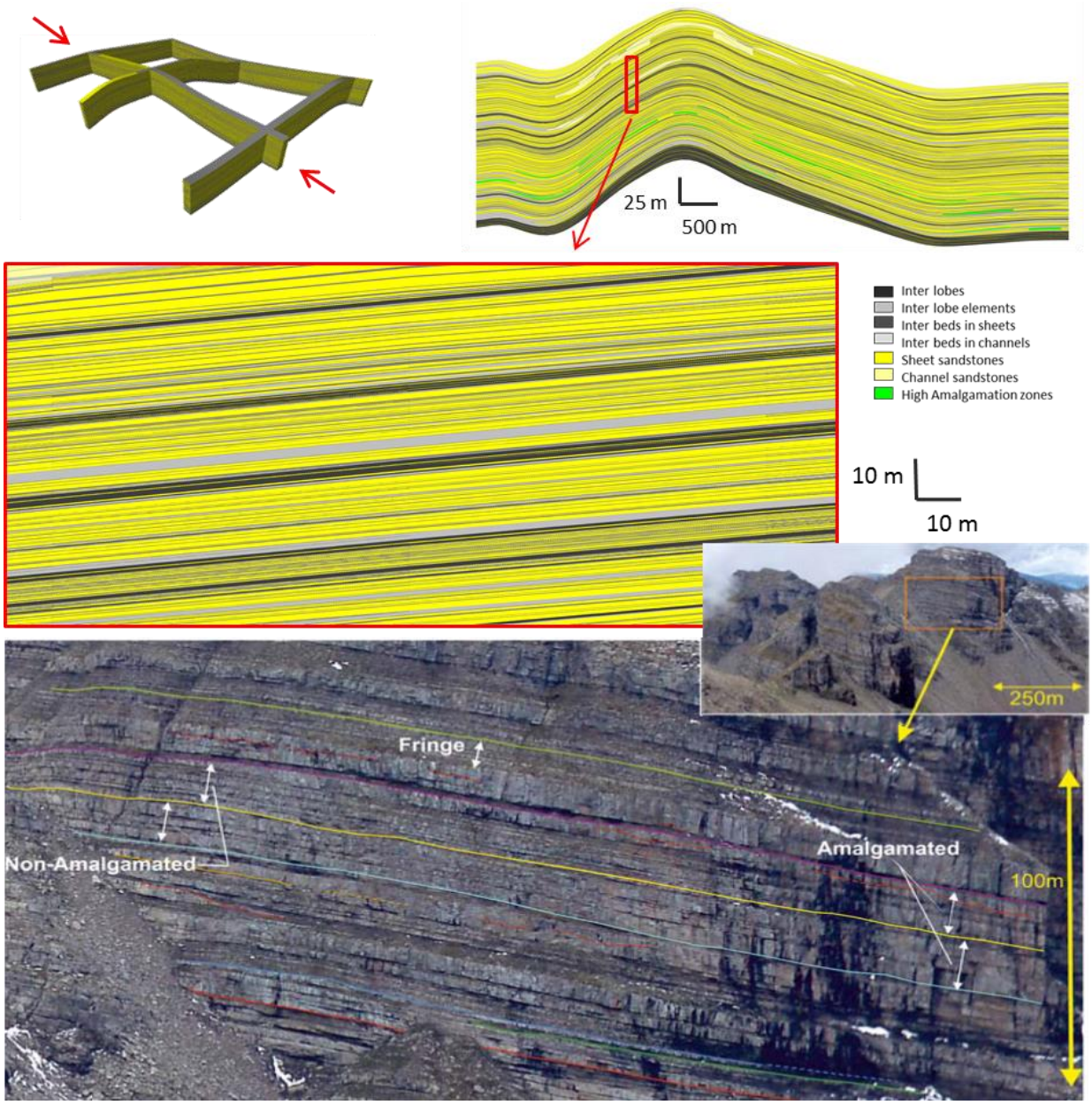


Figure 2. Views of a hierarchical full field 3D reservoir model built using the compression method and conditioned to size and stacking data from a Gulf of Mexico reservoir. From Zhang (2015). Bottom: Outcrop photo from lobes in the Annot sandstone in France, showing very similar stacking patterns. From Collins et al. (2015).

This presentation has emanated from research supported in part by a research grant from Science Foundation Ireland (SFI) under Grant Number 13/RC/2092 and is co-funded under the European Regional Development Fund and by PIPCO RSG and its member companies. Zhang's PhD was supported by the China Scholarship Scheme and UCD.

iCRAG marine spoke projects supporting offshore hydrocarbon activities

Wheeler, A.J.[1], Croot, P.[2], Bean, C.J.[3], Cahalane, C.[4], Crowley, Q.[5], Georgiopoulou, A.[6], Nicholas, S.[2], Le Pape, F. [3], McCarthy, T.[4], Tóth, Z. [1], Walsh, D.[4],White, M. [2]

[1]*iCRAG/Geology, School of Biological, Earth & Environmental Sciences, University College Cork* a.wheeler@ucc.ie

[2]*iCRAG/School of Earth & Ocean Sciences, National University of Ireland Galway*

[3]*iCRAG/Dublin Institute of Advanced Studies*

[4]*iCRAG/National Centre for Geocomputation, Maynooth University*

[5]*iCRAG/ Geology, School of Natural Sciences, Trinity College Dublin*

[6]*iCRAG/School of Earth Sciences, University College Dublin*

The Irish Centre for Applied Research in Applied Geoscience's (iCRAG) Marine Spoke supports Irish offshore hydrocarbon activities through a diversity of projects aimed at derisking offshore operations. The spoke also aims to make Ireland's offshore environment a test bed and natural science laboratory for innovative and novel technologies in the marine sector. The Spoke is organised into three TPs each comprising a cluster of projects (WPs), the details of those *currently* running are given below:

The Marine Acoustics TP (TP2.1) positions Ireland as a leading R&D provider in the application of emerging novel techniques and uses of marine acoustic data using the natural acoustic noise in the environment as an imaging tool to better constrain the risk of offshore operations and impacts. Methods for imaging near seafloor structure using the ocean's background acoustic noise removes the requirement to shoot seismic, resulting in environmental advantages and cost benefits.

WP1: Novel applications of wave climate induced low frequency acoustics in near-seafloor seismic imagery

Wind driven ocean gravity waves generate pressure fluctuations on the sea floor which in turn generate continuous low-amplitude seismic waves (microseisms), in the solid Earth. These microseisms feed acoustic waves back into the water column where they then hold information about sub-surface geological structure. 10 OBS stations (seismometer + hydrophone) and a tsunameter have been deployed west of Ireland to monitor continuous seismoacoustic waves for: (i) methodological development in passive (no seismic shots needed) seismic imagery of the near sea floor, (ii) low frequency water column noise studies including the role of attenuating sediments as a low frequency wave propagation damper, and (iii) investigations of transient hydro-mechanical coupling at the sea bed in deep water.

WP2: Development of an underwater acoustic model to quantify underwater noise levels from seismic surveying in Irish waters

Utilising an existing underwater model for quantifying acoustic noise from seismic surveying in Irish waters via a parabolic approximation to the Helmholtz equation, this project studies the low frequency propagation in fully range dependent environments in shallow water. Due to the significant influence of water column properties on acoustic propagation a parallel study assessing the magnitude and heterogeneity of physical dynamics and processes at the continental margin is also being undertaken.

WP3: Passive acoustic inversion techniques for predicting seabed sediment properties and passive calibration of ocean sound maps

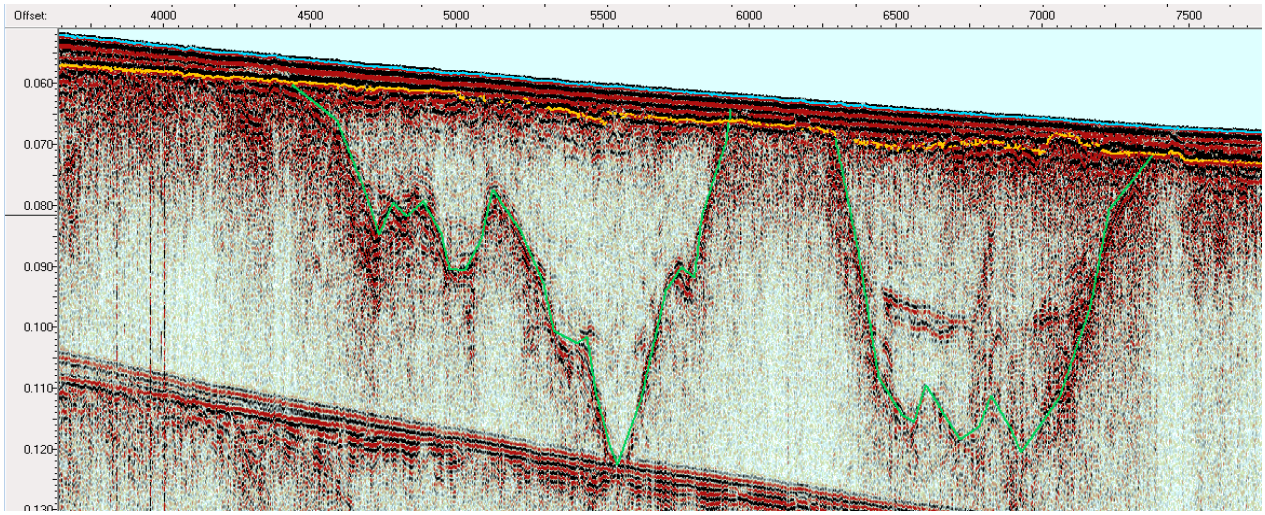
Initial tests have demonstrated the feasibility of using innovative passive inversion techniques to characterise seabed sediment properties over wide areas based on anthropogenic noise and biological sounds. Where existing sediment property maps are already well resolved, the same techniques are used to finely-calibrate basin scale soundscapes and associated products e.g. seasonal percentile sound

level exceedance map. This project further develops and refines these techniques using new in-situ passive sound records and test their applicability and validity in the Irish CS.

The **Enhancing knowledge and understanding of Ireland's seabed** TP (TP 2.2) provides a fundamental understanding of Ireland's seabed with relevance to offshore resources and geohazards. Existing datasets (e.g. INFOMAR) is integrated, updated and interpreted to provide a full inventory of the resources and natural hazards that exist in the Irish Continental Shelf (CS). This research adds value to Ireland's existing flagship seabed mapping programmes.

WP1: Developing an offshore Pleistocene stratigraphic model and 3D database

The definition of shallow seismic Pleistocene stratigraphies for the east and south coastal area within a Kingdom database de-risks planning for nearshore infrastructural developments. Near seabed resources are mapped in 3D forming a coherent stratigraphic model based on 5177 survey lines significantly enhancing existing 2D seabed map coverages. This database can be used to determine the location and thicknesses or suitable lithologies for pipelines, cable laying, foundations or anchors. Spin-offs including imaging of offshore aggregates and an unravelling of Ireland's glacial history.



WP3: Cold-water coral carbonate mounds as archives of submarine canyon exchange

The seabed is a dynamic environment and EIAs often failing to capture environmental variability with natural changes in the seabed sometimes mistaken for impacts following operations. This project develops decadal scale environmental records using geochemical proxies from cold-water coral growth rings in sensitive environments to better understand change.

The **Marine remote sensing applications** TP (TP 2.3) provides Ireland's maritime sector with new tools and information to mitigate risk for metocean conditions and pollution mitigation. Taking advantage of new satellite data (e.g. ESA Sentinel) and integrating with in-situ sensors maximises remote sensing capabilities and provide a new suite of decision making tools for industry and policy makers. This TP develops new remote sensing tools for industry. The ability to monitor and forecast the marine environment is crucial to the maintenance, planning and development of all maritime activities. The launch of the European Space Agency (ESA) Sentinel series of satellites brings new remote sensing data providing opportunities for new software tools customised to Ireland's offshore regions and unique maritime requirements.

WP1: Satellite detection of ocean surface slicks and oil spill management tools

Geospatial technologies such as remote sensing and geoinformatics play an important role in helping collate, analyse and visualise information in order to make good decisions when managing offshore oil-spills. This project develops a data handling engine to support a fusion of dynamic near real-time sensor streams including UAV together with spaceborne EO sensor data. An oil-spill trajectory modelling module is being implemented and programmed to update automatically using real world weather, sea-state and environmental observations.

WP2: Detection of water column tracers of maritime activities from natural processes

The maintenance of Good Environmental Status (GES) in the marine sector requires monitoring of all industrial activities and requires that a well-established set of baseline conditions is known. This project determines the presence of hydrocarbons in the marine environment by the application of 3D EEM fluorescence techniques with subsequent characterisation by PARAFAC. The project further examines the fluorescence signals to distinguish those from natural processes and those made by common products from the Irish maritime industry.

This presentation has emanated from research supported in part by a research grant from Science Foundation Ireland (SFI) under Grant Number 13/RC/2092 and is co-funded under the European Regional Development Fund and by PIPCO RSG and its member companies.

Prospects 2 Go - Europa Oil & Gas - acreage, prospects and farm-out timeline

Mackay, G.[1], Thomas, R.[1], Parkinson, N.[1]

[1]*Europa Oil & Gas (Holdings) PLC* *Email: hugh.mackay@europaoil.com*

Europa now holds two FELs and five LOs offshore Atlantic Ireland (Figure 1). This acreage encompasses a wide diversity of play types, risk and project phasing. Farm-outs are currently in progress for our four Porcupine Licences, where we are at an advanced technical stage. Elsewhere, we have much technical work still to do. Ultimately we will be seeking partners in all of our licences and we would welcome early commercial approaches.

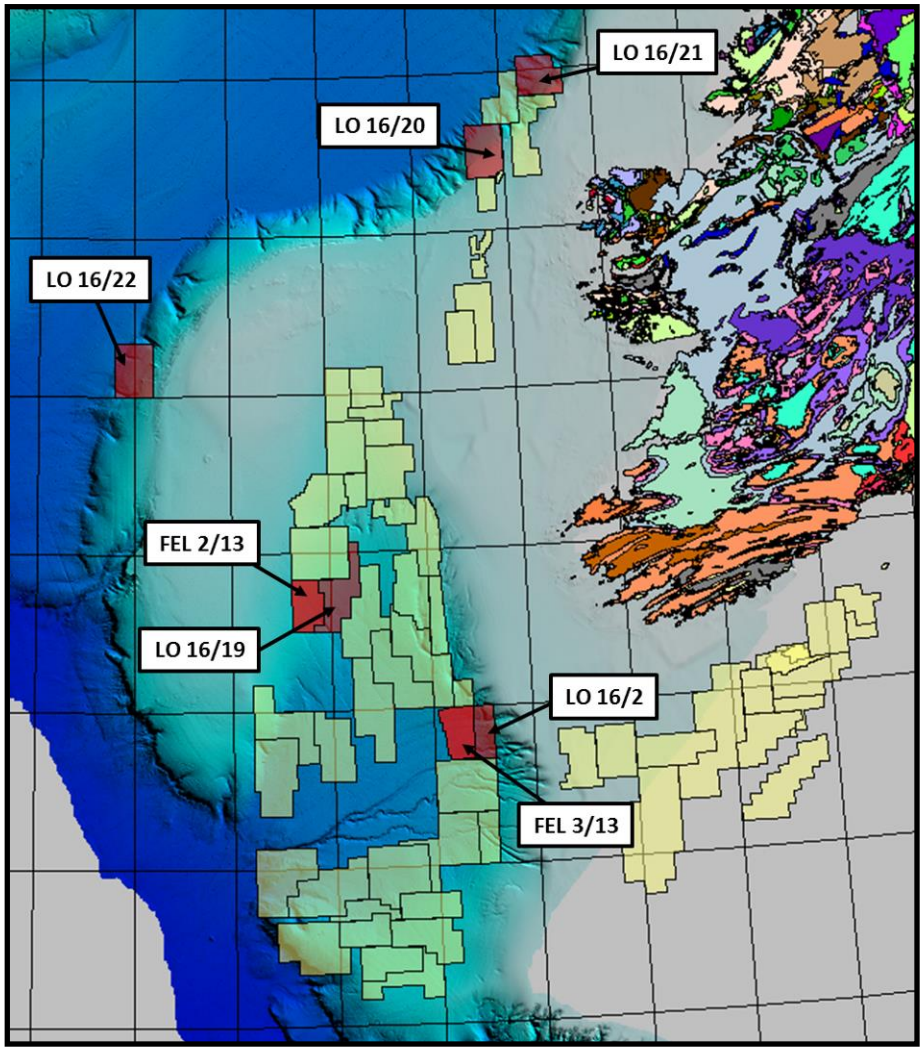


Figure 1 Europa Licences and Licence Options, offshore Atlantic Ireland

FEL 3/13 and LO 16/2 are largely covered by 3D seismic acquired in 2013. FEL 3/13 contains three submarine fan prospects at two Lower Cretaceous levels. At the deeper level (Valanginian?), the "Wilde" fan is confined by remnant pre-rift topography and has good isopach, as well as attribute expression (Figure 2). An independent Competent Person's Report by ERCE suggests Gross Mean Unrisked Prospective Resources (GMUPR) for Wilde of 428 mmboe at a risk of 1 in 5. FEL 3/13 also contains two well-defined fans at a younger (Aptian?) level, prospects Beckett and Doyle. These are estimated by ERCE to contain a total of 1064 mmboe GMUPR. All three prospects are mature and a drill-ready well location exists which would test both the Wilde and Beckett prospects. The dry hole well cost was independently estimated in late 2015 to be $37MM.

LO 16/2 is characterised by pre- and syn-rift targets (Figure 3). Several pre-rift tilted fault blocks have been identified, with early indications of around 900 mmboe GMUPR in total. We recognise that PSDM reprocessing of our existing 3D seismic may be required to mature these targets to drill-ready status.

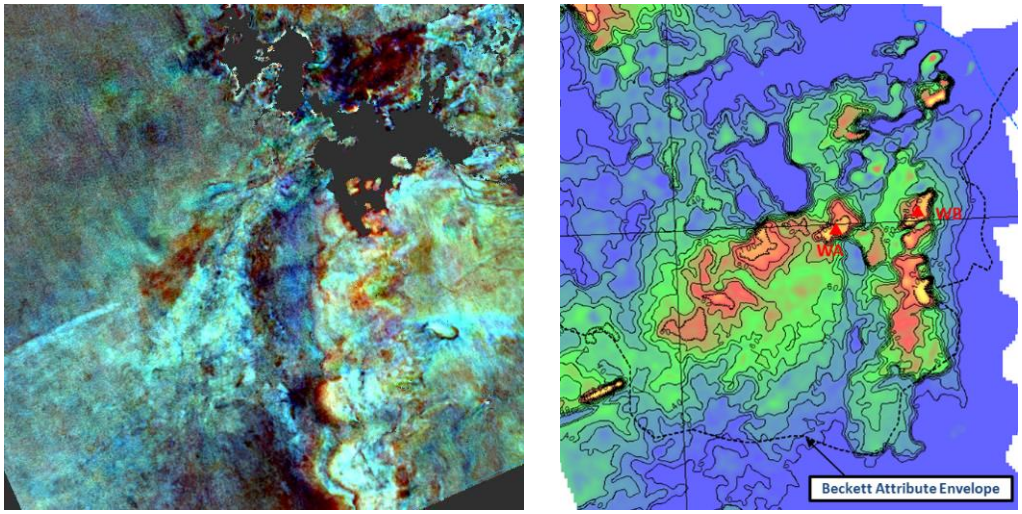


Figure 2 RGB and isopach expression of the Wilde Fan, FEL 3/13

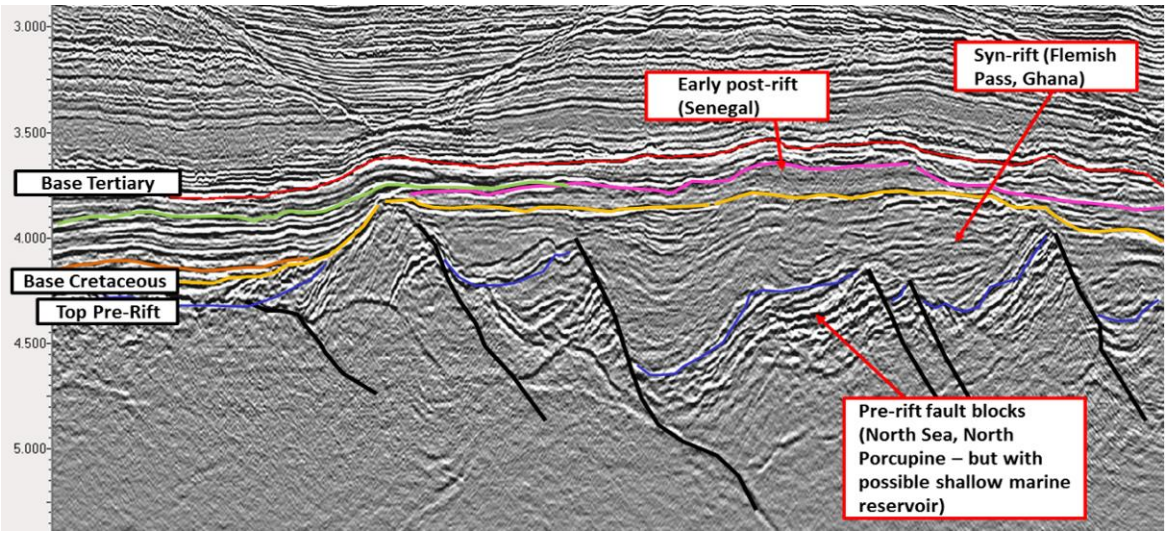


Figure 3 3D inline NW-SE across LO 16/2: pre-, syn- and post-rift leads

Our 3D seismic over FEL 2/13 revealed the presence of significant pre-rift structures. The Cretaceous post-rift showed the presence of converging slope channel systems which we believe fed fans further to the east. This interpretation was used to support our LO 16/19 application. We now seek partners to acquire 3D over LO 16/19 in order to better define the Lower Cretaceous fans which we believe to exist in this Licence Option Area.

With Corrib now finally on-stream, Europa identified a number of neighbouring areas with existing 3D seismic and where significant undrilled Triassic structures appear to exist. The area immediately NW of Corrib (LO 16/20) seems to us particularly attractive. We have seen a large horst block on good quality 3D acquired by Veritas for Enterprise in 2002, and we believe that significant technical progress can be made by reprocessing this data (new acquisition here is currently not possible for environmental reasons). We expect a low-risk gas prospect of the order of 1TCF to emerge and within 16 km of Corrib gas infrastructure.

Finally, Europa is the only company to have acquired acreage on the west side of the Porcupine High (LO 16/22). Our logic was twofold. Technically, plate reconstructions suggest many similarities between this area and the Flemish Pass – a case can be made that the analogy is stronger than with Southern Porcupine, which has attracted so much interest from the Majors. Practically, our LO 16/22 is less remote than many areas now licenced in the South Porcupine – it is some 150km from Spanish Point with modest intervening water depths. We favoured the Padraig Basin over other remnant Jurassic basins on this margin due to large-scale pre- and syn-rift structures and significant Cretaceous cover. There is good quality existing 2D seismic coverage. Our plan is to integrate this with more regional seismic data, improving our seismic horizon and reservoir prediction, and moving to petroleum systems modelling. We have already identified significant structures and once we have refined the geological models we may have very large oil prospects.

Prospects 2 Go - Third Generation Gas Exploration Offshore Ireland

Griffiths, P.[1]

[1]*Predator Oil and Gas Ventures Ltd* *Email: paulgriffiths@eircom.net*

Offshore Ireland has seen so far two generations of exploration for gas leading to the establishment of two independent gas businesses. The initial business was established by Marathon Oil in the Celtic Sea, with a life span from 1978 to potentially 2022. Subsequently Shell (through the acquisition of Enterprise Oil) and its partners led the second wave of gas exploration which resulted in the establishment of the north-western Atlantic Margin as the new core area for a burgeoning gas business. The Corrib gas field has a forecast life expectancy of at least 13 years to 2028.

Significantly these are currently the only proven commercial hydrocarbon businesses offshore Ireland. These have led to the development of a game-changing gas infrastructure network in areas with potential for additional satellite gas discoveries and subsea tie-backs.

Forecast changes to the gas market are not only controlled by regional gas pricing sensitivities that are influenced by annualised daily supply and demand, but also, uniquely when compared to oil, by abnormal peak daily demand caused by adverse weather or interruptions in supply through gas pipelines. Security of Energy Supply becomes a fundamental strategic issue at such times. Supply is also influenced by access to and the competitive pricing of LNG; the political reliability of Russian imports of gas to the EU; and, in the medium term, the contentious development of shale gas. Sustainable reliance on competitively-priced renewable energy is a long-term political and climatological goal.

Ireland imported 85.3% of its energy requirement in 2014 and by 2019 will still require over 350 mm cfgpd to be supplied via the Gas Interconnector with the UK on an annualised daily average basis as indigenous gas production declines. Critically however the 1 in 50 peak daily demand may require over 800 mm cfgpd being supplied by the Interconnector with the UK when daily demand peaks, normally during winter months. Ireland's only strategic gas storage facility at SW Kinsale is set to shut down within 4 to 5 years. Wind Energy, as the main component of Ireland's renewable energy investment programme, is assumed to have little impact on the winter peak day demand. It is sobering to note however that "*on the 2nd February 2015 electricity demand peaked at 4,500 MW at 1900 hours. Despite the installed wind-generating capacity in the ROI of 2,122 MW wind accounted for an average of* ***just 1.1% of system demand****. The overriding balance of supply was made up of electricity from thermal generation". Source Gas Networks Ireland Development Plan 2015.*

Third generation gas exploration offshore Ireland will be a hybrid business incorporating the Atlantic Margin and the Celtic Sea and will be focused in areas where infrastructure can be easily accessed. This

reduces the lead time for a satellite development whilst also reducing initial capital and operating costs, thereby accelerating profitability which in turn also accelerates the State's tax return under the new fiscal regime. The focus for the third generation gas business model is also perfectly aligned with the forecast development of the Irish gas market, as it provides a secure indigenous energy bridge between an over-reliance on fossil fuels and the full development of a sustainable renewable energy resource. Critically it provides for security of supply during 1 in 50 peak daily demand events that cannot yet be guaranteed to be satisfied by renewable energy.

In order to be successful the owners of this business model must move quickly and decisively to exploit the commercial opportunity by 2019. The business is therefore aligned with a safety-conscious and environmentally friendly entrepreneurial management philosophy which smaller companies are perfectly capable of delivering.

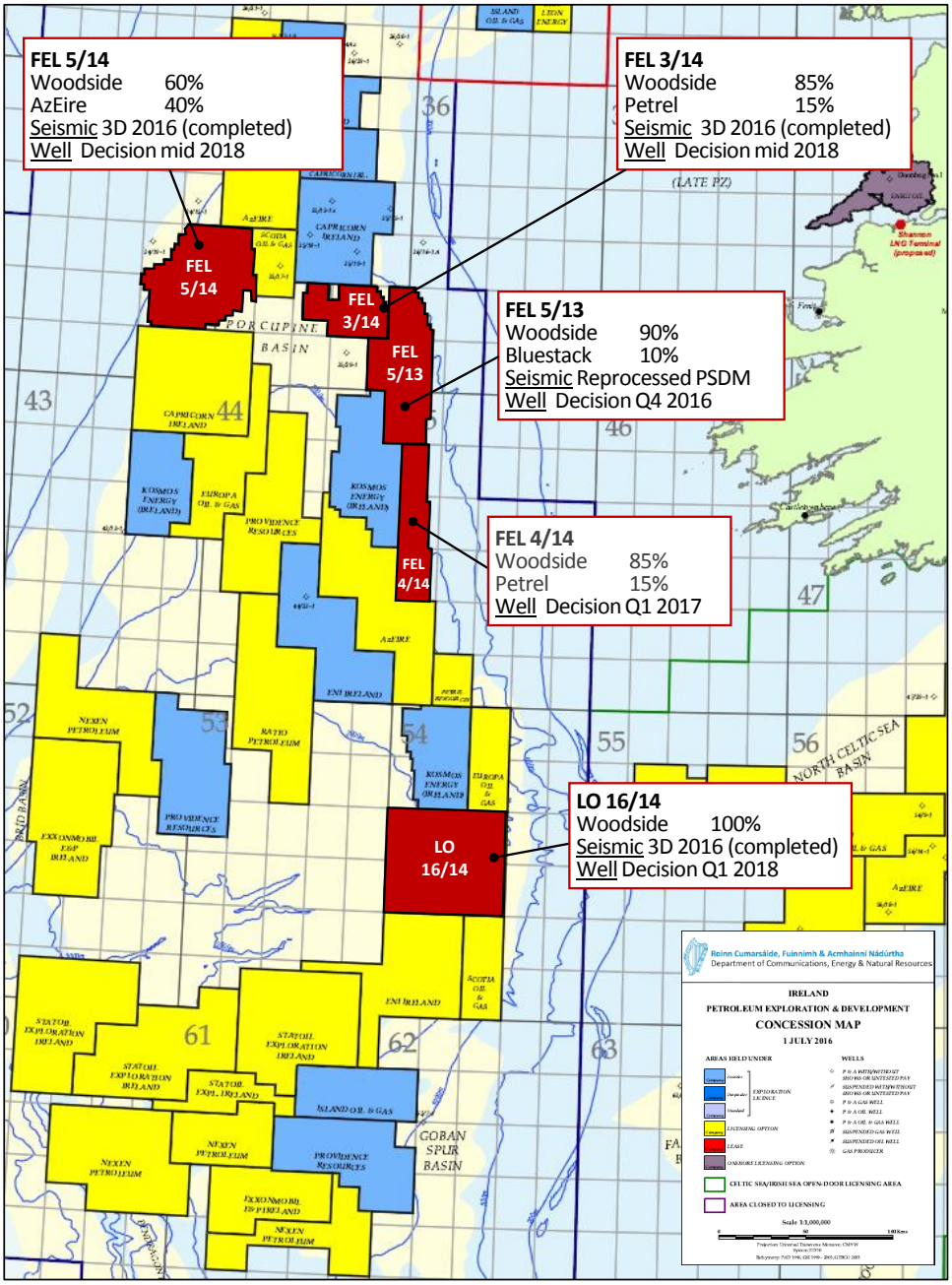
Predator Oil and Gas Ventures Limited and its JV partner has positioned itself to initiate and develop the third generation gas business offshore Ireland by building a portfolio of licences close to existing infrastructure and with the technical and commercial attributes required to deliver its business model. Management has a good track record in early stage gas exploration and appraisal offshore Ireland. The foundation to developing a viable business lies in understanding geological risk and using experience and knowledge to focus effort in those areas where geological risks are known and manageable and the proven reservoirs are capable of supporting the production forecasts.

Prospects 2 Go – FEL 5/13 – Ventry Prospect

Vear, A.[1]

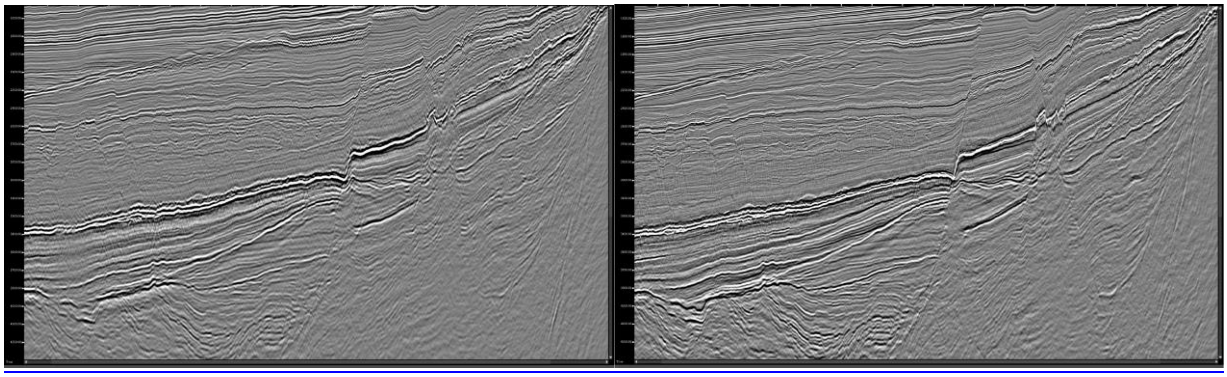
[1]*Woodside Energy (UK) Ltd* *Email:* alwyn.vear@woodside.com.au

Woodside currently operates 4,722 sq km of acreage in the Porcupine Basin on behalf of its JV partners AzEire, Bluestack and Petrel. The four Frontier Exploration Licences (FELs) and one Licensing Option (LO) are located around the flanks of the basin where maturity of the source rock intervals is optimum for recent hydrocarbon generation. Migration routes to a number of prospects and leads from oil-prone source intervals are short-range and simple. Reservoir quality in Woodside's focus areas is considered better than encountered to date in many wells (concentrated mainly in the north of the basin), due to more local provenance. Both structural and combination structural/ stratigraphic traps have been mapped.



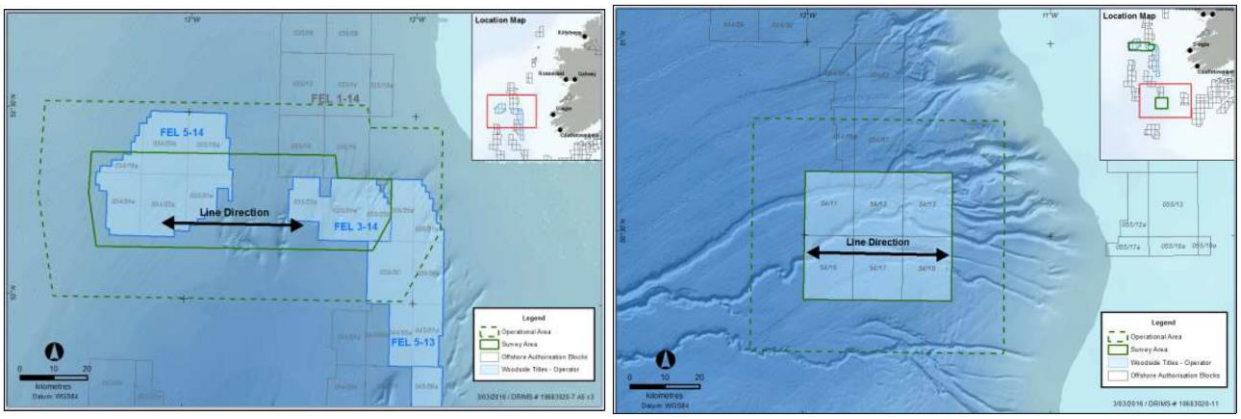
Location of Woodside licences

Reprocessing of existing 3D seismic data to PSDM products has provided the key to unlocking potential in the Woodside-operated blocks. Significant uplifts in data quality were achieved by reprocessing the PAD 1998/03 and PAD 1999 PGS surveys across FELs 5/14, 3/14 and 5/13.



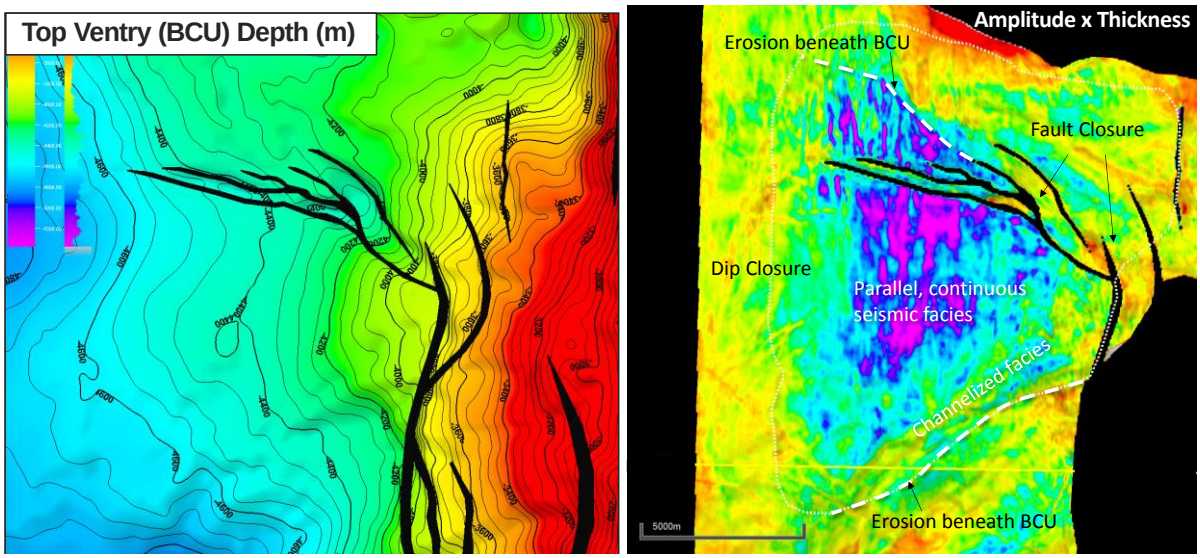
Seismic data quality enhancement from original PSTM (left) to PSDM (right). Courtesy PGS.

An additional 2400sq km of new data were acquired in June/July 2016 (the Bréanann survey) joining the 1998 and 1999 survey areas and filling data gaps in FELs 5/14 and 3/14. Further south, the 1600sq km Granuaile 3D survey was acquired across LO 16/14 covering an area with no previous 3D data coverage. Processing of the two surveys is underway and interpretation will commence in Q1 2017. The combination of reprocessed and new data provide almost wall-to-wall coverage of Woodside's operated licences and will be used to confirm the presence and reduce risk on existing leads and prospects, as well as highlight new targets.

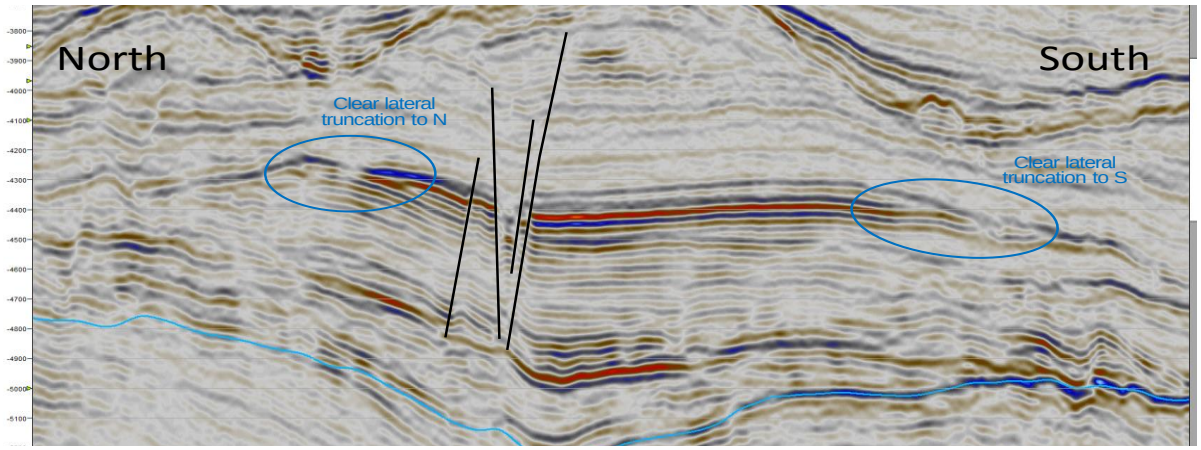


Location of the Bréanann (left) and Granuaile (right) 3D seismic surveys

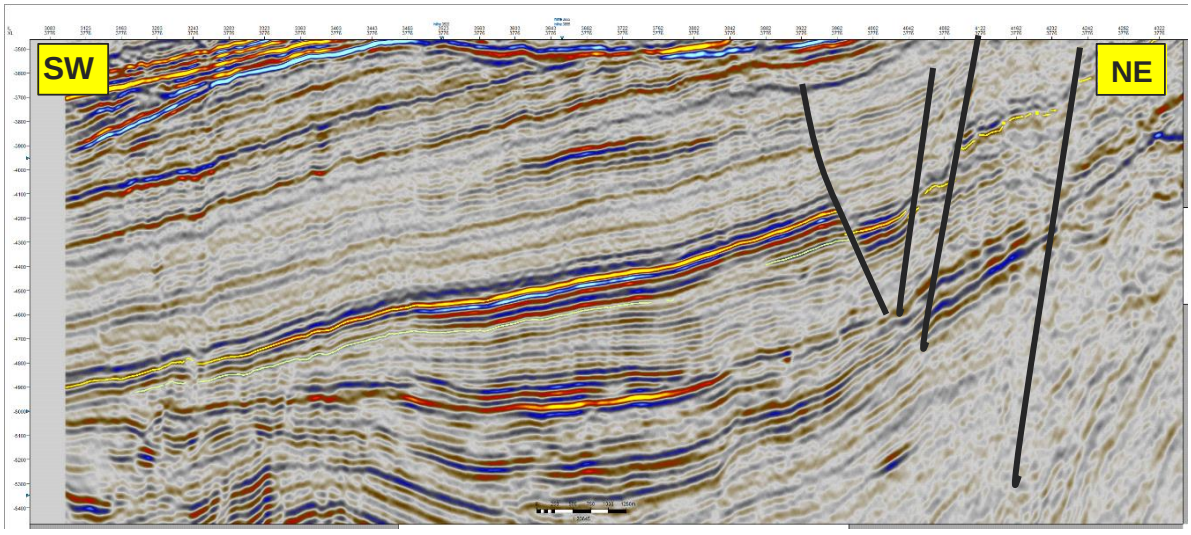
Planning for Woodside's first operated well in the basin has already commenced with the earliest envisaged spud being in the summer of 2018. Currently the most likely prospect to be targeted is Ventry, a late Jurassic slope fan system located in FEL 5/13 in the Moling sub-basin. Ventry is thought to contain commercial quantities of light oil, being located directly above an oil-mature Mid to Late Jurassic source system. Ventry is a combination trap, being dip-closed to the west, sealed by faults at its eastern edge and with the reservoir interval either changing facies or being truncated by the Base Cretaceous Unconformity (BCU) to both north and south. A map of amplitude x thickness of the gross Ventry reservoir package is thought to be an approximate guide to net pay. The southernmost part of the Ventry fan complex appears more channelised and has more chaotic seismic character than the main body itself, which comprises a higher amplitude, more parallel and continuous reflector package.



Depth and amplitude x thickness maps at top Ventry

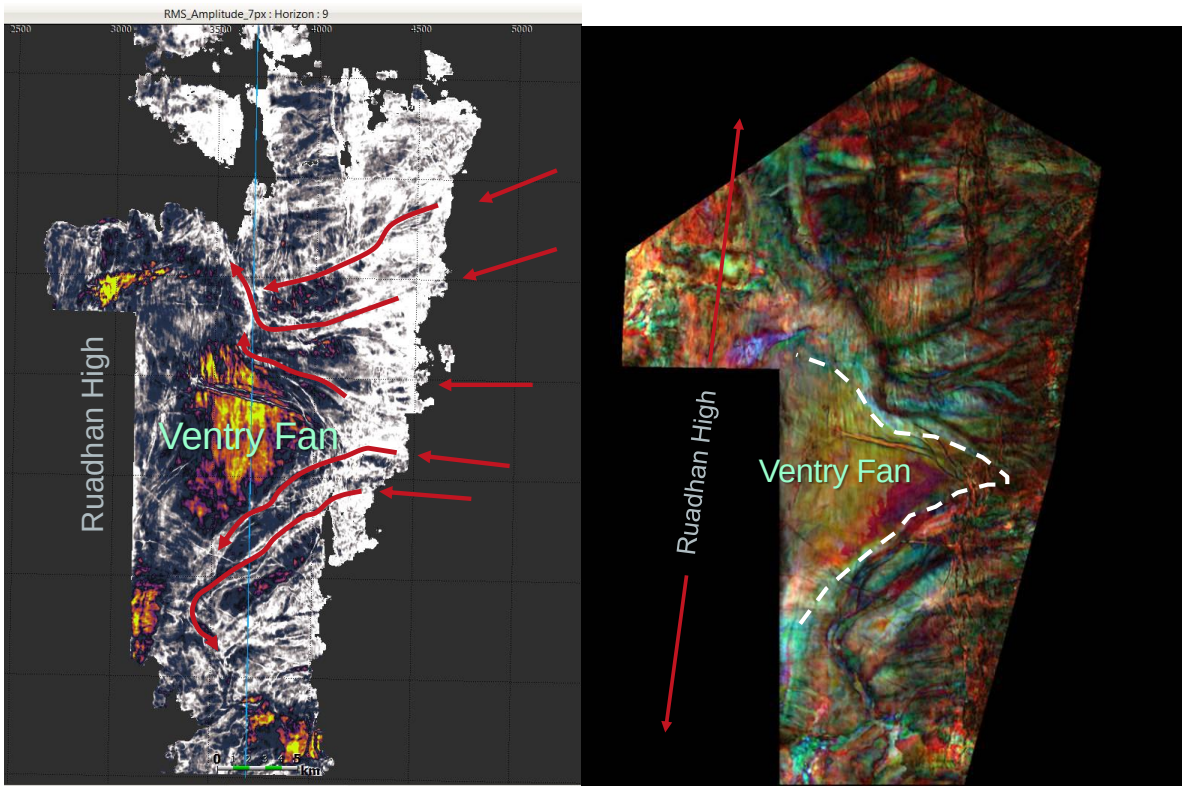


Strike section illustrating truncation beneath BCU to both north and south



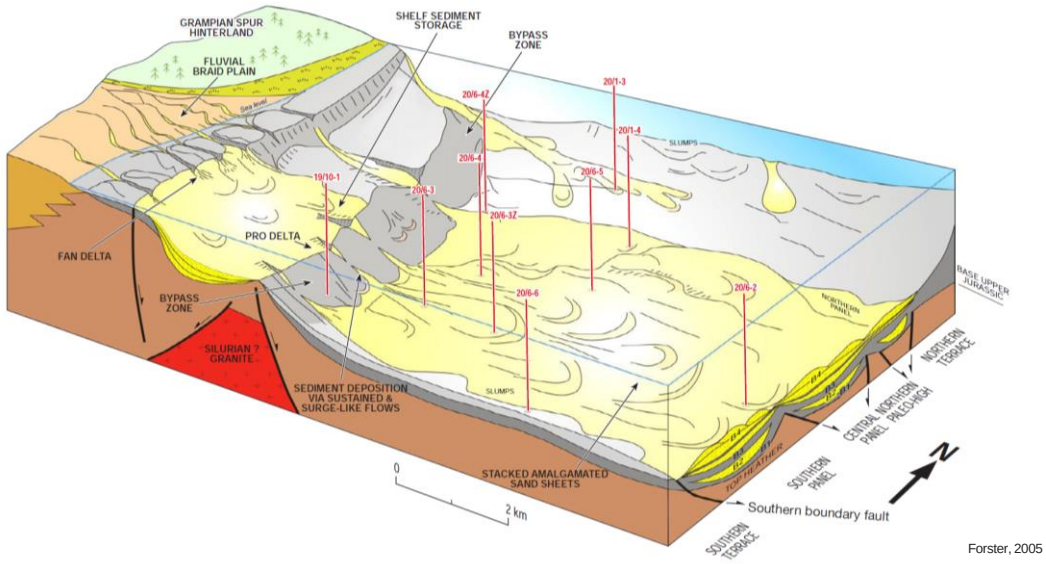
Dip section illustrating fault closure and ultimate shale-out updip

Seismic images from the PSDM data cube clearly show local provenance of the Ventry reservoir package from the basin margin to the east.



Top Ventry reservoir images showing deflection of later channels. A) Paeloscan, B) Spectral decomposition

As complex a trap as the Ventry prospect is, it bears an uncanny resemblance to the Golden Eagle and Buzzard fields in the UK North Sea. Features common to Ventry and these discoveries include: The age of the prospective interval; the overall footprint area; trapping geometry; depositional setting; thickness and seismic character of the reservoir; hard nature of the sands; and lack of AVO response. Buzzard was recently reported as having produced its 600 millionth barrel of oil.



Buzzard Field schematic depositional setting (after Forster, 2005)

In addition to the Ventry and Ventry Deep prospects, more than 20 leads and prospects are currently mapped across Woodside's five licences. All the potentially successful play types are represented in Woodside's portfolio, ranging from Middle Jurassic to Tertiary in age. Of particular focus are the Early Cretaceous and Late Jurassic plays that have proven so successful in recent years on the West African and East Canadian margins.

Driven by Woodside's high interest levels across this portfolio, together with the desire to bring in a strategic partner to help us unlock the Porcupine Basin's potential, a farm-down process is underway in Woodside's London office. Please contact the author or Woodside's Ireland Country Manager for further information.

Prospects 2 Go - LO 16/27 – Porcupine Basin – The Paleocene Avalon Oil Prospect

Watson, M.[1]

[1]*Providence Resources plc* *Email: mwatson@providenceresources.com*

Licensing Option (LO) 16/27 is located c. 150 km off the west coast of Ireland, and is situated in c.1300m water depth. The licensing option contains the Avalon prospect, which was identified by Providence as its highest rank exploration target of the 2015 Irish Atlantic Margin Licensing Round (AMLR). Avalon is a Paleocene deep-water channel and fan system with a mapped areal extent of c. 550km^2 that partially overlies the Dunquin Ridge. LO 16/27 was awarded to Providence Resources plc (80%, Operator) and Sosina Exploration Limited (20%) for an initial 2-year term. The play is analogous to that of the Druid prospect (FEL 2/14), which is planned to be drilled by a Providence-led consortium in summer 2017.

The stratigraphic Paleocene oil exploration play has been a focus for Providence since 2006, when the Druid prospect was initially identified as a promising lead on the then proprietary SPB06 2D long offset seismic reflection dataset. Observed differential compaction related mounding together with an associated strong Class II AVO anomaly on this dataset indicated the possible presence of a large hydrocarbon-bearing deep-water channel and fan reservoir system. Subsequent analysis of a recently acquired (2014) MC3D seismic survey over the Druid feature has served to increase confidence of this interpretation. During its regional technical evaluation for the AMLR, Providence identified similar Paleocene mounding and associated Class II AVO anomaly (Figure 2) present elsewhere on this SPB06 dataset, with further technical evaluation resulting in the development of the Avalon Prospect.

The Avalon prospect sits axially in the basin, with its deposition apparently controlled by remnant bathymetric effects of the Porcupine Arch and the Dunquin Ridge. The Avalon system is currently divided into three fan complexes with associated channels representing the progradation of the system south-wards. As mapped, Avalon sits c. 2500 m BML, with a thickness ranging up to 125 m. Pronounced differential compaction and mounded seismic morphology is suggestive of a high N/G sandstone system, which is considered to mitigate reservoir risk. Sediment provenance is identified as being from the north-east, with identified sediment input points on the eastern Porcupine margin and sediment transport direction from north to south along the basin axis. Avalon is observed to pinch-out towards its margins, and depth conversion utilizing available well and seismic velocity data reveals a flexure of the Cenozoic down to the north. This flexure creates a structural closure in the sediment transport direction (Figure 1), thereby reducing associated trap risk.

The location of Avalon above the Dunquin Ridge has potentially significant positive implications for hydrocarbon sourcing. The Dunquin Ridge is a proven locus of oil migration in the basin, with the Dunquin North carbonate build-up estimated to have hosted a pre-breach STOIIP of 1.2 BBO, which also reduces source risk more generally in the basin. Observed faults and fractures focused above the ridge may facilitate vertical hydrocarbon migration from Mesozoic source rocks into Cenozoic reservoirs. The

potential also exists for breached oil from the Dunquin North structure to re-migrate into Avalon. Given the scale of the Avalon system (c. 550km^2 at Avalon versus c. 400km^2 at the c. 3 BBO STOIIP Druid), the potential exists for a multi-billion-barrel oil accumulation in LO 16/27.

In 2017, Providence and its partners plan to drill the highly anticipated 53/6-A exploration well in FEL 2/14, which is designed to test the Paleocene Druid and potentially Lower Cretaceous Drombeg objectives. This well will potentially greatly de-risk the Avalon prospect, and critically, it will give further understanding regarding the hydrocarbon potential of Class II AVO anomalies in the Paleocene of the Porcupine Basin.

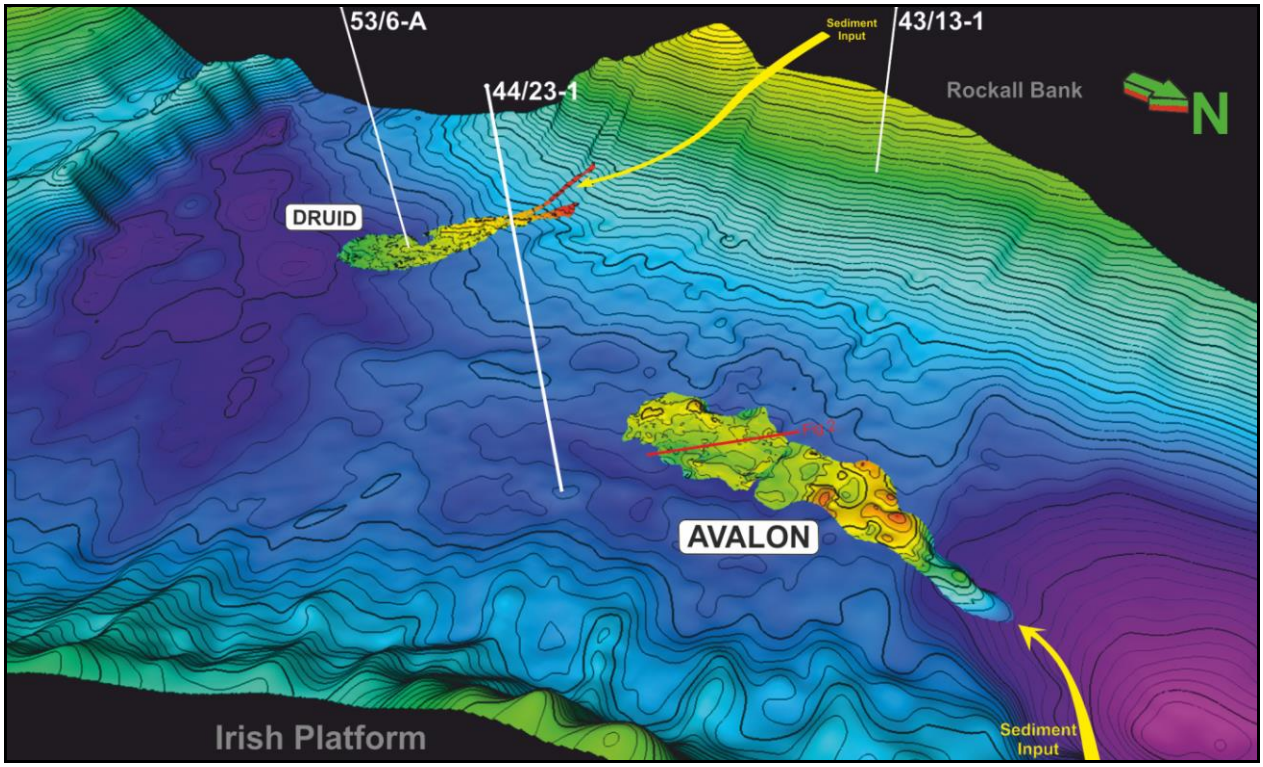


Figure 1. 3D Perspective view of Top Cretaceous Chalk (Depth), with overlain Avalon and Druid (Depth) Paleocene deepwater channel and fan systems.

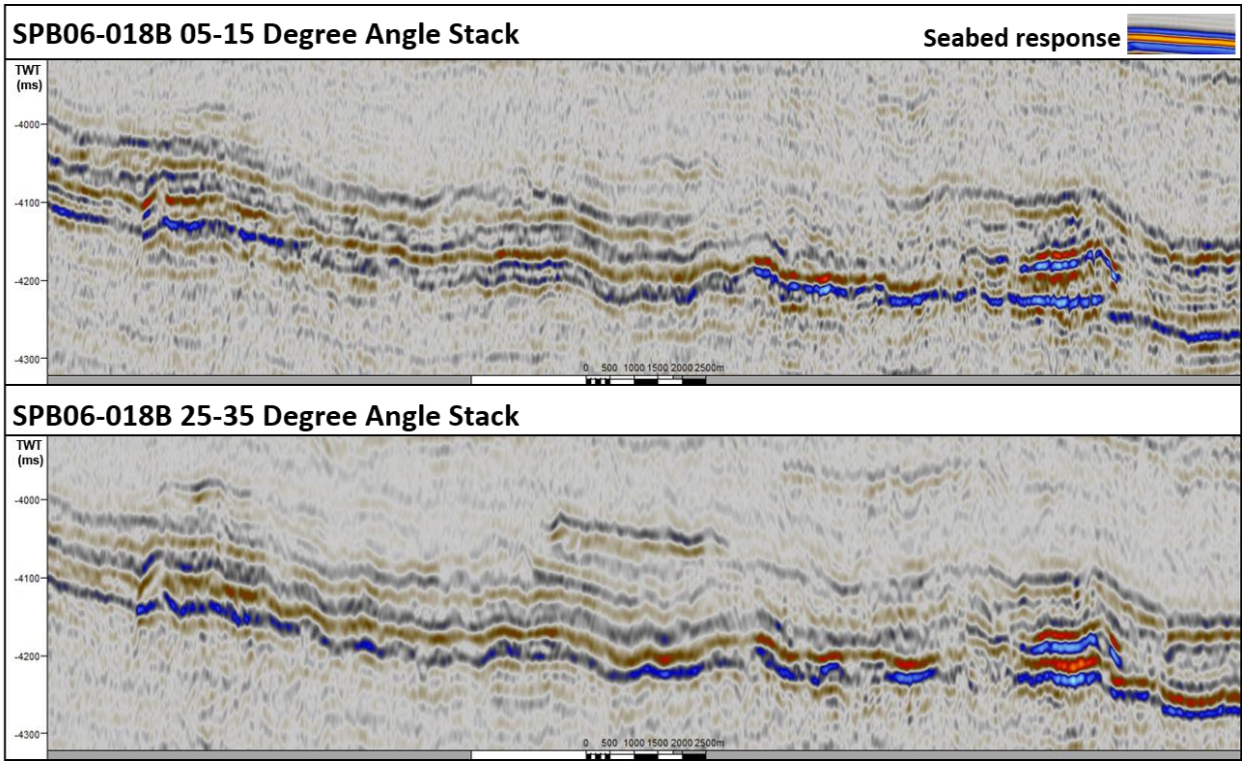


Figure 2. SPB06-018B 2D offset near (above) and far (below) stacks showing a Class II AVO anomaly (the Avalon Prospect). High amplitude laterally continuous reflectors represent the top of the Danian and Upper Cretaceous chalk packages.

Prospects 2 Go - LO 16/23 – Slyne-Erris Basin – The Triassic Edge Prospect

Lawson, S.[1]

[1]*Faroe Petroleum* *Email: slawson@faroe-petroleum.com*

Licensing Option 16/23 (LO 16/23) was awarded to Faroe Petroleum (100%) under the 2015 Atlantic Margin Round for a period of three years commencing 1 July, 2016. Located in the Slyne-Erris Basin, the primary play is represented by the Triassic Sherwood Sandstone, charged from mature gas-prone Carboniferous Westphalian coals and sealed by mudstones and evaporites of the overlying Triassic Mercia Mudstone Group. This play is proven in the nearby Corrib Field which is estimated to have reserves of 870 Bcf and which came on-stream at the end of 2015. A Jurassic play has also been identified within LO 16/23, comprising sandstones of the Lower and Middle Jurassic charged from mature oil prone source rocks within the Pliensbachian to Toarcian Portree and Pabba shales.

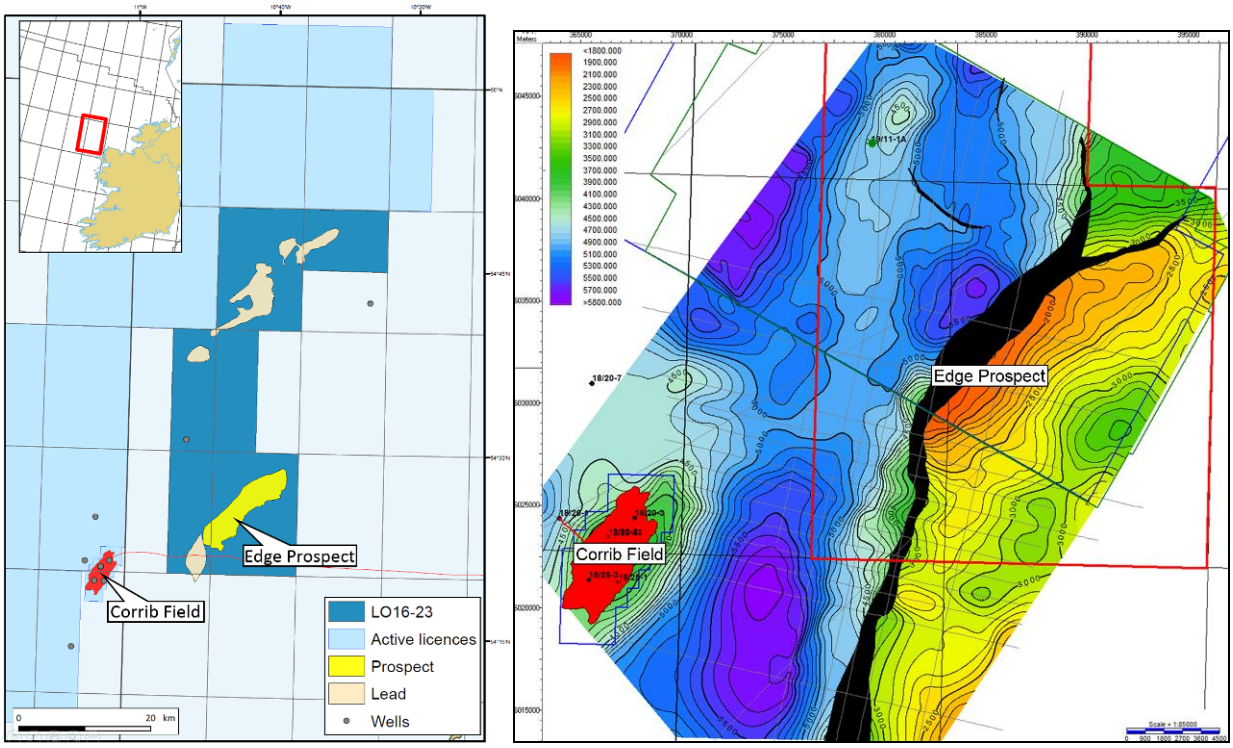


Figure 2: (Left) Location map showing LO 16/23 and identified prospectivity. (Right) Triassic Sherwood sandstone top structure depth map in metres showing the Edge Prospect fault block and the Corrib Field

The Edge Prospect is a very large rotated fault block with estimated mean reserves of 1.2 Tcf. The structure covers an area of up to 55km² at Top Triassic level, with a crestal depth of 1800m. Analysis of well data shows the Sherwood Sandstone to be a very thick, high net-to-gross succession within the Slyne and Erris Basins, and if present at the Edge Prospect would be expected to form an effective reservoir. Charge is most likely to be provided by Carboniferous coals, proven to be mature within the axis of the Slyne Basin and the same source rock for gas reservoired in the Corrib gas field. Oil charge is also possible from Liassic source rocks located within the hangingwall of the Edge bounding fault. The Bandon oil discovery 60km to the south demonstrates an effective oil prone Lower Jurassic source rock. Thick mudstones of the Mercia Mudstone Group are expected to form a top seal to the prospect, with cross-fault seal against Jurassic stratigraphy also required.

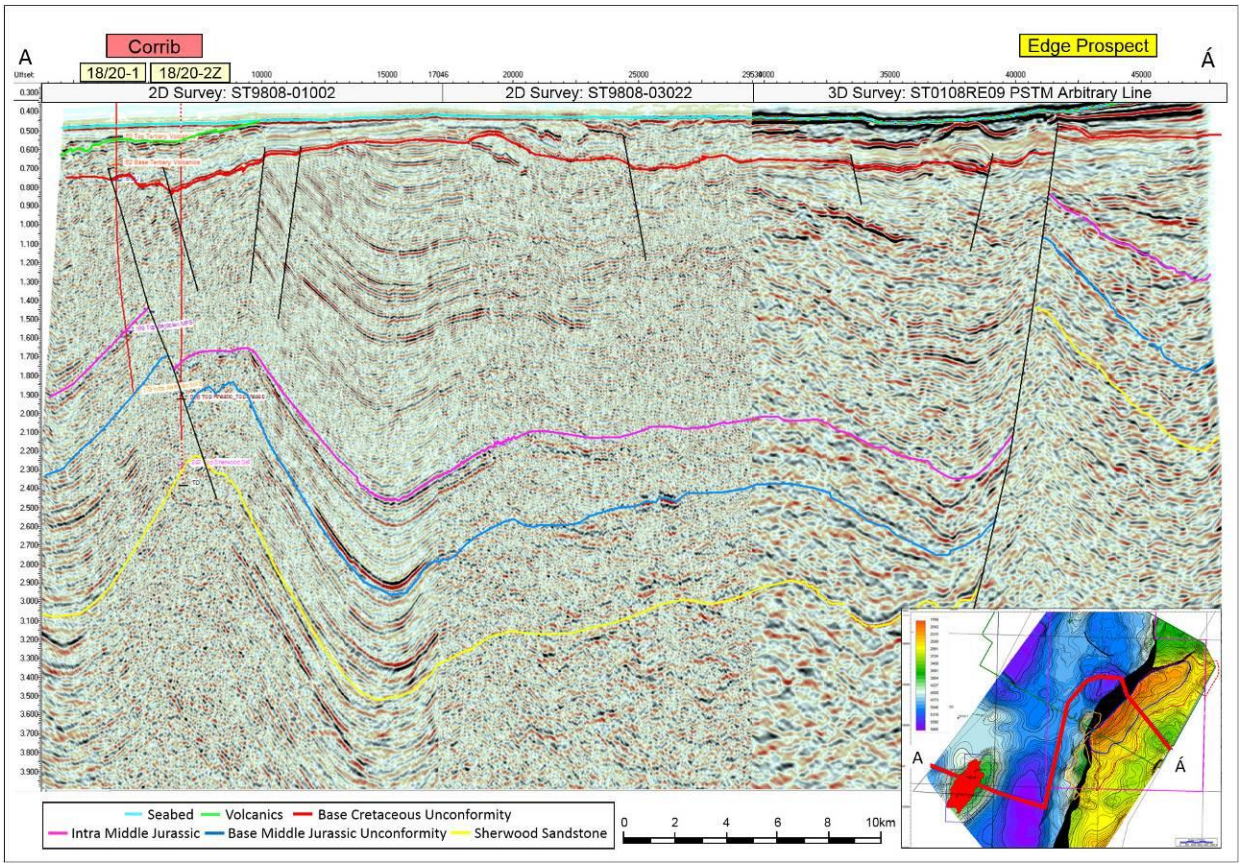


Figure 3: 2D and 3D seismic tie line between the Corrib Field and the Edge Prospect. Source: Supplied by IHS Global Limited on behalf of the Department of Communications, Energy and Natural Resources of the Irish government; Copyright © the Department of Communications, Energy and Natural Resources, Ireland (2015]. All rights reserved.

The key uncertainty associated with the Prospect is trap definition. The structure is largely covered by 3D seismic data however the closure area to the south is mapped on 2D seismic data only. Data quality of both 2D and 3D seismic surveys is very poor in this area of the basin, with imaging problems related to a layer of Eocene volcanics overlying Upper Cretaceous chalk located immediately below the seabed. A key challenge, and fundamental part of the work programme is to significantly improve the quality of the seismic image so the trap comprising the Edge Prospect can be much better defined.

Additional Leads are identified in LO 16/23 within Jurassic stratigraphy. These Leads share a similar structural style being formed by rollovers caused by detachment faulting within Zechstein Group halites. Lower and Middle Jurassic reservoirs are expected to be present within these structural closures potentially sourced by oil prone mudstones of Liassic age.

The Atlantic Ireland Margin - A Super Regional Approach to Trans-Atlantic Exploration

Leppard, C.[1], Allsop, P.[1], Belan, A.[1], Corfield, S.[1], Doubleday, P.[1], Higgins, S.[2], Irvine, S.[1], Jordan, O.[2], Scotchman, I.[1], Scott, M.[2], Sharp, I.[2]

[1]*Statoil UK, London, UK* *Email: CLEP@statoil.com*

[2]*Statoil ASA, Bergen, Norway*

The concept of an Upper Jurassic play fairway extending from the Flemish Pass/East Orphan Basins on the Canada Atlantic margin to the Porcupine Basin on the Ireland Atlantic margin has been postulated since the drilling of the Mizzen L-11 well in Flemish Pass in 2003. However detailed geological understanding of individual play elements from super-regional 'plate' scale down to local 'prospect' scale has been problematic due to sparse data at all scales.

There have been many attempts over the years to reconstruct the Ireland-Canada conjugate margins. The majority of them have focused on observations and models at a plate scale. To reduce uncertainty in the reconstruction of the Ireland-Canada conjugate margins, data and observations at all scales should be interpreted and included. The reconstruction of the Late Jurassic plate configuration is considered by Statoil to be the most important time-step for understanding reservoir and source rock development along this margin as it forms the basis for palaeogeography maps used in their prediction. It is therefore essential that the model honours the data at all scales.

Unravelling the complexities of the Upper Jurassic play across from the Flemish Pass/East Orphan Basins to the Porcupine Basin has therefore been prioritised within Statoil following on from the success of the Statoil-operated Harpoon (2013) and Bay du Nord (2013) discoveries. Although the Upper Jurassic play is proven in northern Porcupine Basin (Connemara/Spanish Point) the undrilled southern Porcupine Basin can be considered to be a frontier area, with the closest well control (with a preserved Upper Jurassic section), the 43/13-1 well, located approximately 180 km north of the southern margin of the basin.

The material presented here outlines the approach taken to reduce exploration uncertainty in southern Porcupine Basin by building upon knowledge gained through integration of data from both the Irish and Canadian Atlantic margins.

Newfoundland and Labrador Update: Emerging Plays

Atkinson, I.M.[1], Wright, R.[1]

[1]*Nalcor Energy* *Email: ianatkinson@nalcorenergy.com*

Nalcor Energy's exploration strategy, initiated in 2009, has greatly improved our understanding of the petroleum potential of the province's basins. At the end of 2015, the TGS/PGS partnership had acquired over 110,000 kms of broadband 2D seismic data in our offshore as part of this strategy. That number will rise to approximately 150,000 kms in 2016. These multi-client seismic surveys provide modern, high quality datasets that allow industry new venture teams to analyse an area ahead of scheduled land sales. In 2015, the first 3D multi-client survey was acquired ahead of a land sale.

In addition to the seismic data programs, Nalcor has been an early participant in other multi-client surveys – a controlled source electromagnetic survey with EMGS in the Flemish Pass Basin and two seabed coring surveys with MG3/AGI in the Orphan Basin and off Labrador. A number of studies have also been commissioned and are available for free download on the Nalcor website. These studies include the Regional Geopressure and the Rock Physics reports by Ikon Science, the Metocean study by C-CORE, the Drilling Metrics report by NSB and the Biostratigraphy Studies by Riley Geoscience.

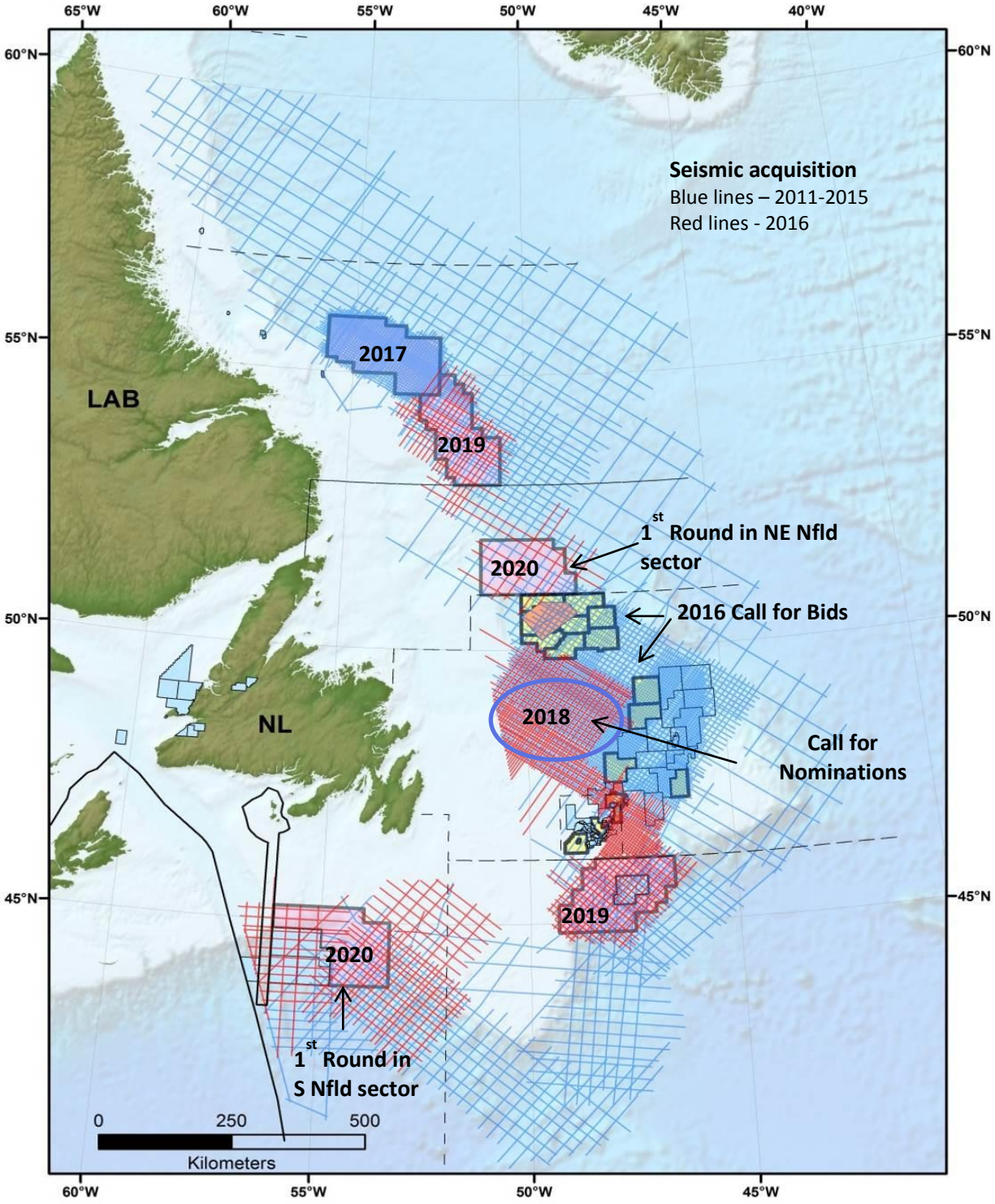
The new data, studies and reports are demonstrating petroleum prospectivity in our under-explored basins that is much greater than was previously acknowledged. The independent resource assessments conducted by Beicip-Franlab for the 2015 and 2016 License Round areas predicted the potential for material volumes of hydrocarbon accumulations to exist. The data have identified many new plays and over 350 leads have been inventoried. One such play is an Eocene-aged, turbidite fan complex in the 2016 land sale area[3]. The depositional extent of the main fan complex covers approximately 550 square kms. This large feature was imaged in detail by the 2015 3D seismic survey, but it is not the only Eocene fan complex in the area. Separate fans have also been imaged by the regional 2D seismic data. Rock physics modelling of the AVO response on the 3D data has provided important insights into the potential fluid charge[4]. Fan complexes of Cretaceous age have also been imaged by the new data. These new plays have gained the interest of the global industry due to their material size and potential.

Nalcor Energy's exploration strategy continues to build our knowledge and understanding of the petroleum prospectivity of the under-explored basins of the province. The strategy will ensure that sufficient data and information will be available to industry ahead of future scheduled land sales. This will allow the industry to make informed investment decisions that potentially will lead to major new discoveries in the future.

[3]Wright, R., Carter, J., Atkinson, I., Gillis, E., Cameron, D., Stead, L., Neugerbauer, T., Witney, J., Hughes, D., Hall, M., 2016, New Lower Tertiary play trend identified in the West Orphan Basin, Offshore, Newfoundland, Presented at the 86th Annual International Meeting, SEG

[4]Montevecchi, N., Atkinson, I., Cameron, D, Carter, J., Wright, R., 2016, 2D seismic modeling and quantitative investigation of an undrilled Eocene fan complex , Orphan Basin, Offshore Newfoundland and Labrador, Presented at the 86th Annual International Meeting, SEG.

Figure 1: Map of TGS/PGS seismic data acquisition to 2016 showing the upcoming licensing rounds



Source rock correlations in Mesozoic basins of the North Atlantic Conjugate Margin, Offshore Newfoundland and Offshore Ireland

Laigle, J.M.[1], Huc, A.Y.[1], Piriou, S.[1], Mouchot, N.[1], Pichot, T.[1] Armstrong, J.[2]

[1]*Beicip Franlab* *Email: Jean-Marie.Laigle@beicip.com*

The North Atlantic Mesozoic basins are tectonically linked and share a common evolution related to the opening of the North Atlantic Ocean. In terms of oil and gas exploration, some basins have proved to be commercially successful (Jeanne d'Arc Basin, Celtic Sea) or are showing promising results (Flemish Pass), whereas others have experienced more limited success to date. To enhance present understanding and help define future exploration strategy, a review of the characteristics and distribution of source facies across North Atlantic basins of Ireland, Newfoundland and Labrador. To date, numerous geochemical well evaluations and integrated basin studies have been undertaken in these basins. This study was able to access such datasets from 620 offshore wells and additionally, from numerous scientific publications. These data were enhanced by further geological, geophysical and petrophysical studies. The primary objectives of this study were not only to produce a fully integrated database of already generated geochemical information in to which future data could be incorporated but also to use these data to produce an atlas of source rock and oil families across the study area. As a result of the initial review of the existing database well sections and oils that would benefit from further analyses were identified and a supplementary analytical programme was commissioned. This new programme includes a large set of Rock-Eval analysis distributed among 14 wells (from Celtic Sea, Fastnet Basin, Goban Spur, Porcupine, Orphan and Flemish Basins), biostratigraphical analyses, gas chromatography, GC-MS biomarker and carbon isotopes analyses on oil samples and rock extracts, as well as kerogen elemental analysis and kinetics determinations on key source samples of Carboniferous and Jurassic age. In addition to this phase of the study, a comparative assessment with analogue basins in Morocco, Iberia, Greenland, Faroe-Shetlands and. Nova Scotia has been made using the extensive of published data for these areas.

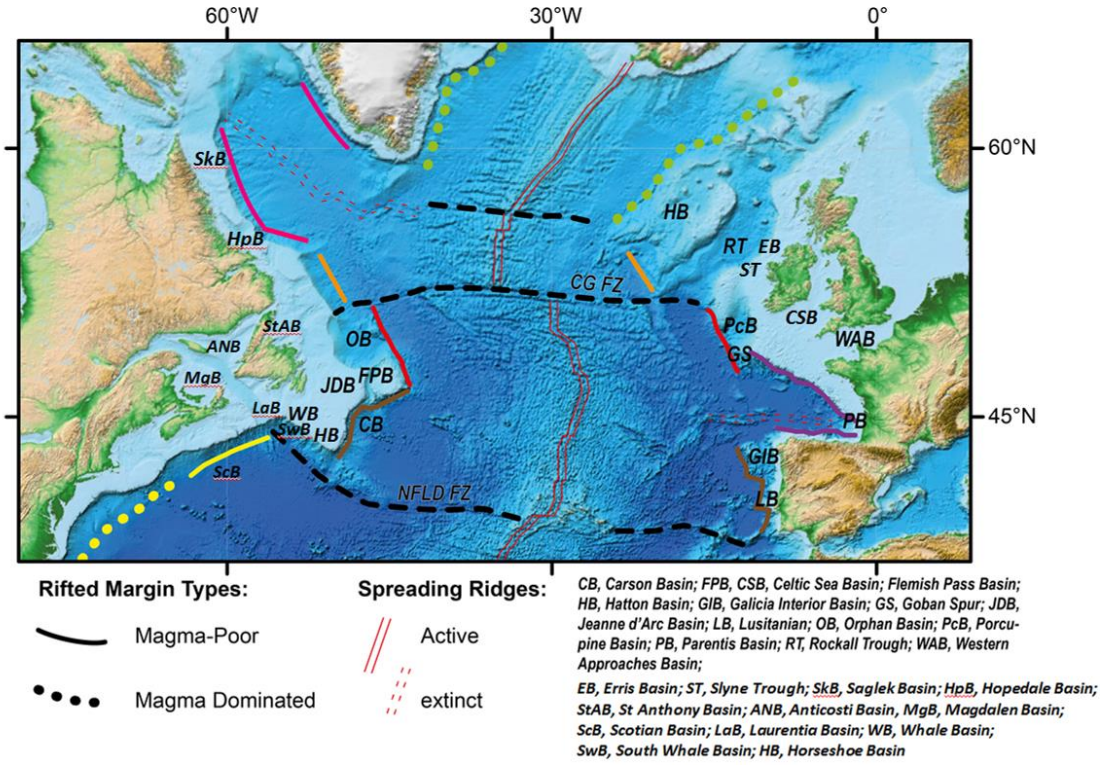


Figure 1. Studied basins in the North Atlantic realm

One new aspect of this study is the calculation of net source rock thickness and average present day TOC per interval. This has been achieved evaluations of well logs from 20 key wells on both margins. Leading on from this, in each of the study basins, source rock maturity history has been assessed using 1D and 2D basin modelling along re-interpreted seismic profiles. Organo-facies distribution and mapping of initial source potential (TOC^0 and HI^0) has been constrained by palaeo-geographical reconstructions. The present day maturity of source facies has been mapped regionally combining basin modelling and previously acquired data. Maturity, organo-facies and source potential maps have been combined to infer Present Day transformation ratio, generated and expelled hydrocarbon volumes and quality from key source rock horizons. This in-depth review has been constructed in a consistent tectono-stratigraphic framework to allow the drawing of important conclusions with respect to the forward exploration strategy in basins on both margins.

Acknowledgements

This project is funded by the Petroleum Infrastructure Programme (PIP) in Ireland and Nalcor Energy in Newfoundland-Labrador. Beicip wish to thank the staff of DCCAE/PAD, Nalcor Energy and the PIP Secretariat for their extensive support and input during this project. The help of James Armstrong who acted as Mentor for this project is gratefully acknowledged. We also thank the members of the project steering committee for their input and constructive discussions: Iain Scotchman (Statoil), Ranald Kelly (Woodside Energy), Ramzi Ghenima (Cairn Energy), Anne Marie Smith (Providence Resources).

An Integrated Biostratigraphic and Lithostratigraphic Framework of Offshore Ireland

Copestake, P.[1], Ainsworth, N. R.[2], Bailey, H. W[3], Donato, J. A.[1], Dunford, G.[4], Farrimond, P. R.[5], Gallagher, L.T.[3], Gehlen, M.[5], Gueinn, K. J.[6], Hampton, M. J.[3], Lavis, O. M.[1], Loy, T.[1], Riley, L. A.[6], Wright, T. D.[1]

[1]*Merlin Energy* *Email: philip_copestake@merlinenergy.co.uk*

[2]*Palaeodate Ltd*

[3]*Network Stratigraphic Consulting Ltd*

[4]*Dunford Exploration Ltd*

[5]*IGI Ltd*

[6]*Riley Geoscience Ltd*

The Irish offshore comprises a diverse set of geological basins, both on the Atlantic margin and in the Celtic and Irish Sea areas, representing a range of geological and structural complexity. The efficient exploration of such a province requires a standard stratigraphic understanding and consistently defined schemes (biostratigraphy, lithostratigraphy, sequence stratigraphy) that all operators, contractors and academia can use. This will provide a common language of communication and also a fundamental chronostratigraphic framework to underpin all other evaluations. Despite its long history of hydrocarbon exploration (the first well, 48/25-1, having been drilled in 1970), such a unified framework has never been defined for offshore Ireland, and this has led different contractors and operating companies to use their own in house schemes for particular regions and basins, with little consistency in terminology from area to area.

In addition to this there are a number of known stratigraphic problems that exist in the region, regarding the chronostratigraphic interpretation and correlation of particular reservoir intervals and their relation to a broader regional scheme. For these reasons, PIPCo RSG has commissioned a project to be carried out to establish and define a biostratigraphic, lithostratigraphic and sequence stratigraphic framework for

offshore Ireland. This project, which commenced at the beginning of July 2016, is being carried out by an experienced team of stratigraphers, seismic interpreters and explorationists, combining extensive knowledge of offshore Ireland and adjacent regions. The project is based on the assessment and re-interpretation of all available existing legacy stratigraphic data from all released wells, and will be supplemented by new data focused on intervals and wells where gaps in the existing database exist, or where further data are required to improve the stratigraphic understanding of particular intervals. The re-evaluation of the legacy stratigraphic data is being tied to a database of released seismic for the region, which is being reinterpreted to tie key wells across the region and to map into undrilled areas.

One of the key aims of the project is to compare the stratigraphy in offshore Ireland with offshore Eastern Canada (Newfoundland), other basins west of the United Kingdom and the North Sea.

Palaeogeographic and play fairway mapping will also be carried out, constrained by the new stratigraphic framework. In particular, source rock data will be placed into the new framework and source kitchen areas mapped.

Project deliverables will include databases (*Stratabugs*, *IC*, *ArcGIS*), a report atlas, and a written report.

To date, reassessments of the legacy stratigraphic database have been carried out for the Donegal, Slyne-Erris and Porcupine basin areas, including correlations of all wells in these areas tied to a set of arbitrary seismic lines. Some examples of this preliminary work will be shown in this presentation (and the accompanying posters).

Acknowledgements

This project is funded by the Petroleum Infrastructure Programme (PIP). We particularly acknowledge the provision of data by the DCCAE/PAD and the PIP Secretariat and the mentorship of Kara English of PAD.

Seabed coring of macroseep and microseep locations for geochemical analyses and select heatflow measurements, offshore Newfoundland-Labrador

De Coster, M.[1]

[1] AGI Email: decoster@agisurveys.net

Introduction

In late 2013 the province of Newfoundland and Labrador announced changes to its offshore land licensing system and moved to a scheduled lease round process. Areas of the offshore never before offered are now available in upcoming license rounds. Understanding the petroleum systems in these regions is critical for explorationists looking to assess the hydrocarbon potential of the region. This study provides new perspective and insight into the working petroleum system supporting both ongoing licensing rounds and future exploration as well as furthering understanding of the various types of geochemical data gathered.

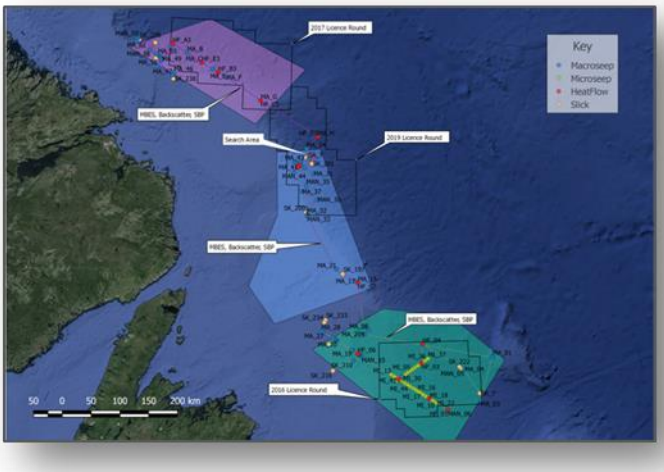


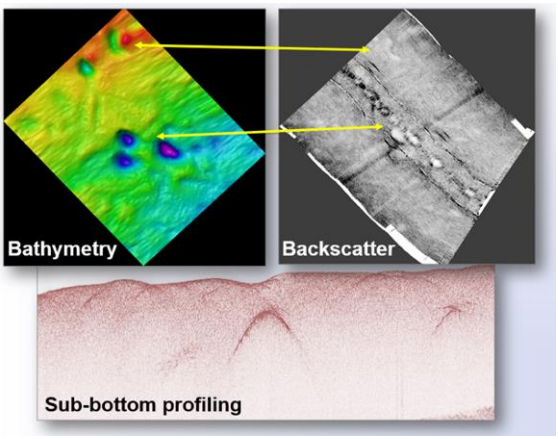
Figure 4: Location of Survey Area: offshore Newfoundland and Labrador, Canada

The key objective of this project was to evaluate working petroleum systems and prospectivity of the area through targeted (multibeam supported) sea bed coring of macroseep and microseep locations for geochemical analyses and select heatflow measurements over the project area. Analytical results from the programme will assist in petroleum system modelling and de-risking source rock potential.

MG3, the geoscience survey vessel operator provided the DP survey and coring vessel and performed all field activities (geophysical, multibeam seabed bathymetric mapping, heat flow, coring and sample acquisition), in effect providing 'intelligent sampling'.

Sampling Programme

General seabed sampling locations were selected via integration of sea-surface slicks (courtesy of Airbus Defence and Space) and seismic expressions in the subsurface (courtesy of Nalcor Energy). Multibeam acquisition for bathymetric analysis over the targeted macroseep areas was used to refine core sampling locations at identified sea floor features (such as pock marks; Figure 2). Slick samples were collected using AGI Slick Samplers. In addition, microseep samples were collected over select subsurface targets identified on seismic data. All seabed coring was conducted using a gravity corer run with a six metre barrel. Sample locations range in bathymetry from shelf to deep water.



The project area includes three of the C-NLOPB Areas of Interest in the upcoming 2016, 2017 and 2019 license rounds. 117 sea floor coring samples, 14 heat flow data points, select multibeam bathymetry transects and surface slick samples have been acquired over these regions.

Figure 2. Integration of multi-beam, backscatter and sub-bottom data to refine location selection

Traditional geochemical methods provide good screening techniques for thermogenic hydrocarbon detection. Additionally, conventional biomarker data can provide important insight into the presence of a known petroleum system, correlation with known regional petroleum systems and understanding of thermogeniety / maturity through isotopic ratios. However, traditional geochemical methods require macroseep-scale features (or liquid samples), which can be difficult to locate and acquire, if present within a prescribed study area. AGI's ultrasensitive technology (passive method) was used in this project to compliment the traditional geochemical analyses for the macroseep-targeted samples of the project, in addition to being the sole technique for assessing microseepage over seismically defined leads directly. The AGI passive sampler contains a specially engineered oleophilic adsorbent encased in a permeable membrane which allows hydrocarbons to concentrate over a specified time period (1,000-fold increase in sensitivity compared to conventional techniques). Analytical results may reach the part per billion (ppb) range rather than part per million (ppm) of conventional methodologies, while reporting on C_2-C_{20} organic compounds. This technique compliments traditional geochemical measurements that report on a possible range for C_1 – C_5 and C_{15}+ (conventional methods). Thus if successfully sampled, the AGI analysis can clearly differentiate between gas, gas condensate, or oil fingerprints, and can elucidate subtle differences from similar hydrocarbon signatures to identify multiple petroleum systems.

Results

Hydrocarbon response is noted at a significant number of seep locations. Thermogenic signatures include a broad range of aliphatic and aromatic compounds over the C_2 – C_{16} range (Figure 3).

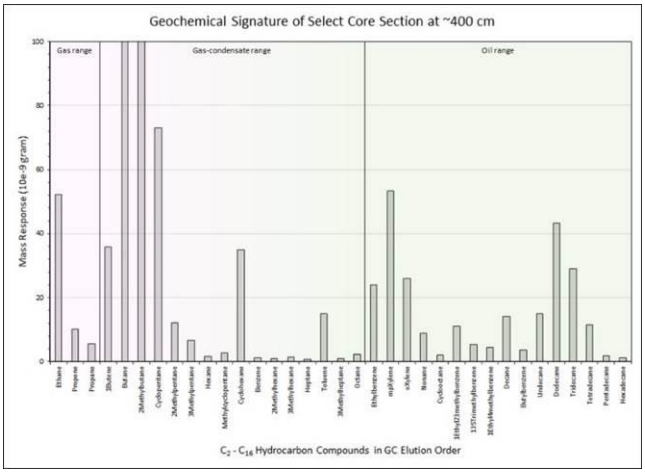


Figure 3. Example signature of hydrocarbon mass response in the data set

The microseep dataset shows some correlation between geochemical results and underlying seismic leads. Hydrocarbon signatures are identified as thermogenic due to presence of such compounds as aliphatics (up to hexadecane), and various cyclic and methylated cyclic aliphatics. Results are positive in that data acquired by targeted sampling and robust analyses provide evidence of an active petroleum system over broad regions of the Newfoundland and Labrador offshore.

Additionally, learnings are offered from the comparison of conventional with passive geochemical results from same core site. Observations are discussed when both conventional and passive results are positive, and when one is positive and the other negative. The combination of both conventional and passive methodologies is a better strategy than either alone, particularly for basins lacking pervasive macroseepage.

Irish Offshore Strategic Environmental Assessment 5 IOSEA5

Ryan, O.[1]

[1]*Dept. of Communications, Climate Action and Environment, Petroleum Affairs Division, 29-31 Adelaide Road, Dublin 2 Email: Orla.Ryan@DCCAE.gov.ie*

Irish Offshore Strategic Environmental Assessments assess any potential impacts on the marine environment associated with activities conducted under petroleum exploration and production authorisations. The IOSEA 5 Statement forms the final output from the Irish Offshore Strategic Environmental Assessment 5 (IOSEA 5) and refers to the SEA requirements associated with the adoption of a plan. The IOSEA5 Plan comprises the award of petroleum exploration and production authorisations for undertaking 2D and 3D geophysical seismic survey and drilling in Irish offshore waters during the period 2015 to 2020.

Modelling and validation of the underwater acoustic impacts of offshore seismic surveys in Irish shelf waters

Crawford, S.[1], Brown, C.[1], McKeown, E.[2], Stapleton, F.[2], Duncan, A.[3], McCauley, R.[3], White, M.[1]

[1]*Earth and Ocean Sciences, School of Natural Sciences, Ryan Institute, N.U.I., Galway, Ireland*
Email: s.crawford1@nuigalway.ie

[2]*RPS Group, Galway, Ireland*

[3]*Centre for Marine Science and Technology, Curtin University, Perth, Australia*

Following Ireland's 2015 Atlantic Margin Oil and Gas Exploration Licensing Round, the Porcupine Basin continues to be a significant site for seismic exploration activities to investigate sub-bottom structure. Recent literature has reported on the environmental implications of marine seismic surveys, highlighting alarmed and avoidance behaviour in several marine mammal species as a common response to air gun signals. The European Habitats Directive orders the protection of all cetacean species in European waters, 23 of which inhabit Irish waters for at least part of the year. As such, underwater acoustic monitoring and mapping has been targeted as a research priority under the EU's Marine Strategy Framework Directive. This research aimed to produce an efficient working model of sound propagation for the Porcupine Basin to enable the prediction of sound levels generated by seismic operations in the area. Here we describe some of the work undertaken to develop and validate a 2D model to predict and replicate underwater seismic sound propagation measured in Irish waters.

Sound exposure levels were recorded around the Porcupine Basin during CV14014 in July 2014, which coincided with a 3D seismic survey by Polarcus MC Ltd (Figure 1). Acoustic recordings were selected for 25 events of interest, which were located at ranges from 5 km to 122 km from the source. Pressure time series data (source and received) were analysed in the frequency domain using the Welch method to establish single-pulse sound exposure levels at each ⅓-octave band from 7.98 – 501.19 Hz. The observed transmission losses (TL) could then be calculated using TL = SL – R, where SL is the sound level and RL the received level. Six of the total 25 source-to-receiver pathways were selected for modelling at ranges of 5 km, 10 km, 20 km, 30 km, 40 km and 60 km (Figure 1).

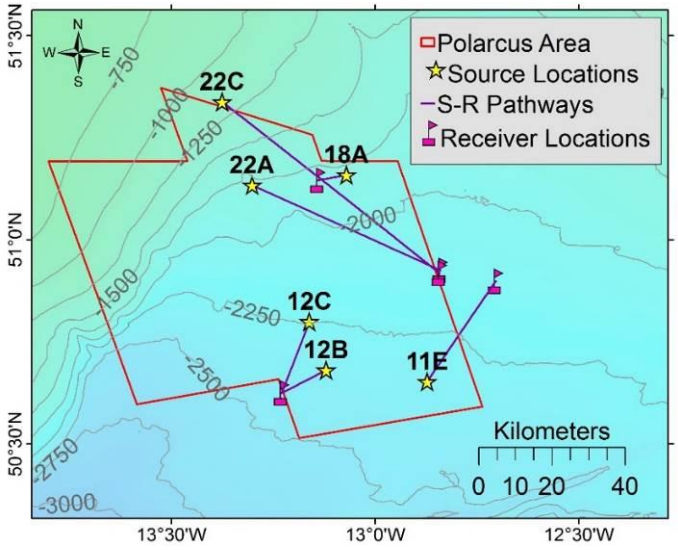


Figure 1. Locations of the source, receiver and pathways between them during acoustic recording events (purple lines), collected during a 3D seismic survey by Polarcus MC Ltd (red polygon).

Modelling was carried out using RAMGeo, a parabolic equation technique available through AcTUP. The bathymetric profile was extracted once the source and corresponding receiver locations were mapped.

The sound velocity profile of the water column was obtained from the hydrographic dataset collected on CV14014 and extrapolated to the maximum depth modelled. The seabed composition was estimated from limited datasets describing the unconsolidated layers and underlying geology. Acoustic parameters input to the model were nominal values assigned to three seabed layers (Figure 2).

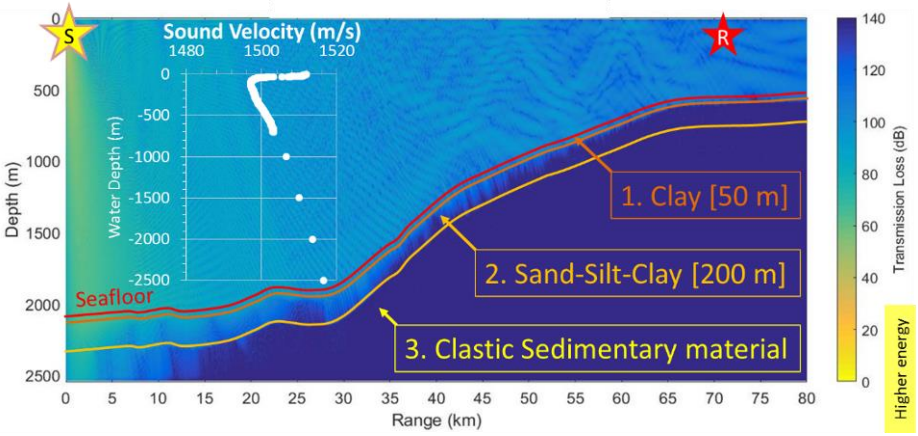


Figure 2. Schematic illustrating sample 2-dimensional transmission loss output from RAMGeo, with water column sound velocity profile, range-dependent bathymetric profile (red dashed line) and the depth-dependent layers defined. Stars indicate the locations of the source (yellow star) and receiver (red star).

Transmission loss was modelled in RAMGeo, for six model versions, at the consecutive ⅓-octave band centre frequencies from 7.98 Hz to 501.19 Hz. Range-averaging modelled transmission losses at the receiver location acted as a proxy for the more computational and time-intensive frequency averaging, required to smooth the discrete-frequency, highly variably (in range and depth) transmission losses modelled, which misrepresent a propagating broadband source. The seabed acoustic parameters used for Porcupine Basin Model A were based on nominal values from Jensen et al. (2011). Using a comparison of theoretic and observed transmission losses of individual ⅓-octave bands, these "Jensen parameters" were modified for Models B and C before exchanging the sound velocity and densities for each layer for the nominal values from Hamilton (1980). Model D used the values corresponding to the compositions of the layers defined and, again using the ⅓-octave band transmission losses, individual parameters were fine-tuned for Models E and F in an attempt to minimise disparities between theoretical and observed results.

Comparisons between observed and modelled metrics indicated that Model E was the strongest predictor of underwater noise, with 68% of ⅓-octave modelled transmission losses within 5 dB and 90% within 10 dB of the observed as well as closer predictions of broadband SEL at every location than the starting model. Broadband single pulse SEL was predicted to within 5 dB re 1 μPa^2s of the observed SEL at all six locations. This model included a depth-dependent sound velocity profile in the seabed (velocity ramped with depth) which resulted in the seafloor boundary having a larger impedance contrast than was produced by the Jensen et al. (2011) nominal values. This corrected the large over-prediction of transmission loss by Model A by creating a reflection coefficient at the seafloor interface such that more energy was being reflected back into the water column, hence lowering the overall transmission loss experienced.

While Model E is considered to be a "working model" for the Porcupine Basin which showed good agreement to the observed values, there are limitations to the model setup. Agreement between the modelled and observed sound levels varies, though not simply, with frequency. The sound exposure criteria for Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS) were not observed to be reached beyond 5 km, which was the closest range for which acoustic data were collected. Modelling,

however, indicates that TTS threshold would be breached for a 100 Hz signal within the 1000 m exclusion zone. Future work on this project area could potentially improve the model, for example, the inclusion of high (spatial and temporal) resolution *measured* acoustic parameters for the Porcupine Basin to refine the transmission loss predictions for the region and remove significant uncertainty in the model environment.

This project is funded by the Petroleum Infrastructure Programme (PIP).

The ObSERVE Programme

Ó Cadhla, O.[1], O'Brien, J.[2], Rogan, E.[3]

[1]*Science & Biodiversity Section, National Parks & Wildlife Service, Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs (DAHRRGA), Dublin Email: oliverocadhla@gmail.com*

[2]*Marine and Freshwater Research Centre, Galway-Mayo Institute of Technology (GMIT), Galway*

[3]*School of Biological, Earth and Ecological Sciences, University College Cork (UCC)*

The ongoing discovery, development and use of major hydrocarbon resources that occur in Ireland's Exclusive Economic Zone (EEZ) have the potential to be very significant economic drivers for Ireland. This is of relevance not only in terms of the potential direct economic and financial benefits but also due to the need to further strengthen Ireland's energy security and sustainability of supply. At the surface, Atlantic Ireland's zones of hydrocarbon interest currently include areas along the western edge of the continental shelf and down the continental slopes that emerge into major deep ocean features such as the Rockall Basin, Porcupine Seabight and Porcupine Abyssal Plain. In addition to its topographical, geological and oceanographic characteristics this Atlantic Margin environment and adjacent shallower seas are home to a diverse array of marine vertebrates that occupy complex and dynamic ecological niches. Many species occupying the higher trophic levels (i.e., higher predators, marine mammals) or those whose populations remain vulnerable to environmental degradation or human interference (e.g., large migratory whales, diving seabirds) are protected under national and international legislation and agreements such as the Wildlife Acts 1976 to 2012, the EU Habitats and Birds Directives and the OSPAR Convention.

Within this setting there is a requirement for improved and robust scientific knowledge with respect to protected species occurrence, habitat and population ecology along the Atlantic Margin to inform and underpin appropriate management and regulatory actions while also facilitating significant industrial practices wherever possible. In this regard in October 2014 the Department of Communications, Energy and Natural Resources, in partnership with the Department of Arts, Heritage and the Gaeltacht, established a ground-breaking data acquisition programme entitled the ObSERVE Programme that is focused around the management of sensitive habitats for protected vertebrates. With a research emphasis on marine mammals and seabirds, new high quality scientific data are now being collected with the latest and best methods to inform management decisions by Government. At present the core objectives of the ObSERVE Programme are:

(1) to update and optimise contemporary ecological information on the Atlantic Margin, including estimates of animal density and abundance;

(2) to assess the importance of waters within the study area for a diverse range of marine mammal and seabird species;

(3) to identify sub-areas that indicate a higher ecological importance, including for vulnerable species.

The Programme also represents a potential future vehicle for high quality environmental research to better inform management of the Irish offshore.

Two projects are currently in operation for 2015-2018 under the ObSERVE Programme: *ObSERVE Acoustic* and *ObSERVE Aerial*, with total Government expenditure nearing €2.75 million.

ObSERVE Acoustic project

Under this project a total of eight moored and six towed acoustic surveys for cetaceans are being conducted during 2015-2016 with a primary emphasis on spring, summer and autumn months in each year. The designated study area for the project covers outer continental shelf, slope and deep Atlantic Ocean waters within Ireland's EEZ, broadly stretching from the Hebrides Terrace to the Goban Spur and concentrating on four key zones of interest (Figure 1).

The acoustic survey contract is being led by Galway-Mayo Institute of Technology with partners the Marine Institute, Jasco Applied Sciences, SMRU Consulting and the Irish Whale and Dolphin Group. All six towed acoustic surveys have now been completed according to the approved line transect designs for 2015 and 2016 (Figures 2a, 2b) while the last four acoustic monitoring stations deployed across zones 3 and 4 (Figure 1) are due for recovery by mid-November. [see: www.observe-acoustic.ie]

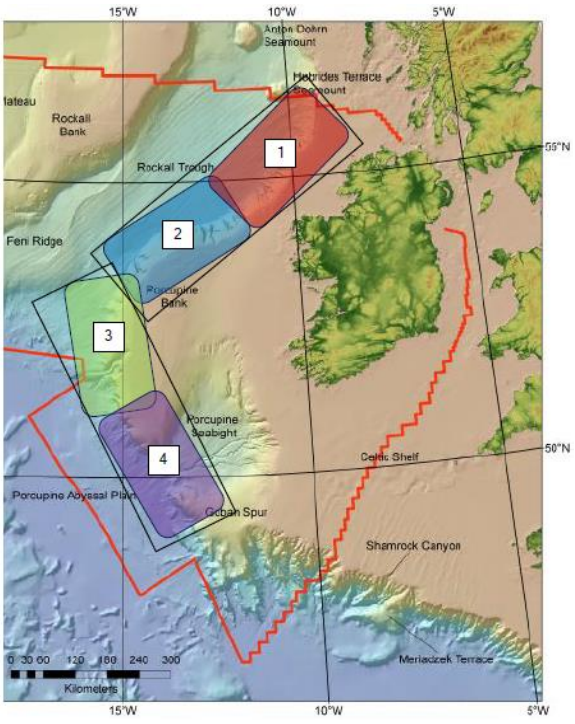


Figure 1. Acoustic study area showing the 4 zones of interest.

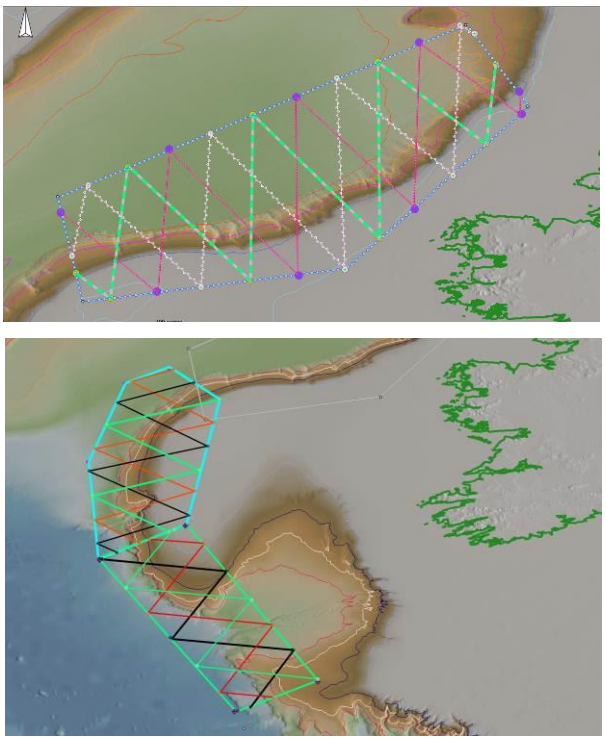


Figure 2a, b. Towed acoustic monitoring designs for (a) 2015 (b) 2016.

ObSERVE Aerial project

Under this project, a series of four extensive line-transect and strip-transect aerial surveys for cetaceans and seabirds respectively is being conducted during 2015-2017 with an emphasis on the summer and winter seasons. The designated study area and >4,700nm design for the project covers a large portion of Ireland's EEZ including the Rockall Basin, Porcupine Seabight, Celtic Sea and Irish Sea (Figures 3a, 3b). Additional finer-scale coverage for seabirds and other waterbirds is being conducted in the Irish Sea (Figure 3b).

The aerial survey contract is being led by University College Cork with partners Aerosotravia, IMARES and ALNILAM. Two replicate survey coverages have been completed in summer 2015 and summer 2016, and with one winter coverage also completed (i.e., 2015-2016) a second replicate coverage is now under way. In addition the Irish Sea parallel design for seabirds and waterbirds will see its third and final coverage over the forthcoming winter months. [see: www.observe-aerial.ie]

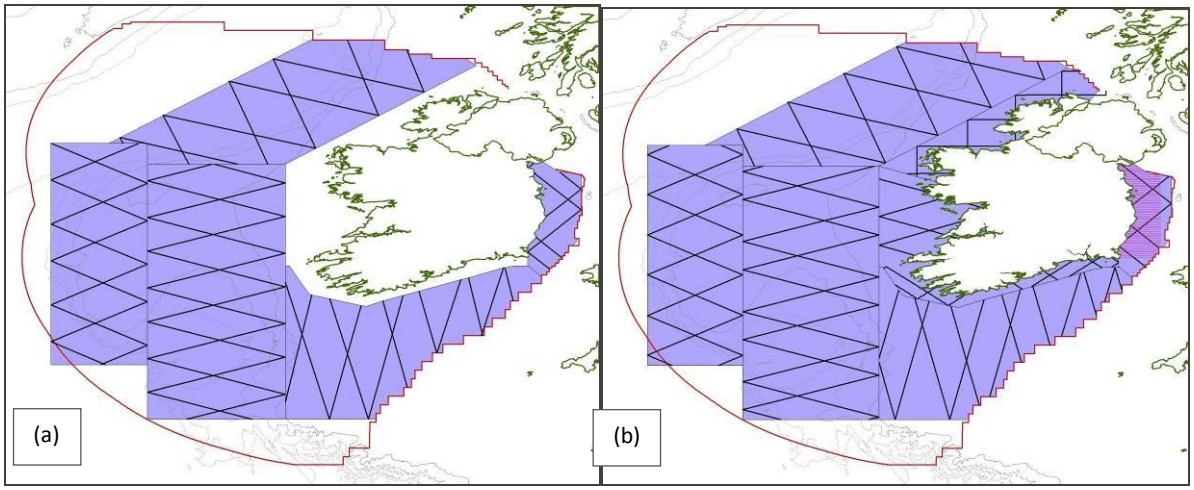


Figure 3a, b. Aerial line transect designs for implementation in (a) 2015 and (b) 2016 within the EEZ (red border).

While in-depth analyses are ongoing both Programme projects have been producing vital scientific results, the first of which are presented at Atlantic Ireland 2016. Final reports will be due in 2018.

Porcupine Basin Autonomous Acoustic Recorder (AAR) Cetacean Study – Results support planning for two 2016 seismic operations

Parry, G.[1]

[1]*Woodside Energy* *Email: Gareth.Parry@woodside.com.au*

Introduction

Woodside Energy (Ireland) Pty Ltd has been exploring in the Porcupine Basin since mid-2014 and is currently operator of four Frontier Exploration Licences (FELs 5/13, 3/14, 4/14 and 5/14) and one Licensing Option (LO 16/14).

Woodside's foundation business and main production facilities are located in North West of Western Australia. Over the past 50 years Woodside has built up a robust understanding of marine ecosystems in the area. This includes detailed baseline information on the distribution and abundance of marine mammals, which is used to underpin risk assessments for exploration, development and production activities.

There are 25 known species of whales and dolphins in the Irish EEZ. These are fully protected under EU and national legislation. While there have been a number of studies to establish baseline species richness and distribution it is generally acknowledged that further studies are needed to fill knowledge gaps.

With this in mind, ahead of planning offshore operations, in 2014 Joint Venture (JV) participants in FELs 5/13, 3/14, 4/14 and 5/14 funded a broadband Autonomous Acoustic Recorder (AAR) study in the Porcupine Basin (Figure 1). Three AARs were moored in the Porcupine Basin between May and September 2014 (summer period) to record ocean noise. These recordings were analysed to discriminate natural and anthropogenic noise in the Porcupine basin, and on the shelf break. Sources identified on the records included wind, ships, seismic surveys and biologicals.

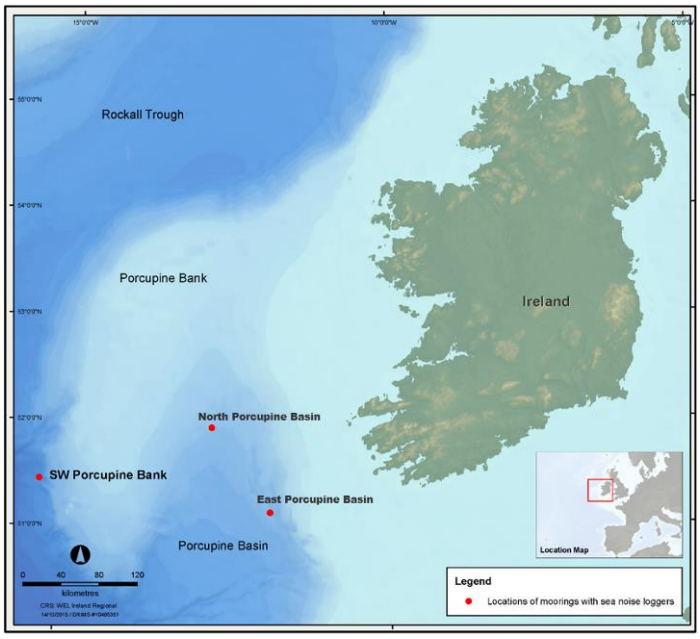


Figure 1: AARs mooring locations

Two marine seismic surveys named 'Granuaile' and 'Bréanann' were planned to be completed by Woodside in the 2016 northern hemisphere summer. The results from the 2014 AAR study were used to underpin marine mammal impact assessments for the seismic surveys and resulted in the adaptation of the seismic surveys to minimise the potential for interactions.

Results

While broadband ocean noise was recorded by the AARs analytical efforts focused on the detection and classification of marine mammal echolocation and communication noises. Signals for the following species/functional groups were identified during the deployment period:

- Fin Whales;
- Blue Whales;
- Humpback Whales;
- Sperm Whales;
- Dolphins; and
- Beaked Whales (aggregated for all species); and
- HF Echolocations

Calling from fin whales was common. Pulses were typically produced in groups of from one to nine, although individual animals could produce more on occasion and had variable time spacings before repeating another set of pulses. There was a slight indication of greater calling overnight time periods and after sunrise and before sunset but these trends were not significant. Fin whales were present across the full recoding period (including times of seismic surveys) at all sites but were highest at SW Porcupine Bank and East Porcupine and increased in call rates from mid-July (Table 1, Figure 2). The calculated number of calling individuals gave the maximum number of calling fin whales as three at each site and the median 1-2.

Blue whale calls were only detected at SW Porcupine Bank in comparatively low numbers (compared to fin whale calls). Detections of blue whales increased across the sampling period, from the first single detection in June to the greatest number of animals detected in August and September 2014. The maximum number of animals calling detected was two and the median one.

Dolphin whistles and a large number of toothed whale echolocation clicks (1.4 million) were found in the data. Clicks were differentiated into groups of: sperm whales, dolphin whistling; dolphin whistling plus low frequency echolocation clicks; tentative beaked whales and unknown high frequency echolocation clicks.

While sperm whales were detected at all sites, their presence decreased at North Porcupine through May, then was consistently less than half the presence compared with SW Porcupine Bank and East Porcupine. At SW Porcupine Bank and East Porcupine sperm whale presence increased through mid-July to September with an oscillating tendency. A median sperm whale calling bout lasted 1.7 hours with bouts separated by a median period of no calling of 12 hours. Many bouts of sperm whale calling also had correlating dolphin whistling, at North Porcupine 17% of samples with sperm whales also had dolphins present, this 32% at SW Porcupine Bank and 52% at East Porcupine. This suggested dolphins often followed sperm whales.

Tentative beaked whale clicks were rarely present and sporadic at North Porcupine but were common at SW Porcupine Bank (< 20% of time overall) with an increasing occurrence up to 40-60% of the time post late July. There appeared to be a 3-10 day periodicity in tentative beaked whale click presence at SW Porcupine Bank and East Porcupine. There was a general trend for an increase of sperm whale, beaked whale, smaller toothed whale and HF clicks post late July at SW Porcupine Bank and East Porcupine. All toothed whale categories had oscillating trends in presence, with periodicity in the 3-15 day period.

No minke, humpback or sei whales vocalisations were detected during the study. The period sampled was not when humpback whales were expected in the area so the lack of humpback detections was as expected.

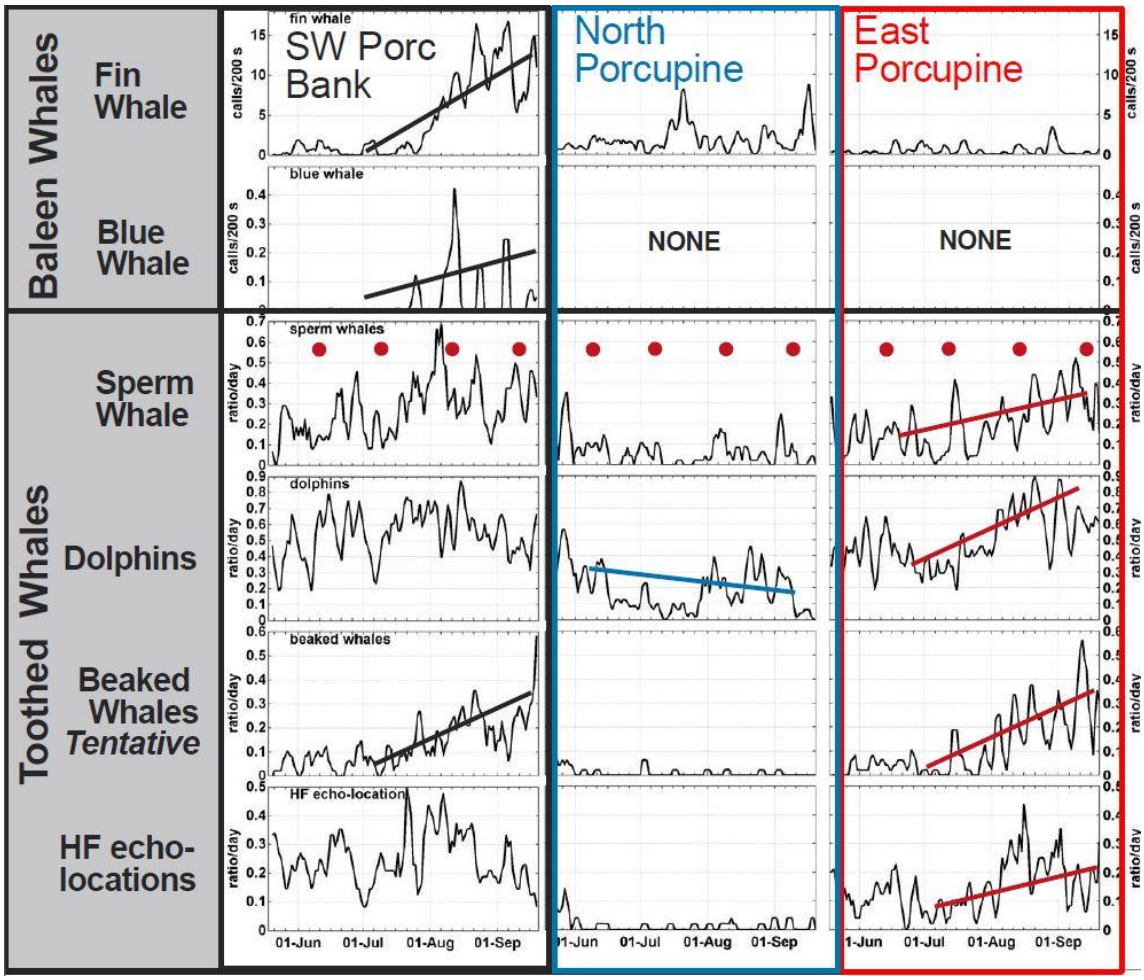


Figure 2. Call frequency by species or functional group by site

A summary of call frequency by species or functional group is shown in Table 2. There is a general trend of increasing call frequency later in the summer/early autumn for several species (fin, beaked and blue whales) in the south Porcupine.

Location	Fin Whales	Blue Whales	Dolphins	Sperm Whales	Beak Whales *(Tentative)*	Minke, Humpback and Sei whales
Northern Porcupine Basin	Moderate – with two small peaks during study	No recorded vocalisations	Low – higher in Aug/ Sept	Low – periodicity in abundance	Low – intermittent during deployment	No signals detected
East Porcupine Basin	Low – no seasonality	No recorded vocalisations	High – higher in Aug/ Sept	Moderate – periodicity in abundance	Moderate – some increase in Aug/ Sept	No signals detected
Southwest Porcupine Bank	High – major increase during Aug/ Sept	High – more in Aug/ Sept	High – higher in Aug/ Sept	High – periodicity in abundance	Moderate – some increase in Aug/Sept	No signals detected

Table 1. Summary of findings for each monitoring site

Seismic Survey Planning

Woodside began planning two marine seismic surveys (MSS) in early November 2015. These surveys, named Granuaile and Bréanann, were designed to cover areas in the southeast and northern areas of the Porcupine Basin, over a Licensing Option bid (now LO 16/14) and FELs 5/14 and 3/14 respectively.

Under the Department of Communications, Energy and Natural Resources (DCENR) Rules and Procedures MSS proponents are required to complete impact assessment screening, including assessment of the potential for interactions between the MSS and marine mammals. This impact assessment is split into two parts. Firstly, a description of the receiving environment and planned MSS, and secondly an assessment of the potential for interaction between the MSS and the receiving environment. Mitigation measures are adopted in the second part to effectively minimise the level of interaction. As the most effective form of mitigation, operators and regulators alike concentrate efforts on a demonstrable *avoidance* of potential interactions.

The 2014 AAR study conclusions provided significant support for both the definition of the receiving environment and demonstrable avoidance measures in the MSS impact assessment. In particular the AAR study conclusions supported phasing the surveys to demonstrate avoidance of relatively busier times for cetaceans, particularly fin whales, in the southern Porcupine Basin. The Granuaile MSS was fast-tracked and prioritised based on this, and several other conclusions, commenced in late May and was completed by 18 June, thereby avoiding the relatively more sensitive period in late summer/early Autumn.

The AAR study also showed clear patterns in overall activity levels at each of the sites, with the SW Porcupine Bank site having the highest levels of call frequency, across detected species, followed by the East then North Porcupine. It is expected that this 2014 study will complement general spatial and temporal distribution conclusions from the DCENR-DAHG ObSERVE programme which will in turn support future MSS planning and impact assessments.

References

McCauley, R. D. Offshore Irish noise logger program (March to September 2014): analysis of cetacean presence, and ambient and anthropogenic noise sources. A report produced for the Woodside JV in FELs 3/14, 4/14 and 5/14


A New Energy
Nexen is an exploration and production (E&P) company that responsibly explores for and produces oil and gas in Western Canada, the United States, the UK North Sea and offshore West Africa.
A wholly-owned subsidiary of CNOOC Limited, Nexen is truly global with unique opportunities for cross-cultural collaboration and growth.
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STANDS (in alphabetical order)

AGR Stand

Global service company AGR is focused on the needs of its customers in the upstream Oil and Gas sector, delivering Well Engineering and Construction, Reservoir and Subsurface Management, Consultancy Services, bespoke Software Solutions and Training.

From frontier exploration and appraisal, development and production to late life asset development and finally field abandonment and decommissioning, AGR delivers tailored solutions throughout the life cycle, through value-added performance and operational safety.

With offices in all major petroleum provinces, AGR clients benefit from its impressive track record:

- No major HSEQ incidents/accidents
- More than 500 well projects spanning six continents
- 80 remote operations including, base set-up, equipment and personnel mobilisation and supply chain provision; Barents Sea to the Falkland Islands
- Over 70 wells deeper than 15,000 ft (4,572 m)
- Over 60 HPHT wells
- More than 1,000 reservoir studies in only five years
- 3,000 consultants placed in 100 locations through our Consultancy division
- Over 25,000 people trained in 45 countries
- Software products developed in collaboration with end users allowing significant operational cost reductions.

AGR is the leading global independent Well Management & Reservoir Management Company.

For enquiries please contact Nick Chilcott, *nick.chilcott@agr.com*, 01224 629000.

AQUAFACT Stand

AQUAFACT has since its foundation in 1986 been directly and indirectly involved with many environmental aspects of both the National and International Oil and Gas industry. From the early days of the exploration of appraisal wells in the deep sea (>2000m) off the west coast of Ireland in the 1990s to the current established Shell site off the north west of Ireland, AQUAFACT has been to the forefront of hydrographic, environmental and monitoring studies. In addition to an in-depth knowledge of the Irish marine environment, AQUAFACT has developed innovative technologies to look at specific aspects of the seafloor in the vicinity of drilling activities. AQUAFACT is a listed supplier to the Achilles Procurement Group for the Oil and Gas Industry.

AQUAFACT has co-authored three of the four IOSEAs for Oil and Gas Activity in Irish Waters and as a result is very familiar with the procedures involved in the licensing of exploratory wells and the European and Irish legislation and guidelines that must be taken account of. AQUAFACT was involved in compiling the Impact Assessment for Exploration & Appraisal Drilling Activities in the three IOSEAs. This included examining the impacts from noise, discharges of drill cuttings and disturbance to the seabed, atmospheric emissions, physical presence and accidental events.

Internationally, the company has worked in the North Sea, The Arctic Sea, off the coasts of Angola and Nigeria, of Guyana, in Namibia, in a number of Gulf States, off the Californian coast, in Western Canada and in the Barents Sea.

AQUAFACT International Services Ltd., Kilkerrin Park, Galway – marine ecological consultants. *info@aquafact.ie*

AzEire Petroleum Stand

AzEire Petroleum is an Oil & Gas Exploration company focused on offshore Ireland. AzEire has a number of exploration acreage positions in the Porcupine Basin, offshore the west coast of the Republic of Ireland.

AzEire is actively focused on the extensive use of advanced seismic data and other geoscience processes and de-risking technologies ahead of drilling high-impact oil & gas exploration wells. AzEire has been active offshore Ireland since 2013 and the company is currently advancing held acreage toward potential exploration drilling in c. 2018. AzEire is actively pursuing new projects across the Irish offshore.

AzEire is part of a group of companies owned by Seacrest Capital Group that together have over 50 offshore exploration and production projects across the world. In addition to Ireland, the group is active in UK, Norway, Brazil, Namibia and Indonesia. Together, these companies have a staff in excess of 80 people, providing experienced and specialist capabilities across the group.

Seacrest Capital Group is leading energy investor specialising in offshore oil & gas investments. Seacrest levers its proprietary assets and partnerships to manage a diversified, global portfolio of regionally focused oil and gas exploration, development and production companies.

AzEire is led by Managing Director David Sturt with a team of senior explorationists who have been involved in numerous offshore discoveries and have over 150 years of collective worldwide oil and gas exploration experience. The Team have diverse energy operating backgrounds with companies that include, among others, Amerada Hess, BP plc, ConocoPhillips, PetroKazakhstan, Ukrnafta, Schlumberger, Petroleum Geo-Services, Chevron and Royal Dutch Shell plc. AzEire is privately owned and has offices in Bermuda and London.

Beicip-Franlab Stand

We are a leading independent petroleum consultancy firm and geoscience software editor highly reputed for technical quality, reliability and competitiveness. For more than half a century, we have been providing best-in-class consultancy and software solutions in exploration, reservoir and field development, production optimisation, process optimisation, midstream-downstream studies. We have leading edge Enhanced Oil Recovery solutions and extensive experience with unconventional hydrocarbon resources assessment and development (shale and tight reservoirs).

We help our clients discover new oil and gas reserves, optimise the development of their oil and gas fields and optimise their upstream and downstream portfolio. Our expertise is available through consulting services, software solutions, technical assistance and advisory services. In order to optimise synergies with your teams, we have developed international branch offices in more than ten countries, and continue to open new international branches. Since our creation in the mid-1960s, we have been operating in more than 100 different countries. We are currently active in most oil and gas provinces across the globe.

We provide our customers with optimal, innovative, value-adding consultancy and software solutions. Whatever your needs (acquisition of proven, effective software solutions, technical consulting and advisory services), Beicip-Franlab is your partner of choice in a large variety of domains:

Oil and Gas Exploration from regional to prospect scale (conventional and non-conventional hydrocarbons) Oil and gas field development and production optimisation, from marginal fields to super giant fields and non-conventional reserves, Midstream-Downstream decision optimisation.

BGS Stand

The British Geological Survey (BGS) is a component part of the Natural Environment Research Council (NERC), with a UK-wide remit as the research body for strategic and applied research and monitoring in the environmental sciences. It advises the UK government on all aspects of geosciences, and provides impartial geological advice to industry, academia and the public. It was founded in 1835 and is the world's longest established national geological survey.

The BGS carries out research in strategically important areas including energy and natural resources, vulnerability to environmental change and hazards, and earth system science, often in collaboration with the national and international scientific community. BGS maintains stable data archives and develops understanding of earth sciences to improve policy making, enhance national wealth and reduce risk.

The BGS undertakes surveying, modelling, research and environmental and geological monitoring to deliver UK and NERC science objectives. It also works overseas, where it plays an important role in building geological infrastructure and capacity in developing countries.

The BGS has a long and successful track record of independent evaluation of hydrocarbon potential and associated data management and training for many parts of the world. The BGS has worked closely with United Kingdom authorities for more than 30 years providing an independent assessment of the UK hydrocarbon potential, onshore and offshore. In parallel with this work, the BGS has undertaken many projects with international governments and the oil industry both in the UK and overseas. International projects have been completed in South West Africa (including Namibia and Angola), the Falkland Islands, South America (Venezuela and Trinidad & Tobago), Papua New Guinea, the Former Soviet Union, Ireland, India, the Middle East and Indonesia. BGS has a team of petroleum database specialists and petroleum geologists and geophysicists supported by state-of-the art seismic interpretation and display equipment, and a thriving research programme.

The Survey has world leading carbon storage scientists with extensive experience in advising regulators; developing techniques for monitoring, measuring and verification of carbon storage and storage assessment. The Team have worked on numerous European Commission projects since the 1990s with international partners. BGS undertakes applied research on geothermal energy, providing site specific feasibility and UK wide studies for clients dependent on requirements. For shallower sources, BGS provides engineering geology reports, advice, modelling and assessment of the sustainability of site specific heat sources as well as UK national digital data.

CGG Stand

CGG (www.cgg.com) is a fully integrated Geoscience company providing leading geological, geophysical and reservoir capabilities to its broad base of customers primarily from the global oil and gas industry. Through its three complementary businesses of Equipment, Acquisition and Geology, Geophysics & Reservoir (GGR), CGG brings value across all aspects of natural resource exploration and exploitation.

CGG employs around 6,500 people around the world, all with a Passion for Geoscience and working together to deliver the best solutions to its customers.

CGG is listed on the Euronext Paris SA (ISIN: 0000120164) and the New York Stock Exchange (in the form of American Depositary Shares. NYSE: CGG).

Commissioner of Irish Lights Stand

Irish Lights is a maritime organisation delivering an essential safety service around the coast of Ireland, protecting the marine environment, and supporting the marine industry and coastal communities. In recent years Irish Lights has transformed how they deliver their services, putting the emphasis on efficiency, cost-effectiveness and sustainability, while exploiting new technology and new opportunities wherever possible.

As the general lighthouse authority for the island of Ireland, Irish Lights is responsible for providing marine aids to navigation (AtoN) under the Safety of Life at Sea (SOLAS) convention.

The Irish Lights Vessel; *ILV Granuaile* is a versatile Class 1, 80-metre, DP vessel that serves Irish Lights' Aids to Navigation management and maintenance programme – and it is also available for hire.

Address: Commissioners of Irish Lights, Harbour Road, Dun Laoghaire, Co. Dublin, Ireland, A96 H500

Phone: + 353 1 271 5400

Email: *info@irishlights.ie*

www.irishlights.ie

Donegal County Council Stand

Killybegs Harbour

Donegal County Council's stand promotes the facilities available to the offshore oil industry from the deep water port of Killybegs. Killybegs is a modern, vibrant, avant-garde harbour operation, located on the northwest coast of Ireland and is very well placed for servicing offshore energy exploration along Ireland's west coast and Europe's western approaches.

Killybegs has a deep-water, all-weather natural harbour. The experience of many local contractors in the offshore industry, coupled with the excellent engineering expertise has enabled Killybegs to develop as the major port for all energy industries on the west coast of Ireland. The town has a proud maritime heritage, which was developed initially as a fishing port. Since 1997, it has played a pivotal role in facilitating offshore exploration, and in particular the development of the Corrib gas field. The seasonal nature of both fishing and oil and gas industries are very complimentary to each other ensuring facilities for all. It is also the port of choice for wind-farm developers, with importation of wind turbines for delivery throughout the county. Companies such as Shell E&P, Statoil, Lundin, Serica / AGR, Eni, DOF Subsea,

Allseas, Technip, Van Oord, CTC Marine, BGP, PGS, Seabird Exploration, CGG, Fugro, Enercon, Nordex, Gamesa, GE Wind Energy, Siemens, Vestas and Wavebob have all availed of the services of Killybegs port.

Donegal Airport

Donegal Airport located within close proximity at Carrickfinn (CFN) has been the airport / heliport for offshore oil and gas industry for many of the major oil companies. Helicopters are based at the airport and fixed-wing charters operate to/from Aberdeen. Other airport services include SAR services, air corps, private charters and general aviation.

Cruise Ships

Finally, Killybegs is also an ideal deep water harbour for the accommodation of cruise ships from various locations dotted throughout the world. A warm welcome is ensured by the able staff of Killybegs Information Centre and visitors are afforded the opportunity to partake in a broad range of local outdoor activities, attractions and entertainment.

DownUnder GeoSolutions Stand

DownUnder GeoSolutions (DUG) is an innovative geosciences company with a diverse range of capabilities. Our products are at the cutting edge of exploration and production services to the global oil and gas industry. One of our major strengths is the integrated approach we offer our clients across the breadth of our services. Our unique, comprehensive workflows have proven time and time again to succeed in getting results for clients where others have failed.

- Illumination Studies
- Seismic Processing
- Full Waveform Inversion (FWI)
- Depth Imaging
- Petrophysics
- Quantitative Interpretation
- Geostatistical Depth Conversion
- DUG Software

The key to DUG's success is our people. We have managed to put together an enviable team of highly experienced professionals. Our team has experience and expertise working on projects the world over.

Whilst we are a 100% Australian-owned company, we are truly a global enterprise. We have offices in Perth, London, Houston, Kuala Lumpur and Jakarta. Find out more at www.dug.com

Europa Oil & Gas Stand

Europa has been active in exploration in Ireland's Atlantic basins since 2011 and has grown to become a leading operator. We are ranked top for net operated area under licence (5,818 km2), equal top for number of operated licences (seven) and we were awarded more licences in the 2015 Atlantic Margin licensing round than any other operator (five).

Prospect Wilde in FEL 3/13 is a drill ready Cretaceous fan prospect with gross mean un-risked prospective resources of 428 mmboe and 1 in 5.3 chance of success. Drill costs are estimated to be US$ 37 million excluding mob and demob.

Europa is working to mature more leads and prospects across the whole portfolio to drill ready status. This is likely to include pre-rift targets in the South Porcupine basin in FEL 2/13 and LO 16/2, Cretaceous fan targets in LO 16/19 and also in the South Porcupine, Triassic gas targets in the vicinity of the Corrib gas field in LO 16/20 and LO 16/21, and finally pre-rift targets in LO 16/22 in the Padraig basin.

With exposure to a variety of basins, plays, risks and operating environments Europa has a diversified Irish Atlantic portfolio and will be well placed to benefit from the growing momentum in exploration activity in the Atlantic Ireland.

Europa has net production of 123 boepd from onshore UK, with a further net 150 bopd in development and with a portfolio of exploration, appraisal and field redevelopment targets also in onshore UK.

For further information: visit our stand at the conference

mail@europaoil.com

+44 20 7224 3770

Exceed Stand

Exceed specialises in delivering well management and performance improvement solutions for the upstream Oil & Gas industry.

We operate globally, supporting client projects across the entire well lifecycle - from concept to completion, intervention, workover and end-of-life decommissioning.

Safely delivering results across the entire well lifecycle

- Well management
- Well Intervention
- Well Decommissioning
- Performance Improvement
- iVision

Faroe Petroleum Stand

Faroe Petroleum ('Faroe') has, through successive licence applications and acquisitions, built a substantial and diversified portfolio of exploration, appraisal, development and production assets in Norway, the UK and Ireland.

Faroe Petroleum is an experienced licence operator having operated several exploration wells successfully in Norway and the UK and is also the production operator of the Schooner and Ketch gas fields in the U.K. Southern Gas Basin. Faroe recently applied to be operator of two producing fields in Norway, Trym and Oselvar, which the Company has agreed to acquire from DONG Energy. Faroe also has extensive experience working with major and independent oil companies both in Norway and in the UK.

Faroe's substantial licence portfolio provides a considerable spread of risk and reward. Faroe has an active E&A drilling programme and has interests in five principal producing oil and gas fields in the UK and Norway, including the Schooner and Ketch gas fields and the Blane oil field in the UK, and interests in the Brage and Ringhorne East fields in Norway. Full year average production for 2016 is estimated to be between 7,000 boepd and 9,000 boepd. In July 2016 Faroe announced the acquisition of a package of Norwegian producing assets from DONG Energy including interests in the Ula, Tambar, Oselvar and Trym fields which together produced just under 10,000 boepd in the first four months of 2016.

In November 2013 and March 2014 Faroe announced the Snilehorn and Pil discoveries in the Norwegian Sea in close proximity to the Njord and Hyme fields. More recently, in July 2016 Faroe announced the Brasse discovery next to the Brage field in Norway.

Norway operates a tax efficient system which incentivises exploration, through reimbursement of 78% of costs in the subsequent year. Faroe has built an extensive portfolio of high potential exploration licences in Norway which, together with its established UK North Sea positions provides the majority of prospects targeted by the Faroe's sustainable exploration drilling programme.

Faroe Petroleum is quoted on the AIM Market of London Stock Exchange. Faroe is funded from cash reserves and cash flow, and has access to a $200 million reserve base lending facility, with a fully funded committed drilling programme through 2016. Faroe has a highly experienced technical team who are leaders in the areas of seismic and geological interpretation, reservoir engineering and field development, focused on creating exceptional value for its shareholders.

GSI Stand

The Geological Survey Ireland was established in 1845. Since then it has evolved to become Ireland's national geoscience agency and knowledge centre providing geological data, advice and information.

A division of the Department of Communications, Climate Action and Environment; the Geological Survey carries out field mapping programmes as well as compilation and interpretation of geological data gathered throughout Ireland. The Geological Survey contributes towards the sustainable development of Earth resources and the protection of our environment, leading to better land use and planning decisions. It also provides an increased appreciation and awareness of geology, geological processes and the role they play in influencing and enhancing our everyday lives. The Survey's vision is to:

1. Support sustainable development of Ireland's natural resources
2. Provide reliable geoscience support for environmental protection and effective spatial planning

3. Complete geological surveys and mapping in priority areas in response to the needs of specific sectors and customers

4. Support the knowledge economy through the provision of access to geoscience databases and supporting business development, priority research and education services.

This vision is reflected in the new Research Roadmap, which underpins each of these goals through supporting the development of new knowledge and improving our understanding of the natural world.

As the national geoscience knowledge centre, the Geological Survey provides a range of support services and specific products across all of its operational thematic programmes. These include: Marine mapping, Land mapping, Groundwater, Minerals, Geotechnical, Geological Heritage and Geohazards. An ever-growing store of Earth-science information comprising an extensive library, cartographic information and reports, physical materials and digital databases are maintained at our offices in the Beggars Bush, Dublin.

All Geological Survey datasets are freely available online via www.gsi.ie

Key points of interest to Atlantic Ireland attendees are; the seabed mapping programme INFOMAR – a collaboration with the Marine Institute; the new tectenostratigraphic atlas and database of the North East Atlantic – a collaboration with partners from North Atlantic Geological Surveys; the Tellus project, a national airborne geophysics and ground geochemistry initiative.

iCRAG Stand

Established in 2015, iCRAG is the national geosciences research centre, bringing together expertise from seven major institutes: University College Dublin, Trinity College Dublin, Dublin Institute for Advanced Studies, University College Cork, National University of Ireland Galway, Maynooth University and Teagasc. Comprising 150 researchers, and collaborating with more than 50 industry partners, iCRAG's principal aim is to ensure research results are, insofar as possible, embedded within industry. In this way, the Centre ensures maximum impact of its research output; both scientifically for the wider geosciences and economically for the island of Ireland.

iCRAG is structured around four major research fields – raw materials, marine geoscience, groundwater and hydrocarbons. Each of these areas is further supported by four research platforms in the areas of geophysics, geochemistry, 3D modelling of the subsurface of Ireland, and the public perception and understanding of geosciences. The Centre is dedicated to facilitating a collaborative environment, allowing for the invaluable cross-fertilisation of ideas between disciplines.

Collectively, iCRAG research will help to unlock Ireland's natural resources through developing improved technical knowledge and innovative techniques, which will then increase the success rate of hydrocarbon, mineral and groundwater exploration. This will, in turn, stimulate and incentivise greater investment in Irish exploration, providing commensurate improvement in Ireland's potential to discover and develop offshore oil and gas resources, and onshore mineral wealth and groundwater supplies. Security of supply of clean water and energy, which together with the enhanced educational and training environment and improved geosciences information that iCRAG will provide, will be the principal societal benefits of iCRAG work.

iCRAG is funded by Science Foundation Ireland, the European Regional Development Fund and industry partners from the applied geosciences sector. With a total funding of €26 million from 2015 to 2020, it represents the largest investment by the State in applied geosciences in Ireland.

IHS Markit Stand

IHS and Markit combined in July 2016 to create a unique global information powerhouse covering Energy, Chemicals, Security/Risk, Transport and Finance.

IHS Markit is the data release agent for Ireland's Department of Communications, Climate Action and Environment. As such IHS Markit provides **released Irish 2D/3D seismic surveys and well data**, to exploration companies. All data is provided in a consistent workstation ready format. Where only plots are available, IHS Markit reconstructs to a SEG-Y format. IHS Markit also provides well attributes including core headers and analyses, directional surveys, and checkshot surveys.

IHS Markit also supplies the international oil industry with **Kingdom** Software for interpretation of logs and seismic and prospect generation. Renowned for its ease of use, IHS Kingdom provides geoscientists with a breadth of functionality for both quick-look and in-depth geophysical and geological data interpretation, resulting in faster interpretation and modelling, simplified sharing of complex data, more confident decision making and value.

Our researchers and editors draw on their broad industry experience, extensive connections, and deep technical understanding to deliver global coverage unmatched by any competitor. This expertise enables IHS Markit's industry-leading products **EDIN** and **GEPS** to provide customers with access to E&P and midstream content, regional reports, and industry briefings. IHS Markit also track worldwide shipping and oil flows (IHS Maritime and Trade), rig availability and seismic surveys (IHS Petrodata).

IHS Markit provides **QUE$TOR** infrastructure cost estimation software which enables rapid evaluation of costs of rigs/pipelines based on a continually updated labour/materials cost database. IHS **Vantage** supports complex strategic planning, making it possible to rapidly, accurately and consistently value more than 13,000 global assets.

For more information on our subsurface data, energy information or software contact *emea.energy@ihs.com* or call +44 (0) 1344 328155

Lloyd's Register Stand

Lloyd's Register applies its expert knowledge and independence to help clients across the Energy industry design, construct and operate their capital intensive assets and businesses to their highest levels of safety and performance. Our world class expertise allows us to resolve and share solutions to the most complex situations, providing the confidence demanded by engineering principles, government regulations and industry codes and standards. We draw on a long heritage of fresh, innovative thinking in response to new technologies and challenges. The one consistent element is our commitment to independence, integrity and always doing the right thing.

Marine Institute 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 Research Vessel Operations section of the Marine Institute operates two Research/ Survey vessels, the 65 m RV Celtic Explorer and the 31 Meter RV Celtic Voyager. The Institute also operates a 3000m

rated work class ROV. The vessels and ROV are available for use by both Government agencies, academia and commercial organisations.

The Marine Institute has provided a range of turnkey survey services to the oil and gas industry utilising both vessels over the past ten years including Analogue and HR digital site surveys, Acoustic Pipeline inspection surveys, ROV Pipeline and cable surveys, Pipeline route surveys, Geotechnical surveys and environmental surveys.

The RV Celtic Explorer is undergoing a major refit in 2015 which includes the installation of a 6000m rated deepwater Multibeam system (EM302), a high resolution multibeam (EM2040) and a deep water sub bottom profiler. This increased vessel capability together with its deepwater ROV and deepwater USBL system allows the RV Celtic Explorer to offer unique capability to operators operating in the deeper Irish Offshore. The vessel is routinely mobilised with seismic equipment to allow the acquisition of Digital and Analogue site surveys.

The 31m RV Celtic Voyager has recently been upgraded with a Kongsberg EM 2040 multibeam system which has greatly increased its capability for seabed mapping. The vessel is frequently used for analogue and environmental site surveys in Irish waters.

The deepwater workclass ROV “Holland 1” can be configured with a full suite of equipment for pipeline inspection surveys. The system most recently completed a 150 km pipeline survey and jacket survey in the Celtic sea.

The Marine Institute advanced mapping section is a partner with GSI in the INFOMAR program which aims to map the remaining unmapped 13% of the Irish territorial seafloor, concentrating on specific areas of interest such as priority bays and areas of biological interest.

For further information please contact:

Aodhán Fitzgerald

afitzgerald@marine.ie

www.marine.ie

Merlin Energy Stand

Merlin Energy is a geoscience consultancy with global reach, working across the full exploration and production life cycle. Our prime focus is providing value through the application of high class geoscience to the delivery of oil and gas projects. Our Merlin Datawise division offers data storage and management solutions. Merlin provides a highly personalised service to clients, who trust us to deliver a bespoke solution, whatever their needs. Through a teaming agreement with Belltree we also provide an integrated geoscience and engineering solution for production assets, including the application for the ‘Locate the Remaining Oil’ workflow and recovery factor ‘Benchmarking’.

Newfoundland-Labrador (DNR) Stand

The Province of Newfoundland and Labrador, located on the east coast of North America, is Canada's offshore oil producing region. Since first oil nineteen years ago the province's four fields in the Jeanne d'Arc Basin; Hibernia, Terra Nova, White Rose and North Amethyst have produced in excess of 1.6 billion barrels of oil. Discovered reserves/resources now total ~ 4.0 billion barrels of oil and ~13 trillion cubic feet of natural gas.

Hebron, expected to be the province's fifth producing field, is currently under development. All of the topsides modules and components have been delivered to the Bull Arm Construction site for assembly and construction of the gravity base structure continues in the deep water area of the site. The field has estimated recoverable reserves of 707 million barrels and first oil is expected in 2017.

Further development is expected in the region as Statoil has announced new oil discoveries in the Flemish Pass Basin. While no assessment has been released on the size of the Harpoon, Bay du Nord, Bay de Verde and Baccalieu discoveries, Statoil has estimated that the Mizzen and Bay du Nord fields contain recoverable oil reserves between 400 and 800 million barrels.

A new Scheduled Land Tenure System was recently implemented for the province's offshore area. This system divides the offshore into eight regions and categorises them based on the level of historical exploration activity. Scheduled licensing rounds will be held in each region, on either a one, two or four year cycle. This new system provides additional time for explorers to evaluate the resource potential and opportunities in the lesser explored basins of the province. The Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) issued Calls for Bids in the Eastern Newfoundland (Flemish Pass and West Orphan basins) and Jeanne d'Arc Regions in April of this year. An independent resource assessment recently conducted by Beicip-Franlab on the nine parcels in West Orphan Basin has identified 25.5 billion barrels of oil and 20.6 trillion cubic feet of gas potential. The 2016 bid rounds closes on November 9, 2016.

ObSERVE Stand

In October, 2014, the Department of Communications, Energy and Natural Resources, in liaison with the Department of Arts, Heritage and the Gaeltacht (National Parks and Wildlife Service), established a significant data acquisition programme designed to acquire new baseline data, with the aim of filing existing data gaps with regard to protected marine species and sites in key offshore basins.

In consultation with NPWS, a programme of targeted acoustic and aerial surveys of Cetaceans and Seabirds in the Irish offshore was agreed. This programme has been given the title of ObSERVE.

Under the OBSERVE Programme, a total of eight (8) static (i.e., moored) and six towed acoustic surveys for cetaceans in selected Atlantic Margin waters between 2015 and 2016 will be undertaken. The study area broadly covers outer continental shelf, slope and deep oceanic waters stretching from the Hebrides Terrace to the Goban Spur and concentrated on about four key zones of interest.

The programme provides for both static and towed acoustic surveys to be carried out between the spring and autumn seasons with combined detailed coverage of two zones of interest to take place in each survey year, respectively. The core purpose of these surveys is to use acoustic sampling methods and a towed survey design of standard transect length to best describe animal occurrence, distribution, density and abundance (where possible, otherwise relative density/abundance) within the prescribed offshore area, based on the acoustic data acquired.

Under the OBSERVE Programme a series of four combined line-transect and strip-transect aerial surveys for cetaceans and seabirds, respectively, in Irish offshore waters will be undertaken. Each survey will be carried out within a prescribed season and so will comprise a single replicate coverage of the study area.

The aerial element of the programme is being led by University College Cork with partners Aerosotravia, IMARES, and ALNILAM and the acoustic element of the programme is led by the Galway-Mayo Institute of Technology (GMIT) in collaboration with the Marine Institute, Jasco Applied Science, SMRU Consulting and the Irish Whale and Dolphin Group.

Links to the websites for both the acoustic and aerial surveys have been registered at:

www.observe-acoustic.ie and *www.observe-aerial.ie*

PAD / DCCAE Stand

The role of Petroleum Affairs Division (PAD)

The core role of the Petroleum Affairs Division of the Department of Communications, Climate Action and Environment (DCCAE) is to develop and implement policies which have the aim of maximising the benefits to Ireland from exploration for, and production (E&P) of, Ireland's indigenous oil and gas resources, while ensuring that activities are conducted with due regard to their impact on the environment and other land/sea users.

DCCAE seeks to achieve this through a range of strategies which have the following key objectives:

- maximising the level of oil and gas exploration and production activities in Ireland with a view to optimising the return to the State.
- ensuring that the regulatory framework in place is robust, clear, promotes certainty and is in keeping with international best practice, while encouraging exploration, development and production activities to be carried out in an effective and timely manner.
- maximising the area of continental shelf under Irish jurisdiction.

In pursuing these strategies it is DCCAE's aim to achieve the twin objectives of contributing to ensuring Ireland's security of energy supply while providing a fair financial return to the State from its natural resources.

The Petroleum Affairs Division of DCCAE is responsible for promoting the opportunities for the private sector to invest in oil and gas E&P in Ireland and regulating such activity through its licensing terms and conditions. The Department actively promotes Ireland as an attractive location for international investment building on the outputs of applied research projects and focused interpretative reports, together with the release of basic geological, geophysical and well data to the industry.

DCCAE's regulatory approach is primarily focused on ensuring effective and timely exploration. The department seeks to achieve this by agreeing appropriate work programmes with operators and monitoring delivery of the work programmes to ensure that they are carried out in full and in accordance with best industry practice, having particular regard to the environment and other land/sea users.

The Integrated Petroleum Affairs System (IPAS) (www.pad.ie/ipas) provides access to information relating to authorisations, wells, potential field and seismic surveys using search screens or through map interface.

PGS Stand

PGS has a history of supporting exploration in the Irish offshore, including a regional 2D simultaneous Towed Streamer EM and GeoStreamer® MultiClient investment in 2013 and a large scale 3D GeoStreamer survey during 2016. The integration of GeoStreamer and resistivity data not only provides a competitive advantage in frontier de-risking and prospect screening as demonstrated in the Celtic Sea, but can also be applied on a reservoir level. Estimation of hydrocarbon saturation has application in drilling hazard identification as well as near field exploration and prospect delineation, extending the applicability of the technology from frontier exploration to appraisal and development activities, potentially saving oil companies the cost of a dry or misplaced well.

PGS is a dedicated marine geophysical company. Our business is technology driven and we provide a broad range of seismic, electromagnetic and reservoir services, including acquisition, imaging, interpretation and field evaluation.

The PGS MultiClient data library currently comprises more than 650,000 square kilometres of 3D data, almost 30% of which is GeoStreamer 3D data. In addition, PGS has over 475,000 line kilometres of 2D seismic, of which 60% is GeoStreamer data. www.pgs.com/data-library/

PGS has a presence in 19 countries with regional centres in London, Houston and Kuala Lumpur. Our headquarters are in Oslo, Norway and the PGS share is listed on the Oslo stock exchange (OSE:PGS).

PIP Stand

The Petroleum Infrastructure Programme (PIP) was set up by the Petroleum Affairs Division (PAD) of the Department of Communications, Climate Action and Environment (DCCAE) in 1997. The ISPSG Group, the successor to the joint industry Rockall Studies Group and Porcupine Studies Group, was set up 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.

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.

For further information on the Petroleum Infrastructure Programme, please visit the website - www.pip.ie

The ISPSG currently (October 2016) comprises: BP Exploration Operating Co Ltd, Cairn Energy Plc, Chevron North Sea Limited, ENI Ireland BV, Europa Oil & Gas Plc, ExxonMobil E&P Ireland (Offshore) Ltd, Kosmos Energy LLC, Maersk Oil North Sea UK Ltd, Nexen Petroleum UK Ltd, Petroleum Affairs Division of the Department of Communications, Climate Action and Environment, Providence Resources plc, Repsol Exploración SA, San Leon Energy Plc, Serica Energy Plc, Shell E&P Ireland Ltd, Sosina Exploration Ltd, Tullow Oil Plc and Woodside Energy (Ireland) Pty Ltd.

Polarcus Stand

Traditional towed streamer marine seismic acquisition has been stuck with the same old geometries for many years: two sources at the head of multiple streamers. When Polarcus undertook the Capreolus multi-client project on the North West Shelf of Western Australia, the area was sufficiently big enough to potentially require two conflicting survey designs in order to accommodate the different play types – one high-fold for the shallow water area and the other conventional fold with a long time record for the deep water area.

The solution proposed was to acquire data with overlapping shots, a concept that has been brewing within the industry for many years and was proved to work by the principal pre-funder of the Capreolus survey, Quadrant Energy, over a series of surveys acquired by them since 2011. Overlapping shots occur when sources are sending acoustic pulses more often, such that the energy from one source is visible on the recorded data of another - i.e. they overlap. This overlap noise needs to be removed or 'de-blended'. An advantage of this method is to increase the fold, and as data is recorded continuously, we dissociate the record length from the shot-point interval. By using overlapping sources, we thus solve the high-fold and long record length that was desired for Capreolus.

'Triple source' was an idea born in the nineties, but was not very successful as the data was difficult to process – the inline distance between shots made sub-surface line processing in the common receiver and 2D CMP domains difficult, with large trace spacing and low-fold respectively. Our Capreolus experience confirmed that the problem of maintaining adequate fold and long-time records could be solved by source de-blending. If we marry this solution with triple sources, we can mitigate the inherent weaknesses of using multiple sources. We call it Polarcus XArray™.

The benefits of XArray™ are extensive. It allows for the widening of the streamer separations to acquire the same cross-line bin size that one would obtain from a conventional dual source design, resulting in a significant increase of data per pass. In addition to this, we should also consider the reduced HSE exposure when acquiring data in such an efficient manner; there is simply less in-sea equipment that the crew have to handle. As a result, the small boat operations needed to maintain streamers – the most hazardous aspect of marine seismic – are reduced significantly.

Polarcus is an innovative marine geophysical company with a pioneering environmental agenda, delivering high-end towed streamer data acquisition and imaging services from pole-to-pole. www.polarcus.com

Providence Resources Stand

Since its formation, Providence has built the largest and most diversified portfolio of oil and gas exploration licences and concessions offshore Ireland. The Company's board and management have a well-established background in the Irish oil and gas upstream business and have worked closely with many major companies including ENI, Repsol, Petronas and Cairn.

Providence's oil and gas interests offshore Ireland comprise a portfolio of appraisal and exploration oil and gas assets.

We operate to a number of broad corporate strategic guidelines that have led us to the development of our current portfolio.

These guidelines may be summarised as follows:

- We are a front end E&P company, with a focus on early stage exploration and appraisal opportunities;
- We achieve a controlled and cost-effective expansion of our interests with a specific geographic focus on opportunities arising from our Irish interests;
- We engage in strategic relationships/partnerships with third parties on a project-by-project basis with a view to controlling financial and project risk without compromising standards; and
- We establish ourselves, where appropriate, as operator and project leader, particularly at the early stages, with a view to being in a position to ensure the cost-effectiveness of projects and observance of best practice.

PwC Stand

The energy industry contends with a great amount of uncertainty and risk, and yet companies have to focus on the future to ensure financial and operational success. At PwC, we study industry trends and issues closely, so that we can better understand the challenges that our clients face, and how we can best help them to achieve success.

The energy industry requires long lead times for new projects, and even though the current global economy is struggling, the world's population continues to grow. With this growth, energy demand will increase. Weighing the risks versus benefits of new projects, new products and how much capital to invest, energy companies also have to consider regulatory, safety and environmental concerns. Balancing the need to supply the world with hydrocarbons, companies are also looking at investments in alternative energy sources, including unconventional sources, biofuels, renewable energy sources, and ways to improve energy efficiency.

So at PwC, we are not only watching these developments in the industry, but we are analysing these changes from the perspective of how they will impact our clients, and how we can best help companies prepare and manage the changes. We examine the issues, and build teams of subject matter specialists who develop appropriate solutions through our assurance, tax and advisory services. Our experienced professionals are on the ground in 158 countries around the world contributing local insight and understanding.

For further information please visit our stand or our website at www.pwc.ie

RockWash Prep & Store Stand

RockWash Prep & Store Ltd provides the first digital documentation service for core and cuttings samples and advanced cuttings sample preparation through a purpose-built, consistent and controlled process.

PhotoSTRAT™ high resolution images deliver the ultimate 'type cuttings-sample record' for samples from exploration and development wells applicable to a wide range of exploration and production applications.

RockWash core and petrographic slide scanning services completes the digital documentation of exploration, appraisal and development well samples.

RPS Group Stand

RPS is a leading multidisciplinary consultancy providing services in Marine, Environment, Planning, Engineering, Project Management and Communications.

RPS provides comprehensive marine environmental services to the public and private sectors throughout Ireland and the EU. We help our clients to ensure their developments and activities are sustainable and fully compliant with environmental legislation and policy obligations.

Our services include strategic research to inform government policy development and the management of large multidisciplinary projects including oil and gas projects, port development, marine aggregate extraction, renewable energy, fisheries and aquaculture, coastal protection and flood defence.

Our multidisciplinary teams of ecologists, scientists and engineers deliver sensitive environmental projects from initial assessment through design, implementation, remediation and monitoring stages. We provide environmental impact assessments, strategic environmental assessments, ecological studies, monitoring and surveys to support exploration and development applications, licensing, permitting and other marine related requirements.

Contact: *Gareth.mceilhinney@rpsgroup.com*

Schlumberger Stand

Schlumberger (NYSE:SLB) is the world's leading supplier of technology, integrated project management and information solutions to customers working in the oil and gas industry worldwide. Employing approximately 105,000 people representing over 140 nationalities and working in more than 85 countries, Schlumberger provides the industry's widest range of products and services from exploration through production.

The company comprises two business segments:

Schlumberger supplies a wide range of products and services from formation evaluation through directional drilling, well cementing and stimulation, well completions and productivity to consulting, software, information management and IT infrastructure services that support core industry operational processes.

WesternGeco is the world's largest seismic company and provides advanced acquisition and data processing services.

Schlumberger has principal offices in Paris, Houston, London and The Hague. Schlumberger manages its business through 35 GeoMarket regions, which are grouped into geographic areas: North America, Latin America, Europe & Africa, Russia, Middle East and Asia. The GeoMarket structure offers

customers a single point of contact at the local level for field operations and brings together geographically focused teams to meet local needs and deliver customised solutions. Working together with the company's technology segments, the GeoMarkets provide a powerful conduit through which information and know-how flow to the customers, and through which Schlumberger engineers and geoscientists maximise technological synergies over the entire life of the field.

Schlumberger offers its clients four key advantages:

- Deep domain knowledge of exploration and production operations gained through more than 80 years of experience
- The service industry's longest commitment to technology and innovation through a network of 125 research and engineering technology centres
- A global reach in more than 85 countries coupled to strong local experience and the diversity in thought, background and knowledge that more than 140 nationalities bring
- A commitment to excellence in service delivery anytime, anywhere.

The company was founded by the two Schlumberger brothers who invented wireline logging as a technique for obtaining downhole data in oil and gas wells. Today, it continues to build on the industry's longest track record of providing leading edge E&P technology to develop new advancements - from reservoir to surface. Schlumberger has always invested significant time and money on research and engineering as a long-term strategy to support and grow its technology leadership. Short-term business cycles do not affect this. In 2014, we invested $1.21 billion in R&E for our oilfield activities. Schlumberger invests more each year in R&E than all other oilfield services companies combined.

Seabird Stand

SeaBird is a leading provider of long offset broadband 2D, niche shallow water 3D and source vessel solutions. The company concentrates on contract seismic surveys, but is also actively engaged in the multi-client sector.

SeaBird is uniquely positioned with its industry-leading health, safety, security, environment and quality (HSSEQ) culture and accreditations. Operational excellence ensures best-in-class performance. SeaBird’s focus on technological development ensures continuous service improvement.

Long offset acquisition and deep, slanted towing for improved imaging in the deep, is the company’s specialty from a multi-client perspective.

SeaBird is listed on the Oslo stock exchange. With headquarters in Oslo, the company has regional offices in Limassol, Singapore, Houston, Odessa and St. Petersburg.

SeaBird’s fleet utilises industry standard equipment, operated to the highest HSSEQ standards; accredited/certified to ISM / ISPS, OGP, ISO 9001, 14001 and OHSAS 18001.

SeaBird manages both Maritime and Seismic operations, providing for a unified crew and operation. Our in-house offshore Support department assists our field crews with every aspect of the operation.

For more details about SeaBird Exploration, please come visit us at our booth or take a look at our website: www.sbexp.com

Serica Energy Stand

Serica have three licences in the Irish Atlantic; **FEL 4/13** and **FEL 1/09** in the Rockall Basin, and **FEL 1/06** in the Slyne Basin, and is seeking a farminee or farminees to drill a well on one or more of the licences.

Licence FEL 4/13 is located to the west of the Dooish Discovery and contains a significant early Cretaceous stratigraphic target in the form of a turbidite fan (the **Derryveagh Prospect**) mapped on 3D seismic data at Albian level, onlapping the flanks of the underlying **Aghla More Prospect**. Both Derryveagh and Aghla More could be targeted with a single exploration well. Derryveagh carries a P_{50} recoverable resource of 1.3 tcf gas + 84 mmbbls condensate and Aghla More carries a P_{50} recoverable resource of 1.4 tcf gas + 94 mmbbls condensate.

Licence FEL 1/09 lies immediately to the north of Dooish, and contains the **Muckish Prospect**, a significant pre-rift tilted fault block structure mapped on 3D seismic data. The structure is analogous to Dooish, and by analogy, gas-condensate charged sandstone reservoirs of Permian to Middle Jurassic age are anticipated. Muckish carries a P_{50} recoverable resource of 1.3 tcf gas + 85 mmbbls condensate.

Licence FEL 1/06 is located in the Slyne Basin 40kms south of the Corrib Field. It contains the Bandon oil discovery, drilled by Serica in 2009, which encountered a 38m oil column within a high-quality early Jurassic sandstone reservoir. The **Boyne Prospect** is located in close proximity and is a clearly defined tilted fault block mapped on 3D seismic data, with reservoir potential at both Jurassic and Triassic levels. It carries a P_{50} recoverable resource of 116mmbo in the Jurassic and Triassic combined (Serica in-house estimates). The Boyne Prospect, which is located in water depths of around 230m, is ready to drill.

Seismic Image Processing Stand

At SIP we offer a strong combination of experience and unique eTechnology. Our team have decades of experience and significant strengths in marine and land processing, velocity modelling, depth imaging, seismic inversion, rock physics, interpretation, depth conversion and de-risking.

SIP wins repeat business and has service agreements with oil companies ranging from medium-size explorers to oil majors. We have experience of mature provinces and frontier environments and our experts can handle both single discipline and large integrated projects.

We are flexible and market-driven, and ensure we provide you with leading-edge technology to deliver a premium-quality service and remain your contractor of choice.

Imaging Services - Many of our clients recognise us as experts in depth imaging and accurate velocity model building. We receive many projects which have been previously processed by other contractors using conventional approaches. Very often our clients realise that the image derived is not optimum and disagrees with the geology. This could be due to an inaccurate velocity model and/or an inappropriate migration algorithm used.

Our unique technologies include AutoImager™ for simultaneous velocity estimation and imaging which overcomes the limitations of tomography-dependent velocity modelling. We have a track record of improving data using these methods and delivering the best possible results to our clients.

Reservoir Services - Our service encompasses rock physics, AVO and pre-stack seismic inversion. These tools can be tailored to resolve the particular geo-technical uncertainties facing your exploration play or field development.

Utilising a broad range of proprietary and industry techniques our specialists will apply their extensive worldwide expertise to optimise your data.

SIP will move your data from the seismic to the geologic domain. Seismic inversion creates volumes of rock property data in a layered pseudo-geological form. Rock physics analysis highlights the key methods that will target the geo-technical features under investigation. Impedance, porosity and net-to-gross can be derived and calibrated against wells. Water saturation volumes can indicate areas of un-swept hydrocarbons and assist in placement of future development wells.

Interpretation & De-risking - Interpretation of your data integrates our high resolution imaging and reservoir technologies into drillable prospects and development in-fill locations. Our experts have experience in mapping from Americas, UK, Libya, Middle East, Kazakhstan and India will work closely with you to define and develop your exploration/production license concepts and objectives.

Tenaris Stand

Tenaris is a leading supplier of tubes and related services for the world's energy industry and certain other industrial applications. Our mission is to deliver value to our customers through product development, manufacturing excellence, and supply chain management. We seek to minimise risk for our customers and help them reduce costs, increase flexibility and improve time-to-market.

Tenaris consists of a network of manufacturing facilities, R&D centres, service centres and commercial offices that spans the globe. We provide casing and tubing, line pipe and other mechanical and structural steel pipes for different applications. Our state-of-the-art manufacturing facilities have a production capacity of over six million tons per year.

We manufacture our steel pipe products in a wide range of specifications, under strict quality standards and complying with ISO 9001 requirements.

Tenaris employees around the world are committed to continuous improvement by sharing knowledge across a single global organisation.

Tenaris promotes the professional growth of its more than 20,000 employees worldwide through TenarisUniversity.

TGS Stand

TGS is the leading energy information company, providing geoscience data to the global energy industry. TGS' extensive geotechnical data library covers the full exploration cycle from geological well log data to 2D/3D seismic data and well performance data. TGS continues to add value to its data sets through seismic imaging services, geologic interpretation products, and data integration solutions.

UCD – Statoil Clare Core Display

A major behind-outcrop drilling campaign involving UCD and Statoil has now acquired over 1350 m of split PQ core from 12 boreholes behind the high sea cliffs in west Clare and north Kerry. The coring has targeted the Ross Sandstone Formation, a 500-m-thick Pennsylvanian deep-water fan system comprising nine high-frequency cycles of deposition forced by glacio-eustasy. The cores have been integrated with additional outcrop work and ammonoid biostratigraphy and used to build a new framework and understanding of the system architecture and evolution. The new subsurface data have high value as an

analogue dataset for use in training and reservoir characterisation. The ambition is to have selected cores available from next year in west Clare for use in both academic and industry courses.

The 24 m of core on display (from the pilot borehole at Fisherman's Point) capture some of the main elements of the uppermost Ross as seen in outcrop at the Bridges of Ross, a popular destination for the many geological trips visiting the Loop Head area. Key features include a variety of different bed types (both conventional turbidites and hybrid event beds), a channel complex and basal erosion surface, the Ross Slump that reworks a condensed section, and a series of sheet sandstones (lobe elements) beneath the slump.

Woodside Stand

Woodside is an Australian oil and gas company with a global presence, recognised for its world-class capabilities – as an explorer, a developer, a producer and a supplier.

Woodside's mission is to deliver superior shareholder returns through realising our vision of becoming a global leader in upstream oil and gas.

Our proven track record and distinctive capabilities are underpinned by 60 years of experience, making us a partner of choice. We operate 8% of global LNG supply and our assets are renowned for their safety, reliability and efficiency,

Our producing assets in Australia include the landmark North West Shelf (NWS) Project, which has been operating since 1984. In 2012, we commenced production from the Pluto LNG Plant and we will add additional volumes from our non-operated Wheatstone LNG interests in mid-2017. We also operate a fleet of floating production storage and offloading (FPSO) facilities. In mid-2019, we will add additional oil production from the Greater Enfield Project via our existing Ngujima-Yin FPSO vessel.

Woodside's global exploration portfolio includes emerging and frontier provinces in Australia and the Asia-Pacific region, the Atlantic Margins, Sub-Saharan Africa and Latin America. We also have significant equity interests in high-quality development opportunities in Australia (Browse), Canada (Kitimat) and Myanmar and are pursuing new concepts, technology and contracting strategies to enable the earliest commercialisation of these resources.

Woodside continues to expand our capabilities in marketing, trading and shipping and have enduring relationships that span more than 25 years with foundation customers throughout the Asia-Pacific region.

We believe that technology and innovation are essential to bringing down costs and unlocking future growth. Today, we are pioneering remote support and the application of artificial intelligence and advanced analytics in our operations. We recognise that long-term meaningful relationships with communities are fundamental to maintaining our licence to operate, and we work to build mutually beneficial relationships.

Woodside is characterised by strong safety and environmental performance in all locations where we are active and we are committed to upholding our values of integrity, respect, working sustainably, discipline, excellence and working together.

Woodside is the operator of four Frontier Exploration Licences (FELs) and a Licencing Option (LO) 16/14 in Ireland's Porcupine Basin between 150 and 200 km west of the Shannon Estuary.

The FELs are operated on behalf of three separate Joint Venture (JV) participants. Woodside is the operator of LO 16/14. In 2016 Woodside acquired approximately 4,000 km^2 of proprietary 3D seismic data over FELs 3/14, 5/14 and LO 16/14.

X-ray Mineral Services Stand

X-ray Mineral Services Ltd is an independent company established in 1997 to provide high quality X-ray Diffraction (XRD) and X-ray Fluorescence (XRF) analytical services. We maintain a fully equipped laboratory in the UK and offer confidential, comprehensive and efficient XRD and XRF analyses at a competitive price using fully trained and experienced personnel.

The company has expanded rapidly over the last 19 years and now provides exclusive analytical services to a substantial number of petroleum service companies and oil companies. Geographical experience over this period has included projects from numerous global areas of petroleum exploration and production.

Our laboratory is equipped with the most advanced analytical techniques which include a 'Spray Drier' for preparation of XRD bulk-rock powders, together with innovative interpretation software including 'Search-Match' with PDF-4 (Minerals) ICDD database and 'Siroquant' (Quantitative phase analysis).

Zenith Energy Stand

Zenith Energy has grown to be one of the leading Well Engineering and Project Management Providers.

We are an independent company, owned and managed by Engineers, with a core team behind us that are experienced and respected within the Industry. Our multidiscipline team include Drilling Managers, Well Team Leaders, Senior Drilling Engineers and Drilling Engineers whom are all based together at our Aberdeen office.

Zenith and our staff bring their vast experience and skills to every project we are involved in. Our personnel have experience with operations on land rigs, jack-ups, semi submersibles and drill ships globally. We have experience in various drilling conditions including HPHT, ERD, TTRD, Deepwater and horizontal wells.

Over 24 UK and International operators benefit from the knowledge and experience of our specialist engineers and industry experts who provide significant value to projects of all sizes.

Zenith Energy is a member of Achilles First Point Assessment (FPAL) and committed to health, safety, environment and quality through our HSEQ Management System which is certified to ISO 14001:2015 and 9001:2008 accreditation.

"We are a totally independent company with one objective – to deliver the correct technical and commercial solution to our clients".

POSTER ABSTRACTS (in alphabetical order)

Linking sedimentary facies and sediment sources in the NW Carboniferous Basin

Anders, B.[1], Tyrrell, S.[1,3], Murray, J.[1,3], Graham, J.R.[2], Marks, C.[2,3], Chew, D.[2,3]

[1]*Earth and Ocean Sciences, School of Natural Sciences, National University of Ireland, Galway, Ireland*

[2]*Department of Geology, Trinity College Dublin, Dublin 2, Ireland*

[3]*Irish Centre for Research in Applied Geosciences (iCRAG)*

The Northwest Carboniferous Basin (NCWB), with an area of ~600 km^2, has been the focus for unconventional hydrocarbon exploration in Ireland. Development of a clearer understanding of the nature, evolution and architecture of the sedimentological fill of the basin is thus of crucial importance in terms of assessing its economic resource potential and also the impact of possible extraction by hydraulic fracturing. This pilot project sets out to investigate the sedimentary infill of the NWCB, initially focusing on the Viséan [Carboniferous, Mississippian] Mullaghmore Sandstone Formation (MSF), onshore in north counties Mayo and Sligo. This research specifically aims to constrain links between sediment supply and the depositional architecture of this ancient fluvial/deltaic system through high-resolution sedimentological and provenance analysis. This type of approach will help reconstruct the palaeogeography of the NWCB and its hinterland, and it will shed light on how the sedimentary system evolved through time.

Detailed sedimentological logs have been generated from a complete lithostratigraphic section through the MSF and distinct facies packages identified. High resolution sampling through the succession was carried out and a multi-proxy provenance approach, using optical microscopy, scanning electron microscopy, major and trace element whole rock data, U-Pb zircon and Pb-in-K-feldspar analysis, has been utilised. Importantly, this approach, integrates provenance information obtained from labile and stable mineral phases (feldspar and zircon respectively) potentially maximising insight into fluctuating sand supply. Preliminary results suggest a large-scale sedimentary supply system, with derivation from multiple sources located to the north of the NWCB during the mid-Viséan.

This project is funded through the Geological Survey of Ireland shortcall programme (project code: 2015-sc-029)

Sourcelands, sand provenance and supply to North Atlantic margin basins during the Cretaceous

Barry, A.[1], Sun, K.1, Tyrrell, S.[1,6], Chew, D.[2,6], Shannon, P.M.[3,6], Daly, J.S.[3,6], Morton, A. [4,5], Cogné, N.[2]

[1]*Earth and Ocean Sciences, School of Natural Sciences, National University of Ireland, Galway, Ireland*

[2]*Department of Geology, Trinity College Dublin, Dublin 2, Ireland*

[3]*UCD School of Earth Sciences, University College Dublin, Dublin 4, Ireland*

[4]*HM Research Associates, Orbayu, Grove Road, St Ishmaels Pembrokeshire, United Kingdom*

[5]*CASP, University of Cambridge, United Kingdom*

[6]*Irish Centre for Research in Applied Geosciences (iCRAG)*

The northeast Atlantic margin comprises underexplored sedimentary basins and poorly-characterised submarine basement highs (e.g., Porcupine High, Rockall Bank). Recent provenance work has suggested that these basement highs strongly influenced the supply of sediment to basins during the Mesozoic (Evans-Young, 2014, Tyrrell *et al*., 2007, 2010). Their composition, therefore, is a possible first-order control on the quality and distribution of potential reservoir sandstones in the adjacent Porcupine, Rockall and Slyne basins. The aim of this study is to address these issues by 1) developing a

better understanding of the distribution, age and crustal affinity of the Porcupine High; and 2) to determine sedimentary dispersal pathways from the highs, and from surrounding areas, during the early Cretaceous. In order to achieve this, a novel, multi-proxy geochemical approach was implemented which combined petrography, heavy mineral analysis, in-situ isotopic analysis of individual sand components, and thermochronological techniques.

Work on newly sampled material from the northern Porcupine High has indicated the presence of an old and complex metamorphic terrane, dominantly comprising Archaean to Proterozoic gneisses. The samples, although collected by seabed dredging, are believed to be near *in-situ* and have a common uplift history as indicated by apatite fission track analysis. Pb isotopic analyses of K-feldspar and U-Pb zircon analyses from these rocks suggest that the basement here shares a close affinity with the Lewisian Complex of NW Scotland and its equivalents, with minor components that correspond with regional Grenvillian crust (e.g. Annagh Gneiss Complex, NW Mayo). This increasingly detailed view of Porcupine High geology is allowing sedimentary supply from these areas to be assessed for the first time.

Lower Cretaceous sands and sandstones have been sampled from wells in Erris and Porcupine basins and from the Goban Spur. Heavy mineral analysis highlight fluctuations in indexes of Garnet-Zircon (GZi), Rutile-Zircon (RuZi) and Zircon-Tourmaline (ZTi) data suggest changes in sand sourcing within the sampled stratigraphy in both the Erris and Porcupine basins. U-Pb zircon ages and Pb isotopes in K-feldspar suggest that older, Lewisian-type, sources dominate supply to the Erris Basin (likely from the adjacent northern Porcupine High), while Grenvillian-type and younger grains, dominate the sediment delivered to the Porcupine Basin. The presence of Grenvillian feldspar and zircon in both basins, paired with the absence of Lewisian-type detritus in the Porcupine Basin, suggests there is a significant drainage divide, buffering the delivery of sand southward from NW Ireland during the Early Cretaceous. In the Goban Spur, U-Pb zircon ages of ~650 Ma may indicate sourcing of detritus from the Flemish Cap to the south or an, as yet, unrecognised equivalent.

This project is funded by the Petroleum Infrastructure Programme (PIP).

Establishment of A Broad-Band Ocean Bottom Seismometer (OBS) and Marine Acoustic Sensing Network for the N. E. Atlantic, West of Ireland

Bean, C.J.[1], Möllhoff, M.[1], Lebedev, S.[1], Donne, S.[1], O'Reilly, B.[1], McConnell, B.[2], Verbruggen, K.[2]

[1]*Geophysics Section, Dublin Institute for Advanced Studies, 5 Merrion Square, Dublin 2*

[2]*Geological Survey of Ireland, Haddington Rd, Beggars Bush, Dublin 4*

The Dublin Institute for Advanced Studies (DIAS) and The Irish Centre for Research in Applied Geosciences (iCRAG), partnering with the Geological Survey of Ireland (GSI), have been awarded *c.* €3 million euro to establish a broad-band seismo/acoustic sea floor sensing capability. The funding is through Science Foundation Ireland (SFI) and the sensing network is formally known as iMARL (insitu Marine Laboratory for Geosystems Research). It will represent the development of the first combined sea-floor seismic, tsunami and marine acoustic observatory in the Irish NE Atlantic. It will be situated to the West covering the shelf, the shelf break and out into deep (*c*. 3km depth) water. It will be a distributed but synchronised system/network comprising 18 elements with seafloor landers monitoring: active and passive seismics; broad-band acoustics; temperature and sea-floor pressure fluctuations. Working together, these 18 nodes/elements will allow seismic and acoustic event detection, localisation and characterisation over a broad geographical region impacting: natural resources quantification through better regional sub-surface images, natural and industrial hazard estimation (seismicity and slope stability), fundamental and applied Earth Science research on ocean-land coupling, in deep water.

Through a mapping of the offshore acoustic and sea floor pressure environments the network will also build our scientific understanding of the spatio-temporal distribution of both natural and anthropogenic marine acoustic noise. A pilot tsunami detection system will also be installed as part of the system.

Surface-wave tomography of Ireland and surroundings

Bonadio, R.[1], Arroucau, P.[1], Lebedev, S.[1], Meier, T.[2], Schaeffer, A.[3], Licciardi, A.[1], Piana Agostinetti, N.[1]

[1]*Dublin Institute for Advanced Studies, Dublin, Ireland*

[2]*Institute of Geosciences, Christian-Albrechts University of Kiel, Kiel, Germany*

[3]*Department of Earth Sciences, University of Ottawa, Ottawa, Canada*

Accurate knowledge of the structure and evolution of the crust and lithosphere of Ireland and surroundings is important for the understanding of the development of Ireland's natural resources. At present, the structure is poorly known at the regional scale, mainly due to the lack of relevant seismic data until recently. In this project, we take advantage of abundant, newly available broadband data from temporary array deployments and permanent seismic networks in Ireland, Britain and westernmost continental Europe and perform high-resolution, Rayleigh-wave tomography of the entire region. We perform cross-correlation of teleseismic surface waves using a new, automated technique that produces robust dispersion curves for station pairs in a very broad period range (from 4 s to over 200 s). The period range is being broadened further by the addition of phase-velocity measurements using ambient noise wavefield (intermediate to short period measurements, periods down to 1 s) and those using waveform inversion (intermediate to very long periods). Phase-velocity maps at shorter periods show clear contrasts between areas with and without thick sedimentary cover (low vs high velocities, respectively). Beneath the Irish Sea and surroundings—the area of early-Cenozoic uplift and volcanism within the British Tertiary Igneous Province—low phase velocities indicate anomalously thin lithosphere, suggesting that the uplift and volcanism were caused, in large part, by the thinning of the lithosphere, possibly triggered by the Iceland Hotspot activity.

Thermal regime of the Irish Atlantic basins

Bonté, D.[1,2], Pasquali, R.[1]

[1]*GeoServ, Dublin, Ireland*

[2]*Utrecht University, Utrecht, the Netherlands*

The formation of the basins in the Irish offshore relate to the opening of the North Atlantic. These basins have experienced a series of depositional phases observed in the sedimentary record since the Devonian. In this project, we combine these records with the state of the art understanding of the geodynamic evolution, to model the tectonic evolution of the considered basins and the related heat flow. The assessment of the thermal component is extremely important in the understanding of the development of hydrocarbons within these basins. Our areas of interest are the Porcupine Basin, Slyne Basin, Erris Basin, Donegal Basin, and the north-east Rockall Basin.

To assess the validity of our modelling assumptions, Vitrinite Reflectance (VR) data are required for calibration. A review and compilation of VR data from wells in the Irish offshore has been completed. A total of 18 wells (15 in the Porcupine Basin) from the 36 wells that have VR data have been modelled based on the quality and number of VR data and available sedimentary information.

The stratigraphic column (including the lithology) from top of the sequence to the basement has been compiled based on composite well log records. In order to have fixed thermal boundary conditions, the tectonic-heat flow modelling considers the evolution of the entire lithosphere. The different lithospheric layers are defined as part of the model inputs. These include: the lithospheric mantle, the lower crust, and the upper crust. The principal geodynamic steps that have influenced the evolution of the basins have been defined as part of the modelling. These steps include: the deposition at the Lower Carboniferous, a large erosion phase at the Upper Carboniferous to Early Permian boundary, two successive rifting phases in the Middle to Late Jurassic and Early Cretaceous. The modelling steps also include a period of uplift at the Palaeocene that could have been the result of the Iceland Plume.

The methodology allows the tectonic subsidence from the model to be compared to the tectonic subsidence described from the stratigraphic column in the well records, the modelled VR values that can be compared with the gathered VR measurements, and the heat flow from the basement through the lifetime of the basin. The results obtained from the modelling show a heat flow of around 70 $mW.m^{-2}$ at the early stage of the evolution of the basins that progressively decreases to reach a value of around 60 $mW.m^{-2}$ for the present day. In addition, intense thermal activity occurred at the end of the Carboniferous and generates heat flow values of between 110 and 180 $mW.m^{-2}$. The geological origin of this thermal activity has been related to magmatism related to the dismantlement of the Variscan orogeny.

This project is funded by the Petroleum Infrastructure Programme (PIP).

Satellite Derived Bathymetry

Cahalane, C.[1], Monteys, X.[2], Magee, A.[1], Lewis, P.[1], McCarthy, T.[1]

[1]*National Centre for Geocomputation, Maynooth University*

[2]*Geological Survey of Ireland*

Bathymetry is traditionally acquired using shipborne echo sounding equipment, recording depth values as single-shot points or via multibeam sensor arrays. This method produces accurate depth measurements along transects but is constrained by relatively high operating cost and an inability to survey in very shallow waters or complex maritime (navigation) regions. Airborne LiDAR is free of these restrictions and is able to produce accurate bathymetric information over clear waters at a depth up to 70m (Irish and White, 1998). However, this method is costly and experience in Irish waters gained from the INFOMAR research program has resulted in very poor results in seabed detection along the East coast and limited penetration in the West coast up to 15m (Coveney and Monteys, 2011).

Satellite optical sensing is an alternative remote sensing method based on the manner of light transmission in water that potentially offers more flexible, efficient and cost-effective means of mapping bathymetry over broad areas. The primary objective of this study is to advance the development of a methodology for coastal bathymetric mapping based on spectral measurements captured by satellites and aerial platforms, both manned and unmanned. This methodology has the potential to advance the state of the art by better discriminating between changes of sea bed type and increasing optical penetration of the water column, thereby leading to more accurate optical bathymetric mapping. This innovative geospatial methodology will provide the research community, decision-makers and industry within the marine sector with accurate, timely and affordable near-shore depth information for a variety of coastal applications.

This project is funded by the Geological Survey of Ireland INFOMAR Short Call, 2015

Slick Feature Mapping

Cahalane, C.[1], Walsh, D.[1], McCarthy, T.[1]

[1]*Irish Centre for Research in Applied Geosciences (iCRAG), National Centre for Geocomputation, Maynooth University*

Earth Observation technologies enable synoptic, near real-time mapping and monitoring over large areas of our national waters. These techniques have the potential to significantly contribute to the de-risking of oil and gas exploration and as a result work is underway to develop an EO methodology for mapping natural and anthropogenic oil-seeps/slicks over Ireland's offshore exploration area. The team at the National Centre for Geocomputation (NCG), Maynooth University are in the process of design, development and evaluation of a scalable, cloud-based marine observation platform to support this. This platform incorporates remote sensing and in-situ data and will be accessible by both the oil/gas industry and researcher alike. Imagery from satellites (SAR, multispectral, hyperspectral), light-aircraft and low flying drones are assessed in a processing chain to locate, classify and quantify marine slicks through their surface-roughness and/or their spectral and thermal signatures. Information on weather, geology and oceanic processes are combined with other spatial datasets to help inform the classification of the slicks and assess the impact of different weather and sea conditions on classification accuracy.

iCRAG is funded under the SFI Research Centres Programme and is co-funded under the European Regional Development Fund and by PIPCO RSG and its member companies.

Waveform Tomography of the North Atlantic Region

Celli, N.[1], Lebedev, S.[1], Schaeffer, A.[1], Gaina, C.[1]

[1]*Dublin Institute for Advanced Studies, Dublin, Ireland*

The enormous volumes of newly available, broadband seismic data and the continuing development of waveform tomography techniques present us with an opportunity to resolve the structure of North Atlantic and Arctic at a new level of detail. Dynamics of the Mid Ocean Ridge and the Iceland Hotspot, evolution of the passive margins, and the nature of the upper-mantle flow beneath these regions are some of the important fundamental problems that we can make progress on using new, more detailed and accurate models of seismic structure and anisotropy within the lithosphere and underlying mantle. We assemble a very large waveform dataset including all publicly available data in the region, from both permanent and temporary seismic networks and experiments conducted in Northern and Western Europe, Iceland, Canada, USA, Greenland and Russia. The tomographic model is constrained by vertical-component waveform fits, computed using the Automated Multimode Inversion of surface, S and multiple S waves. Each seismogram fit provides a set of linear equations describing 1D average velocity perturbations with respect to a 3D reference velocity model within an approximate sensitivity volume between the source and receiver. The equations are then combined into a large linear system and jointly inverted for a model of shear- and compressional-wave speeds and azimuthal anisotropy within the lithosphere and underlying mantle. The isotropic-average shear speeds reflect the temperature and composition at depth, offering important new information on both regional- and basin-scale lithospheric structure and evolution. Average S-wave velocity profiles for the oceanic lithosphere as a function of its age show significantly slower lithospheric cooling in the North Atlantic compared to the global trend. This comparison offers an insight into the dynamic effects of the hotspot activity in the North Atlantic region.

An Integrated Biostratigraphic and Lithostratigraphic Framework of Offshore Ireland

Copestake, P.[1],Ainsworth, N. R.[2], Bailey, H. W [3], Donato, J. A.[1], Dunford, G.[4], Farrimond, P. R.[5], Gallagher, L.T.[3], Gehlen, M.[5], Gueinn, K. J.[6], Hampton, M. J.[3], Lavis, O. M.[1], Loy, T.[1], Riley, L. A.[6], Wright, T. D.[1]

[1] *Merlin Energy Resources Ltd*
[2] *PalaeoDate Ltd*
[3] *Network Stratigraphic Consulting Ltd*
[4] *Dunford Exploration Ltd*
[5] *IGI Ltd*
[6] *Riley Geoscience Ltd*

The Irish offshore comprises a diverse set of geological basins, both on the Atlantic margin and in the Celtic and Irish Sea areas, representing a range of geological and structural complexity. The efficient exploration of such a province requires a standard stratigraphic understanding and consistently defined schemes (biostratigraphy, lithostratigraphy, sequence stratigraphy) that all operators, contractors and academia can use. Despite its long history of hydrocarbon exploration, such a unified framework has never been defined for offshore Ireland. In addition to this there are a number of known stratigraphic problems that exist in the region, regarding the chronostratigraphic interpretation and correlation of particular reservoir intervals and their relation to a broader regional scheme. For these reasons, PIPCo RSG has commissioned a project to be carried out to establish and define a biostratigraphic, lithostratigraphic and sequence stratigraphic framework for offshore Ireland. The project is based on the assessment and re-interpretation of all available existing legacy stratigraphic data from all released wells, and will be supplemented by new data focused on intervals and wells where gaps in the existing database exist, or where further data are required to improve the stratigraphic understanding of particular intervals.

Some preliminary examples of this work will be shown in two posters (and the accompanying presentation).

This project is funded by the Petroleum Infrastructure Programme (PIP).

Microseism Source Distribution Observed from Ireland

Craig, D.[1], Bean, C.J[1], LePape, F.[1], Donne, S.[1,2]

[1] *Irish Centre for Research in Applied Geosciences (iCRAG), Geophysics, Dublin Institute of Advanced Studies*
[2] *School of Earth Sciences, University College Dublin*

Oceans generate persistent low frequency signals known as microseisms. Energy for ocean generated microseisms (OGM) originates as ocean waves formed in regions of low barometric pressure (depressions) over the oceans. The energy is subsequently transmitted to the sea-floor and propagates as elastic energy in the Earth's crust. Consequently, OGM carry important meteorological information relating to both the atmosphere and the hydrosphere. OGM then can be used as climate indicators and to estimate ocean wave parameters using onshore seismometer data. Also many modern seismological methods make use of OGM signals. For example, the Earth's crust and upper mantle can be imaged using noise tomography; analysis of the geometric dispersion of surface waves and spectral ratio techniques can provide information on velocity structure; and cross-correlation techniques can be used to monitor seismic velocity changes. Given the importance of such signals in modern seismology, relatively

little is known about the effects of the source distribution on these methods. Ireland is proximal to a major source region for OGM and an ideal place to study these signals.

The ability to use OGM as ocean-wave proxies or for imaging strongly depends on the source distribution. Seismic arrays can be used to determine source locations for such signals. Maps of the source distributions near Ireland will be developed and compared to sea-floor measurements for a particular source area. This will help to determine the validity of current OGM generation theory in a real world situation.

iCRAG is funded under the SFI Research Centres Programme and is co-funded under the European Regional Development Fund.

Sound levels from a 3D seismic survey in the Porcupine Basin: Development of a sound propagation model using observed data

Crawford, S.[1], Brown, C.[1], McKeown, E.[2], Stapleton, F.[2], Duncan, A.[3], McCauley, R.[3], White, M.[1]

[1]*Earth and Ocean Sciences, School of Natural Sciences, Ryan Institute, N.U.I., Galway, Ireland*

[2]*RPS Group, Galway, Ireland*

[3]*Centre for Marine Science and Technology, Curtin University, Perth, Australia*

Following Ireland's 2015 Atlantic Margin Oil and Gas Exploration Licensing Round, the Porcupine Basin continues to be a significant site for seismic exploration activities to investigate sub-bottom structure. Recent literature has reported on the environmental implications of marine seismic surveys, highlighting alarmed and avoidance behaviour in several marine mammal species as a common response to air gun signals. The European Habitats Directive orders the protection of all cetacean species in European waters, 23 of which inhabit Irish waters for at least part of the year. As such, underwater acoustic monitoring and mapping has been targeted as a research priority under the EU's Marine Strategy Framework Directive. The aim of this research is to produce an efficient working model of sound propagation for the Porcupine Basin which will enable the prediction of sound levels generated by seismic operations in the area. In this study, a modelling method which employs the Parabolic Equation technique (RAMGeo) was used to model the transmission loss (TL) of low frequency noise across real, range-dependent 2D source-to-receiver sections from the Porcupine Basin. RAMGeo, run in a Matlab environment, is freely available through the Acoustic Toolbox User Interface and Post-Processor (AcTUP) developed by Curtin University. The TL computed using the model, and the model-predicted Sound Exposure Levels, were measured against their corresponding observed values, which were recorded during a research cruise in July 2014 to coincide with 3D seismic operations in the area at locations across the Basin. The Porcupine Basin model-definition run through RAMGeo is evaluated for its predictive power, before model limitations are addressed.

This project is funded by the Petroleum Infrastructure Programme (PIP).

Predictive distribution mapping of central-place foragers to inform marine spatial planning

Critchley, E.[1], Grecian, J.[2], Jessopp, M.[3], Quinn, J.[1]

[1]*School of Biological, Earth & Environmental Science, University College Cork*

[2]*Sea Mammal Research Unit, Scottish Oceans Institute, University of St Andrews*

[3]*MaREI Centre, Environmental Research Institute, University College Cork*

Large marine vertebrates, such as seabirds, are considered to be key indicator species for assessing the health of marine environments. Their distribution at sea has often been used for identifying important bird areas (IBAs) and further designating sites for protection as Marine Protected Areas (MPAs). However mapping seabird distributions at sea through at-sea surveys or tracking studies can be costly and intensive work. On the other hand, predictive distribution models have the potential to allow a quick assessment of distributions on a large scale, and can help identify biodiversity hotspots for further investigation. This information is vital for conservation efforts as it will allow for more rapid risk assessment and inform allocation of MPAs. Here we report on a predictive distribution model that uses a foraging radius approach, and can be applied to all central-place marine foragers. We have generated predictive distribution maps for all seabird species breeding in the UK and Ireland at a $5km^2$ resolution, for both individual species and feeding guilds, with predictions validated with tracking data for some key species.

The applications of the model and predictive distributions generated by it are wide ranging, including highlighting at-sea abundance or biodiversity hotspots. One of the key advantages of the predictive distribution maps is the ability to assess impacts to biodiversity at a large community level, regional scale. Grid cells in the maps can be weighted by species-specific vulnerability indices across a range of potential impacts including susceptibility to oil spills or collision risk with offshore wind turbines to highlight areas of increased risk. An open-access online GIS platform has been developed concurrently to enable stakeholders, including fossil fuel and renewable energy sectors, to identify, manage and mitigate potential at-risk hotspots where vulnerable species occur.

This project is funded by the Petroleum Infrastructure Programme (PIP).

The impact of Cenozoic deformation on potential hydrocarbon traps in Irish offshore basins

Delogkos, E.[1], Walsh, J.J.[2], Childs, C.[1], Manzocchi, T.[1], Saqab, M.M.[2]

[1] *Fault Analysis Group, School of Earth Sciences, University College Dublin*

[2] *iCRAG (Irish Centre for Research in Applied Geosciences), School of Earth Sciences, University College Dublin*

Hydrocarbons on the NW European continental shelf are often contained within Upper Jurassic traps, though increasingly both structural and stratigraphic traps are being recognised within younger Mesozoic and Cenozoic sequences. Cenozoic deformation may be important in controlling both the geometry and charging of these traps and also in determining the integrity of Jurassic traps. In this study, we aim to establish constraints on the geometry, kinematics and spatial distribution of Cenozoic structures in the major basins offshore Ireland. We show how the nature of Cenozoic Alpine-related deformation changes around offshore and onshore Ireland, with strong inversion in the Celtic Sea Basins, milder inversion, strike-slip faulting and plume-related uplift in the Irish Sea and Northern Ireland, which is directly linked to strike-slip faulting extending into the Slyne Basin. Cenozoic sinistral strike-slip movement on pre-existing Carboniferous normal faults, is strongly localised and appears to be related to major Caledonian Terrane

Boundaries. In the Western offshore basins, no indicators of Alpine deformation are observed, other than very rare strike-slip faults. Instead, Cenozoic deformation is represented by a Mid Eocene-Oligocene phase of N-S normal faulting, together with broad-scale plume related uplift and localised halokinesis in the Slyne Basin. The boundary between the southern part of the Porcupine Basin and the Cenozoic inversion seen in the Celtic Sea Basins is very sharp and is believed to be defined by pre-existing Variscan structures. Future work will concentrate on providing quantitative constraints on the nature of Cenozoic deformation, including the potential for hydrocarbon leakage along reactivated faults and the generation of associated anticlinal closures adjacent to inverted faults.

This project is funded by the Petroleum Infrastructure Programme (PIP).

Thresholds for sediment bypass by turbulent flows: implications for stratigraphic traps in turbidite systems

Dorrell, R.M.[1], Amy, L.A.[2]

[1]*Turbdites Research Group, School of Earth and Environment, University of Leeds, LS2 9JT, UK.*
r.m.dorrell@leeds.ac.uk

[2]*School of Earth Sciences, University College Dublin, Dublin 4, Ireland.* *lawrence.amy@ucd.ie*

The stratigraphic architecture of turbidite and many other systems dominated by turbulent flows is underpinned by the flows' ability to transport sediment as suspended load. This fundamentally controls the slope equilibrium profile and hence the location of turbidite reservoir sands along the slope profile as well as the potential for upslope stratigraphic pinchout traps. Predominately bypass-erosional flows transport their sediment load downslope to the basin; forming sand-starved slope channels and canyons. In contrast, flows that cannot suspend their sediment are depositional on inbound slopes leading to constructional slope systems with sand-filled slope conduits and potentially sand starved basins. An experimentally validated mathematical model for polydisperse turbulent suspension is used to estimate the critical shear velocity (u*c) for the threshold between depositional and erosional regimes in gravity driven flows. The model shows that the criterion is a function of flow concentration and grain-size distribution increasing as stratification increases within flows: arising from either higher particle concentrations or maximum sizes (increased mean, standard deviation and decreased skew). Predicted values of u*c are as much as two orders of magnitude greater than those derived using standard monodisperse sediment transport models (e.g., Rouse criterion). The results presented have significant ramifications for our understanding of sediment transport by turbulent flows notably that sediment grain size distribution alters the conditions for erosional and depositional regimes. Importantly for stratigraphic trap prediction the results help constrain critical slope angles required for total sediment bypass at which upslope pinchout traps may be formed. Critically, this demonstrates that upslope pinchout traps are difficult to form in relatively coarse-grained and poorly sorted depositional systems by bypass even if steep slopes (>10^{o}) are present. Conversely, finer grained and better sorted systems should have better potential for pinchout development.

First detrital mica Ar-Ar ages from Devonian and Mesozoic sediments of onshore and offshore southern Ireland

Fairey, B.[1], Meere, P.[1], Mulchrone K.[2], Kerrison A.[1], Kuiper K.[3], Linnemann U.[4], Hofmann M.[4], Gärtner A.[4], Sonntag B.[4]

[1]*School of Biological, Earth and Environmental Sciences, University College Cork*

[2]*School of Applied Mathematics, University College Cork*

[3]*Faculty of Earth and Life Sciences, Vrije Universiteit Amsterdam*

[4]*Senckenberg Naturhistorische Sammlungen Dresden, Museum für Mineralogie und Geologie, Königsbrücker Landstraße 159, D-01109 Dresden, Germany*

New detrital mica Ar-Ar ages, in addition to detrital zircon U-Pb ages, for the eastern Upper Devonian Munster Basin as well as the Mesozoic North Celtic Sea and Fastnet Basins provide further constraint on the provenance of sediments within these basins. Due to its low closure temperature in the Ar-Ar system, muscovite affords an opportunity to assess the age of the latter stages of major thermal events. This becomes a very valuable tool where the thermal histories of potential source areas are known. Two samples from the Munster Basin, one from the Middle Devonian and one from the Lower Carboniferous, yield dominant detrital mica Ar-Ar age peaks at around 395 Ma and 450 Ma respectively. The Harrylock Formation, a time equivalent of the Kiltorcan Formation that is thought to be separate from the Munster Basin, shows a single Ar-Ar age peak at around 400 Ma. Two Lower Cretaceous samples from the North Celtic Sea Basin both have single peaks around 430 Ma with the western sample, from well 48/24-4, having a greater spread of ages than the eastern sample (well 49/9-2). One sample was taken from the Upper Jurassic North Celtic Sea Basin (well 49/9-3) has a dominant detrital mica age peak at around 405 Ma. A single sample was taken from a Triassic section in well 56/26-1, yielding a dominant detrital mica age peak at around 578 Ma. Lastly, one sample was taken from a section in the south western limit of the North Celtic Sea Basin (well 56/15-1) and is thought to be of Lower Carboniferous age. This sample yielded a major detrital mica age peak at around 380 Ma. Two of the youngest micas in the sample both have ages of 282 ± 3 Ma. This suggests that the formation is likely to be at most Permian in age, not Carboniferous. With the exception of the Triassic sample, these results are consistent with a Caledonian source for detrital micas. The broad similarity between onshore and offshore detrital mica ages adds further support for recycling of Old Red Sandstone sediments, at least into the North Celtic Sea Basin. The late Neoproterozoic age of most of the detrital micas in the Triassic sample would suggest the exposure of a peri-Gondwanan sediment source during the Triassic in the Fastnet Basin. Finally, this would also suggest that the basement to the Fastnet Basin has not exceeded upper greenschist facies metamorphism since the end of the Proterozoic.

This project is funded by the Petroleum Infrastructure Programme (PIP).

Compositional and Thermal Structure of the Crust from Geophysical and Petrophysical Data

Farrell, T.[1,2], Fullea, J.[1], Bagdassarov, N.[3], Muller, M.[4], Feely, M.[2], Vozar, J.[5], Hogg, C.[1]

[1]*Geophysics Section, Dublin Institute for Advanced Studies, Dublin, Ireland*

[2]*Earth and Ocean Sciences, National University of Ireland, Galway, Ireland*

[3]*Fachenheit Geophysik, J. W. Goethe Universitat, Frankfurt, Germany*

[4]*Independent Geophysical Consultant, Cambridge, UK*

[5]*Earth Science Institute, Slovak Academy of Sciences, Bratislava, Slovakia*

We present an update from ongoing work to constrain the compositional and thermal structure of continental crust in western Ireland. This work focuses on the Galway granite on the west coast of

Ireland, which has been the subject of a geothermal investigation as part of the IRETHERM project (www.iretherm.ie).

Magnetotelluric data is integrated with electrical conductivity, density, heat production, thermal conductivity, and geothermal heat flow density data to examine in 1D the thermal and compositional structure of the crust and lithosphere, in which the Galway granite batholith resides. On a shallower scale, geotherms and temperatures are separately calculated to depths of 8 km within the Galway granite.

The results show that the temperatures within the Galway granite have previously been underestimated. This underestimation is primarily due to two reasons. Firstly, the effect of increasing temperature with depth on thermal conductivity was not considered in previous calculations. Secondly, the effects of palaeoclimate conditions on present-day heat-flow and geothermal gradient have been underestimated in the past. The calculated constraints on temperature at depth within the Galway granite batholith are key to assessing geothermal energy prospectivity.

Fluid Inclusion Signatures of North Atlantic Conjugate Marginal Basins, Eastern Canada and Western Ireland: Aspects of Fluid Dynamics in Sedimentary Basins

Feely, M.[1], Costanzo, A.[1], Hunt, J.[1], Wilton, D.[2], Carter, J.[3]
[1]National University of Ireland Galway, Galway, Ireland
[2]Memorial University, St. Johns, Newfoundland, Canada
[3]Nalcor Energy, St. Johns, Newfoundland, Canada

Fluid inclusion studies of oil prospective basins can contribute to models of aqueous and hydrocarbon fluid dynamics in sedimentary basin environments. Geofluid studies of the Porcupine basin and of eastern Newfoundland and Labrador basins illustrate the application of such studies to frontier oil exploration in the conjugate marginal basins of the North Atlantic. Porcupine basin studies of detrital quartz and authigenic cement hosted fluid inclusions show that basinal aqueous fluids trapped in cements are consistently of low to moderate salinity (<10 eq. wt.% NaCl). Migration of at least two chemically distinct hydrocarbon fluids, occurred post cementation, as lateral flow along Jurassic sandstones. Cement hosted primary aqueous fluids in Jurassic sandstones were trapped at temperatures (~70-120°C) and at deeper levels. Post cementation migration of aqueous fluids occurred at high temperatures (up to 175°C) maybe associated with plume related activity during the opening of the North Atlantic. Similar studies of offshore Newfoundland and Labrador reveal the presence of hydrocarbon bearing fluid inclusions in the Cretaceous Markland Formation. They yield temperatures of homogenisation of ~80°C and display blue fluorescence under UV light indicating trapping of a high maturity oil with an API gravity of ~40-45°. Aqueous fluid inclusions were trapped between 80ºC and 120ºC, salinities are < 10 eq. wt.% NaCl. These inclusions represent low temperature (<120ºC) and low salinity (<10 eq.wt.% NaCl) fluids, typical of basinal fluids and similar to those recorded in the Porcupine Basin. Monophase aqueous inclusions occur in trails crosscutting detrital quartz grains in all conjugate marginal basins and indicate fluid trapping temperatures of <50ºC.

Provenance of Triassic Sandstones in the Slyne Basin: Investigating the Primary Controls on Reservoir Sandstone Quality

Franklin, J.[1], Tyrrell, S.[1]

[1]*Irish Centre for Research in Applied Geosciences (iCRAG), Earth and Ocean Sciences, School of Natural Sciences, National University of Galway, Galway*

Sediment transport on the Irish Atlantic Margin during the Triassic remains relatively elusive. Sediment dispersal systems supplying these basins are thought to be independent from those which fed UK basins, such as the Budleighensis river system, which was sourced in the Variscan uplands (Tyrrell *et al.,* 2012). This study aims to investigate, assess and test the links between source area, sandstone petrography, and reservoir quality and to identify potential causes of provenance-controlled reservoir sandstone heterogeneity. Due to local variations within intervals, the Triassic sandstones of the Slyne Basin, offshore West Ireland, are a good test case. Triassic sandstone intervals within well 27/5-1, equivalent to those within the Corrib gas field 45km to the north, display good porosity/permeability but do not contain significant hydrocarbons. Detailed assessment of Triassic sandstones in well 27/5-1 aims to evaluate whether the variations observed are due to, changes in provenance, or to a difference in burial depth and authigenesis between the northerly and southerly extents of the Slyne Basin.

Petrographic analyses of samples from well 27/5-1 reveal a framework mineralogy comprising quartz, feldspar and lithic fragments of variable proportions. The sandstones are mostly arkosic arenites with significant potassium feldspar, making them perfect candidates for the well-developed Pb-in-K-feldspar provenance tool. Detailed information was subsequently collected on internal grain or crystal structures and grain morphology through SEM analysis which will be used to place extra constraints on the provenance data, giving context to the analysed single grains. Pb isotopic analysis of imaged K-feldspars was carried out on the NEPTUNE LA-ICP-MC-MS at the National Centre for Isotope Geochemistry in UCD. Feldspars were ablated along predetermined tracks of 75 or 100 microns.

In order to identify potential source areas the data were plotted to compare with a map highlighting the variation in Pb isotopes in potential basement sources. A mixed Archaean/Proterozoic source was subsequently identified. These results suggest dominant sediment supply to the southern Slyne Basin from the Lewisian Complex of NW Scotland or its equivalents with a relatively minor supply coming from the Nagsuggtoqidian of eastern Greenland. This confirms the hypothesis of a drainage divide between the basins offshore western Ireland versus onshore UK and eastern Ireland, most likely due to the presence of the Irish Massif which does not appear to itself be a significant sediment source. Similarities can be seen in the provenance signals for the samples from 27/5-1 and the Corrib gas field, however the relative proportion of these populations varies between the two areas.

iCRAG is funded under the SFI Research Centres Programme and is co-funded under the European Regional Development Fund and by PIPCO RSG and its member companies.

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Tyrrell et al. (2012) Large-scale, linked drainage systems in the NW European Triassic: insights from the Pb isotopic composition of detrital K-feldspar. Journal of the Geological Society, London, Vol. 169, 2012, pp. 279 –295.

Geological and geophysical evidence for a mafic igneous origin for the Porcupine Arch, offshore Ireland

Gagnevin, D.[1], Haughton, P.D.W.[1]

[1]*Irish Centre for Research in Applied Geosciences (iCRAG), UCD School of Earth Sciences, University College Dublin, Belfield, Dublin 4, Ireland*

Hyperextended basins west of Ireland contain a number of central arches and ridges that have been variously interpreted as fault blocks, serpentinite extrusions or igneous complexes. Here we focus on the

Porcupine Arch, a deep-level (>10 km) domal feature associated with high-amplitude reflectors and a prominent free-air gravity anomaly high in the northern part of Porcupine Basin. Understanding the origin of such features is important for the mode of basin development and modelling the thermal history.

Detailed seismic mapping of igneous sill complexes in the vicinity of the Arch suggest a possible connection. More than seven large sill bodies have been identified as well as other minor sills forming a thick (>5 km) inter-connected network extending from the Arch into the flanking Cretaceous stratigraphy, with sills climbing as high as the Upper Cretaceous and chalk stratigraphic level. This suggests that the Porcupine Arch may be the top of a large (ultra)mafic intrusion that fed the sills and is consistent with the associated gravity anomaly high, which has been modelled as representing a thick high-density body at arch level. Similar mafic/ultramafic intrusive complexes have been inferred elsewhere on the North Atlantic margin, including the UK Rockall Trough, where the overlying lavas and sill complexes have been drilled. The Porcupine Arch is characterised by high P-wave velocities (>7-7.5 km/s), which could reflect partial serpentinisation of exhumed mantle rocks, but these could equally be interpreted as related, at least in part, to substantial plume-related magma underplating. Underplating is thought to be significant beneath some of the North Atlantic basins, although it is generally linked to breakup and position of the continent-ocean boundary. Other features such as abundant gas chimneys around the arch, updoming of the overlying stratigraphy including the base-Cretaceous unconformity (BCU) and internal continuous reflections within the arch itself, are all in favour of an igneous origin as a result of Tertiary intrusion and accompanying internal differentiation. The hypothesis is also consistent with a phase of documented Tertiary uplift in the Porcupine area, the extremely primitive composition of the sills where sampled in wells, and regional lithospheric beta-factor variations. Whilst we do not preclude a degree of serpentinisation during the late Jurassic - early Cretaceous phase of basin hyperextension, we emphasise that later enhanced igneous addition in this part of the Porcupine may act to obscure the earlier rift architecture. These findings emphasise that higher heat-flow may have prevailed in the early Tertiary in the northern part of Porcupine and this could have impacted on the extent and timing of petroleum generation, an issue that will be addressed by basin modelling.

iCRAG is funded under the SFI Research Centres Programme and is co-funded under the European Regional Development Fund and by PIPCO RSG and its member companies.

Bed-scale clay distribution in deep-water sandstones – results from XRF profiling of Ross cores, western Ireland

Hussain, A.[1], Haughton, P.D.W.[1], Shannon, P.M.[1], Turner, J.[2], Pierce, C.[3]

[1]*Irish Centre for Research in Applied Geosciences (iCRAG), UCD School of Earth Sciences, University College Dublin, Ireland.*

[2]*UCD School of Geography, University College Dublin, Ireland*

[3]*Department of Geology and Petroleum Geology, University of Aberdeen, King's College, AB243FX*

Sediment gravity flow deposits form important hydrocarbon reservoirs in many basins, including potentially the Irish offshore. Emerging evidence suggests detrital clays in these flows can modify flow character and subsequent bed make-up by forcing the deposition of sand and clay together as the flow decelerates. Variable clay distribution has important implications for reservoir quality in deep-water sandstones as documented in many North Sea and Gulf of Mexico fields, particularly close to distal and lateral pinch-outs. However determining the details of continuous clay distribution at bed-level and relating this to original flow processes poses significant challenges. High-resolution XRF core scanners have been widely used to capture continuous bed-level compositional trends in shallow sediment cores, but there has been only limited use of this technology in older rock cores. The Ross Sandstone Formation in western Ireland is an ideal succession to explore the XRF profiling technique in that it contains a relatively simple bimodal mix of dominantly quartz-rich sand and clay. Recent behind-outcrop coring funded by Statoil ASA has identified a wide range of bed-types including conventional turbidites, hybrid event beds and mass-transport deposits. The bed mix is similar to other systems in the subsurface e.g. the Paleocene Wilcox sandstones, Gulf of Mexico. A number of event beds spanning the main types have been selected for detailed (200 µm spacing) elemental profiling using an Itrax core scanner housed in the UCD School of Geography. Furthermore, thin sections from the same beds have been used for petrographical analysis of texture and composition. In addition, the profiles have been calibrated against whole rock ICP-AES data and compared with high-resolution spectral gamma profiles. Si and K are shown to be useful textural proxies for silt/sand grains and clay and/or mica respectively, and Ca for diagenetic overprinting. The elemental profiles give new insight into subtle but systematic vertical compositional trends that may reflect differential settling of coarser quartz sand and silt in arresting suspensions and fluid muds, fractionation of micas, and textural interfaces reflecting internal shear and partitioning of the flow. Profiling of clay clasts as well as the surrounding sand matrix and background mudstones between event beds helps constrain the likely source of the clays incorporated in the original flows. On a larger scale, the elemental data help identify vertical changes in sediment composition and sand input across the Ross Formation as whole; early sandstones are coarser grained, have lower gamma, lower K and higher Si than younger parts of the Ross confirming that the deep-water part of the succession comprises at least two distinct systems.

iCRAG is funded under the SFI Research Centres Programme and is co-funded under the European Regional Development Fund and by PIPCO RSG and its member companies.

Enhancing the value of ecological data collected by MMOs during seismic acquisition surveys: assessing the effect of seismic surveys on cetacean occurrence.

Kavanagh, A.S.[1], Nykanen, M.[1], Hunt, W.[1], Jessopp, M.[1]

[1]*MaREI Centre for Marine and Renewable Energy, Environmental Research Institute, University College Cork*

Reports from Marine Mammal Observers (MMOs) during seismic acquisition surveys contain over 7000 hrs of marine mammal survey effort. These data are often collected in areas, such as the Porcupine Basin, that are not frequented by dedicated scientific surveys and therefore represent a potential valuable source of information on cetacean distribution. However, cetacean encounter rates during seismic surveys are generally lower than for similar surveys carried out from other vessel types. We examined observations from active seismic surveys (periods with airguns running on full power), inactive seismic surveys (periods without active airguns), and control surveys (carried out with similar methodologies on non-seismic vessels). We used a statistical modelling approach (GAMs) to investigate the effect of seismic surveys on cetacean occurrence, while accounting for other possible influential factors such as environmental conditions. Approximately 1000 hrs of control data were collected (using a similar methodology and in similar areas as seismic surveys) as part of the SFI-Kosmos project. Results of the models show a lower probability of observing cetaceans during both active and inactive periods of seismic surveys when compared to control surveys, even when environmental, spatial, and temporal variables were accounted for. However, the observed effect was smaller when airguns were not operational. The results of this study will contribute to quantifying the extent of the influence of seismic surveys on sightings and enhance the usefulness of this extensive data source. Specifically, these data have the potential to increase our understanding of the temporal scale of impacts as well as the distribution of rare and vulnerable cetacean species previously considered to be data deficient in Irish offshore waters. Such information will supply environmental impact assessments with real data, and will contribute to the effective management of human activities such as Oil and Gas exploration.

This project was carried out in the MaREI Centre for Marine and Renewable Energy, supported by Science Foundation Ireland funding under Grant No. SFI/12/RC/2302. The authors also wish to acknowledge industry partner funding from KOSMOS Energy.

Multiscale seismic waveform tomography of western Ireland's offshore basins

Lavoué, F.[1,2], Lebedev, S.[1,2], Prada, M.[1,2], O'Reilly, B.M.[1,2], N. Celli, L.[2], Schaeffer, A.J.[3]

[1]*Irish Centre for Applied Geosciences (iCRAG)*

[2]*Dublin Institute for Advanced Studies (DIAS), Geophysics Section*

[3]*University of Ottawa, Department of Earth and Environmental Sciences*

The offshore basins west of Ireland are of great interest for their potential as hydrocarbon reservoirs as well as for their tectonic history as part of the North Atlantic margin. In this work, we seek to characterise these basins by building quantitative models of seismic properties at different scales, from the large oceanic scale down to the basin scale.

First, at the North Atlantic scale, we present new models of the distribution of shear-wave velocity and of its radial and azimuthal anisotropy in the crust and in the upper mantle, obtained by asymptotic waveform inversion of S and surface waves. Seismic anisotropy is the consequence of the preferential orientation of minerals due to deformation. The separate reconstruction of the shear-velocity isotropic average and of its anisotropy enables to distinguish between the effects of thermal or compositional variations and

those of anisotropic fabric. The former can be interpreted in terms of lithosphere thickness and temperature, while the latter gives us insight into past and present deformation and flow in the lithosphere and the asthenosphere.

Second, we present the outline of a project that aims at producing high-resolution, quantitative models of seismic properties at the basin scale, by adjoint-based full waveform inversion of long-streamer multi-channel seismic data. At this scale, full waveform inversion is expected to provide sub-wavelength images of multiple parameters as seismic velocities, density, anisotropy and attenuation, that can be in turn linked to properties of great interest for the characterisation of the reservoirs, such as rock porosity and fluid content. Moreover, we expect these images to provide new insights into the nature of structures of debated origin, including the Porcupine Median Ridge, and therefore to contribute to the understanding of the tectonic history of the basins.

iCRAG is funded under the SFI Research Centres Programme and is co-funded under the European Regional Development Fund.

Investigating Ocean Generated Microseisms Offshore Ireland

Le Pape, F.[1], Bean, C.[1], Jousset, P.[2], Craig, D.[1], Donne, S.[1], Möllhoff, M.[1], Horan, C.[1], Hogg, C.[1], McCann, H.[1]

[1]*Irish Centre for Research in Applied Geosciences (iCRAG), Geophysics Section, Dublin Institute for Advanced Studies (DIAS), Dublin, Ireland*

[2]*Helmholtz Center GFZ Potsdam, Germany*

In January 2016, 10 broadband Ocean Bottom Seismometers (OBSs) stations, including acoustic sensors (hydrophone), were deployed across the shelf offshore Donegal and out into the Rockall Trough in order to study microseisms. In contrast to earthquakes, microseisms represent continuous background low frequency seismic signals generated by ocean wave pressure fluctuations on the sea floor. With the presence of the stormy NE Atlantic, Ireland is ideally located to investigate further our understanding of ocean generated microseisms. The instruments were recovered in August 2016 providing eight months of seismic and acoustic data from both shallow and deep water regions. The network also had the capability to detect possible micro-earthquakes in the region. Meanwhile, 2D numerical simulations have been carried out to study the coupling of seismic and acoustic signals at the sea bed and its evolution in both the deep water and shelf areas. Ultimately, synthetic and the recently acquired OBS seismic data can be compared to help better understand microseism source locations as well as the effect of the water column and sediments thicknesses on signal propagation. Through recent methodological developments in 'noise correlation' imagery ocean generated background microseisms can be used for broad (regional) scale seismic imagery and time-lapse monitoring (e.g. in reservoirs), without the need to shoot active seismics, which is the motivational application area for this work.

iCRAG is funded under the SFI Research Centres Programme and is co-funded under the European Regional Development Fund and by PIPCO RSG and its member companies

New reservoir modelling approaches for high net:gross, low amalgamation reservoir sequences

Manzocchi, T.[1], Soni, K.[1], Walsh, D.A.[1], Zhang, L.[1]

[1]*Irish Centre for Research in Applied Geosciences (iCRAG), and Fault Analysis Group (FAG), School of Earth Sciences, University College Dublin*

Maximising oil recovery relies in part on decisions made on the basis of results obtained from numerical flow models of reservoirs, which depend on the modelled representation of reservoir heterogeneities at a variety of scales. Appropriate representations of heterogeneity in flow models, as well as robust means of testing uncertainties in the geological parameterisation underlying these representations, are therefore important factors in achieving reliable modelling results. Deep marine reservoir sequences often comprise hierarchical depositional elements which can be poorly interconnected despite occupying a large proportion of the volume at each scale of interest. Traditional object-based models are unable to reproduce the low amalgamation ratios at high net: gross ratios characteristics of many deep marine systems, but a novel geometrical transformation (the compression algorithm) can be applied to honour independently both parameters. A hierarchical modelling workflow centred on the compression algorithm allows the creation of full-field reservoir flow models containing sedimentological elements at scales from beds to lobes and with appropriate hierarchical amalgamation ratio and volume fractions. The method and underlying geological characterisation is being extended to consider also submarine channelised reservoirs. A drawback of the object-based method is that it cannot honour hard data recorded at wells, but encouraging results in this area have been achieved by combining the compression method with multiple point statistics (MPS) methods. A significant research effort within iCRAG aims to develop and streamline these modelling algorithms and workflows as plugins within industrial reservoir modelling software, with the ultimate aim of delivering a mainstream implementation of these improved methods for modelling deep marine reservoir systems.

iCRAG is funded under the SFI Research Centres Programme and is co-funded under the European Regional Development Fund and by PIPCO RSG and its member companies.

Multichannel Analysis of Surface Waves (MASW) for Offshore Geotechnical Investigations

McGrath, T.[1], Long, M.[1], O'Connor, P.[2], Trafford, A.[2]

University College Dublin, Dublin, Ireland

Apex Geoservices, Gorey, Wexford, Ireland

The multichannel analysis of surface waves (MASW) technique is widely used in onshore geotechnical investigations. It provides shear wave velocity (V_s) from which G_{max} can be obtained for input into foundation design. The objective of this research project was to develop the MASW technique for offshore use and to compare the results against those obtained from direct investigations. This will allow its application with some confidence to geotechnical investigations for offshore platforms, pipelines and other offshore hydrocarbon infrastructure. The technique is performed offshore in a similar manner to a traditional land based seismic acquisition. In this poster the acquisition and processing used is described briefly and the results for work carried out at a site in Dublin Bay are presented. The V_s values and geotechnical parameters obtained indirectly from the MASW technique are then compared to those obtained directly by seismic cone testing (SCPTU), showing good agreement between all three methods of investigation.

This project is funded by the Petroleum Infrastructure Programme (PIP).

The Radium quartet (^{223}Ra, ^{224}Ra, ^{226}Ra and ^{228}Ra) as natural tracers of ocean mixing along the western Irish shelf:

Nicholas, S.[1], Grassie, A.G.[1], Brereton, R.[1], MacCarthy, M.[1], Daly, E.[1], Croot. P.L.[1]

[1]*Irish Centre for Research in Applied Geosciences (iCRAG), Earth and Ocean Sciences, School of Natural Sciences, National University of Ireland Galway*

The quartet of naturally occurring radium isotopes (^{223}Ra, ^{224}Ra, ^{226}Ra and ^{228}Ra) can be used as tracers for the mixing of coastal and shelf waters and are potential indicators of natural gas release from sediments (oil/gas deposits are elevated in Radium), or in coastal margins of submarine groundwater discharge (SGD). In particular the measurement of the short lived isotopes ^{223}Ra (11 days) and ^{224}Ra (3.8 days) has become routine through the initial development of the RADECC instrument and subsequent refinement of the analysis and calibration aspects. The long lived Ra isotopes can also be measured using the RADECC after suitable in-growth in the case of ^{228}Ra and for ^{226}Ra by utilising the initial linear in-growth of ^{222}Rn.

Here we report the first results of measurements of the Ra quartet across the western Irish coastal shelf from two recent expeditions on the Celtic Explorer (CE15007 and WESPAS:CE16008 & CE16009). The different half-lives of the Radium isotopes, in combination with other tracers (Salinity, Temperature, CDOM), allows an estimation of the vertical and horizontal mixing scales along the coast which can be used to validate ocean models intended for oil spill or harmful algal bloom dispersion.

iCRAG is funded under the SFI Research Centres Programme and is co-funded under the European Regional Development Fund and by PIPCO RSG and its member companies.

Tectono-stratigraphic study across Mesozoic basins of Newfoundland and Irish conjugate margins, geodynamical implications

Pichot, T.[1], Piriou, S.[1], Laigle, J.M.[1]

[1]*Beicip-Franlab, 232 Avenue Napoleon Bonaparte, 95200 Rueil-Malmaison, 92500, France*

The Newfoundland and the Irish passive conjugate margin broke apart by the end of Albian time. Nevertheless, some critical aspects of tectonic evolution of the Porcupine and Rockall Basins still remain in debate. Two of the main issues concerns the influence of the Late Jurassic rifting over the spatial distribution of the restricted anoxic environments providing organic-rich source rocks during this period and the timing of the rifting further west affecting the Rockall and Orphan area. Within the framework of a consistent and global tectonic framework over North Atlantic margin, a tectono-stratigraphic interpretation is proposed across both margins. High quality seismic data across the Irish basins correlated with most recent publications and well data have allowed an up-to-date assessment of the tectono-stratigraphy of the Irish basins. The timing and structural style of the deformation of the Porcupine – Rockall Basins can be compared with the Flemish Pass - Orphan Basins through regional seismic lines. This has provided key information to understanding of the rifting evolution of these conjugate margins.

The Late Jurassic deformation in the Porcupine Basin is very similar to the eastern Orphan - Flemish Pass Basins resulting in considerable crustal thinning. Both the timing and the thinning of the crust look very similar. These observations suggest that these basins have shared the same tectonic evolution linked to each other during Jurassic times. Further west, the Late Jurassic half-graben structures described in the Central Orphan Basin can be compared to the perched marginal basins such as Bróna, Pádraig, Macdara basins. This Late Jurassic NE-SW-directed extensional stage is coincident in terms of direction and timing with the climax of the Newfoundland-Iberia rifting.

In the south-eastern part of both margins (i.e. south Porcupine and East Orphan-Flemish Pass Basins), the Neocomian faults are the result of mainly reactivation, although some sub-basins recorded localised high Early Cretaceous subsidence. The Western part of the Orphan Basin and the Rockall Basin share common characteristics. These include an Early Cretaceous tectonic subsidence, crustal thinning (hyper-extension) and Early Cretaceous volcanic intrusions. Here in some discrete locations Late Jurassic syn-rift sediments confirm the influence of the Late Jurassic rifting in the area. The "Middle" Cretaceous deformation is sealed by the Late Albian strata. The associated faults are restricted to the edge of the both continental margins, with a NW-SE trend similar to the seafloor spreading direction. The base Tertiary can always be well defined on seismic of both margins. Progressive downlaps overlying the base Tertiary serve to illustrate a regional thermal subsidence of the basin.

The associated Mesozoic basins (Porcupine, Rockall, Orphan and Flemish Pass Basins) record more than 65 Ma of continental extension. Late Jurassic rifting corresponds to a deformation phase with a general NE-SW lineament. A wide region was affected by this stage and can be divided into two branches; one to the west corresponding to the Eastern Orphan – Flemish Pass and Porcupine and Rockall that experienced hyperextension without achieving continental breakup and an eastern branch that ruptured and spreading between Newfoundland and Iberia by the Late Aptian time. North-westward migration of the deformation continued further west and culminated with the "Middle" Cretaceous continental breakup between Newfoundland and Irish margins.

This project is funded by the Petroleum Infrastructure Programme (PIP).

Early and Late Jurassic Source Rock Well-Correlations through the Irish-Newfoundland Conjugate Margin

Piriou, S.[1]
[1]*Beicip-Franlab, 232 Avenue Napoleon Bonaparte, 95200 Rueil-Malmaison, 92500, France*

Funded by PIP and Nalcor, a synthesis has been conducted by Beicip-Franlab on available geochemistry data from the North Atlantic basins in order to map the distribution of potential Mesozoic source rocks and their quality on the Newfoundland-Labrador-Ireland conjugate margin. After data compilation of 343 wells, a stratigraphic analysis has been undertaken by integrating well-logs, biostratigraphic and lithological data, previous and new Rock-Eval measurements, as well as *Carbolog*© analysis applied to 20 key-wells. Along a selection of well-log panels, here are presented and compared the source rock distribution within Early Jurassic and Late Jurassic intervals between the margins.

In Early Jurassic strata, three organic-rich intervals (Sinemurian, Late Pliensbachian and Toarcian) are identified across the basins. Their characteristics vary from one area to another but the quality usually improves in Pliensbachian-Toarcian thanks to a less shallow depositional setting. Marine kerogen Type II are clearly observed on northern Irish margin (Slyne Basin) in the anoxic Portree dark Shale Formation with high TOC and HI, which values range respectively from 4 to 6% and 400 to 600mgHC/g, while on southern Irish margin, oil-gas-prone kerogens Type II/III are identified (TOC range from 1 to 3%; HI range from 50 to 300mgHC/g) probably due to persistence of well-oxygenated shelf conditions. New Rock-Eval analysis from Goban Spur evidences a good potential source rock especially in Pliensbachian. On the Newfoundland margin, Early Jurassic is marked by a development of a thick carbonate shelf sequence (Iroquois Fm and Whale Mb). Gas-prone kerogen is generally identified with organic content inferior to 2%.

Within Late Jurassic strata, five organic-rich layers have been defined with distinctive quality and specific spatial distribution. The carbonate Kimmeridgian Egret Member in Jeanne d'Arc Basin consists of one of the most prolific source rock. Marine in origin, this layer is particularly well marked by a very high HI

content (between 500 to 700mgHC/g) in southern part. This event is predated by another organic-rich layer in Early Kimmeridgian especially in Jeanne d'Arc Basin. Northwards, the lateral equivalent of Egret Member can be easily correlated up to Flemish and Orphan basins but its quality changes due to a more terrestrial influx in paleo-environment. The same conclusion can be made in Porcupine Basin. Tithonian strata contain other major potentialities: two organic layers are well identified in Flemish, Orphan and Porcupine basins with higher effective thickness (compared to Jeanne d'Arc Basin) probably due to a more rapid subsiding setting linked to Late Jurassic rifting. On southern Irish margin, the Late Jurassic corresponds to a regressive period in response to Goban Spur uplift. This situation contributed to the formation of a thick lacustrine source rock (type I) in North Celtic Sea area (Lower Purbeck unit). On the Rockall margin (at well 12/02-2), a good organic event (Tithonian age) is also recorded with a TOC range of 2-3% and a HI mean of 300mgHC/g which bodes well for exploration potentialities in Rockall Basin.

This project is funded by the Petroleum Infrastructure Programme (PIP).

Deep-sea carbonate mounds as archives of submarine canyon processes

Power, K.[1,4], Wheeler, A.J.[1,4], Crowley, Q.[2,4], Georgiopoulou, A.[3,4]

[1]*School of Biological, Earth & Environmental Science, University College Cork*

[2]*School of Natural Sciences, Trinity College Dublin*

[3]*School of Earth Sciences, University College Dublin*

[4]*iCRAG (Irish Centre for Research in Applied Geosciences)*

Submarine canyons are large, dynamic sites that act as conduits between continental shelf waters and the deep sea. Many are recognised as VMEs (Vulnerable Marine Ecosystems) for hosting slow growing, long lived biocoenosis (deep-water coral reefs and mounds, coral walls, coral and sponge "gardens"). Improvements in technology have only recently put these environments within the grasp of discovery science, but also the depth range of deep trawling expeditions, meaning these poorly understood and unique habitats are at risk of being irreversibly damaged before being studied or even discovered. Ireland's largest submarine canyon, the Porcupine Bank Canyon, is designated as a SAC (Special Area of Conservation), protected from fishing activities. With no connection to a terrigenous river system, the processes that occur there are hypothetically devoid of any anthropogenic influence. This makes it an ideal analogue to study and better understand natural canyon depositional processes, and how these environments have changed over time.

Two recent research cruises (QuERCi I & II, 2015 & 2016) assessed the distribution of coral species and rock outcrops in the canyon, and sampled carbonate mounds that occur in a unique position on the edge of the canyon head, spreading down the canyon flank. Given their integration into the canyon system, the opportunity exists to study the mounds as conventional geological archives recording canyon sedimentation and environmental variability. Long lived scleractinian ("stony"/hard calcitic skeleton) corals sampled from the carbonate mounds will undergo geochemical analysis at Trinity College Dublin. These corals preserve the properties of the ambient seawater conditions within their skeleton during calcification, recording isotopic signals of change in their local environment during the duration of their growth. Push cores extracted from the mounds will act as a depositional archive with a comparable timescale, through microfaunal and compositional analysis. Coupled together, the sedimentary and biological archives will produce a short term but high resolution record of environmental variation in a canyon system.

iCRAG is funded under the SFI Research Centres Programme and is co-funded under the European Regional Development Fund and by PIPCO RSG and its member companies

Along-axis crustal structure of the Porcupine Basin from seismic refraction data modelling

Prada, M.[1], Watremez, L.[2], Chen, C. [2,3], O'Reilly, B[1], Minshull, T.[2], Reston, T.[4], Kläschen, D.[5], Shannon, P.M.[6], Wagner, G.[5], Gaw, V.[5]

[1]*Geophysics Section, Dublin Institute of Advanced Studies, Dublin, Ireland*

[2]*University of Southampton, Southampton, UK*

[3]*National Oceanography Centre, Southampton, UK*

[4]*School of Geography, Earth and Environmental Sciences, University of Birmingham, Birmingham, UK*

[5]*Geomar Helmholtz Centre for Ocean Research, Kiel, Germany*

[6]*School of Earth Sciences, University College Dublin, Dublin, Ireland*

The tectonic history of the Porcupine Basin, SW of Ireland, involved several rifting and subsidence phases during the Late Palaeozoic and Cenozoic. Stretching factors (β) derived from subsidence analysis are < 1.5 in the northern part of the basin and increase significantly southwards, where they were estimated to be > 6. However, recent crustal seismic studies concluded that β along the basin axis is significantly higher, suggesting hyperextension and mantle serpentinisation in the basin. Constraining β and the formation processes of the basin will provide insights into the tectonic response to lithospheric extension and the thermal evolution of the basin. Here we present the tomography results of five wide-angle seismic (WAS) profiles acquired across and along the basin axis. The results improved constraints on the location of the base of the crust and allow to estimate maximum β (β_{max}) along each profile. β_{max} in this study are 5-6 times larger than estimates from subsidence analysis in the north. Towards the south, β_{max} increases up to 10-12, but then rapidly decreases to 3.3 southwards. The values in the north and central region are well within the range at which the crustal embrittlement, and hence, major crustal faulting and mantle serpentinisation are expected at magma-poor margins. In agreement with this observation, velocity values of the mantle are lower than those expected for unaltered mantle, supporting mantle serpentinisation. Our results reveal a complex crustal structure that poses key questions concerning the deep formation processes, and hence, the petroleum systems of the Porcupine Basin.

This project is funded by the Petroleum Infrastructure Programme (PIP).

Diagenetic history and reservoir quality of the Carboniferous and Permo-Triassic reservoirs in the Rathlin Basin, Northern Ireland

Raine, R.

British Geological Survey (GSNI), Dundonald House, Upper Newtownards Road, Belfast, BT4 3SB

The Rathlin Basin, onshore Northern Ireland, represents an underexplored area, yet one prospective for hydrocarbons. The basin is filled with over 3 km of sediments and volcanics of Carboniferous to Palaeogene age. The internal structure of the underlying sedimentary basin is largely obscured by the thick cover of the Palaeocene Antrim Lava Group, which inhibits the acquisition of good quality seismic data. The principal targets for hydrocarbon exploration have been the Carboniferous and Permo-Triassic sandstones but to date only one exploration well has been drilled and there are only two other boreholes in the basin more than 1 km deep. Reservoir quality data on these potential reservoir rocks is sparse and this study adds significantly to the existing datasets. Detailed thin section petrography was carried out on 70 samples from the Carboniferous and Permo-Triassic from borehole and outcrop samples, along with poroperm, XRD and SEM analyses. Results show that the Carboniferous and Permo-Triassic reservoirs differ in their primary mineralogy, diagenetic history and resulting reservoir quality. The most noticeable difference between sandstones is the feldspar content, with many Permo-Triassic samples being

feldspathic or subfeldspathic arenite, and Carboniferous samples almost exclusively quartz arenite. Although there was likely a depositional control on the original/primary feldspar content, uplift at the end of the Carboniferous and associated feldspar dissolution has resulted in 'diagenetic' quartz arenites. Residual hydrocarbons were discovered in Carboniferous strata from the Magilligan borehole, from the adjacent upfaulted Ballycastle coalfield, and a small amount of oil was recovered from the Ballinlea-1 well, located toward the basin depocentre. Deep burial led to the generation of hydrocarbons, probably from the Triassic onwards, with peak oil generation in the Palaeogene, but some reservoirs are likely to have been breached during faulting in the Palaeogene and/or Neogene. Sandstones display good reservoir quality and there is a thick regional seal. One uncertainty is the presence of good source rocks and their maturity, but the proximity of the Ballycastle coalfield and common evidence of hydrocarbon staining in samples suggests that this is not a major risk. The identification and structural integrity of potential traps is the key unknown.

Style, geometry and characteristics of Cenozoic inversion structures in the Celtic Sea basins, offshore Ireland

Rodriguez-Salgado, P.[1, 2*], Childs, C.[1, 2], Shannon, P.M.[1, 3], Walsh, J.J.[1, 2]

[1]*Irish Centre for Research in Applied Geosciences (iCRAG), University College Dublin, Belfield, Ireland*

[2]*Fault Analysis Group, School of Earth Sciences, University College Dublin, Belfield, Ireland*

[3]*Marine and Petroleum Geology Research Group, University College Dublin, Belfield, Ireland*

Compressional structures developed as a result of Cenozoic inversion are well known along the north-western Atlantic passive margin but, despite their significance in North Atlantic petroleum systems, many details of their mechanisms of formation remain unclear. These structures are widely developed within the Celtic Sea basins, south of Ireland, where they have special relevance as the main trapping mechanisms for most of the existing producing gas fields and currently undeveloped oil accumulations.

The primary aim of this work is to identify and compare Cenozoic inversion structures in the Celtic Sea basins through regional seismic interpretation of several 2D seismic surveys provided by the Petroleum Affairs Division (PAD). The study area includes the North Celtic Sea Basin, the northern margin of the South Celtic Sea Basin and the north-eastern Fastnet Basin.

Seismic interpretation and mapping of key horizons (Base Chalk, Berriasian Unconformity and Top Basement) has identified more than 30 inversion structures and constrained their ages of formation. All the mapped structures are elongate, low relief anticlines showing a predominantly ENE – WSW orientation. This orientation coincides with the pre-inversion Mesozoic extensional fault trends that configure the basin geometry which in turn follow the orientations of older Caledonian and Variscan structures.

Despite these common characteristics, the inversion structures show differences in the mechanisms controlling their growth depending on location within the basin. Structures close to the basin depocentres (pre-inversion infill thickness > 3 km) tend to be wide, asymmetrical domes controlled by deep blind thrust faults or wide symmetrical structures controlled by buttressing between normal faults. In contrast, structures at the basin margins (pre-inversion infill thickness < 3 km) are tighter symmetrical and elongated anticlines controlled by reverse reactivation of major Mesozoic extensional faults or shallow low angle thrust faults.

iCRAG is funded under the SFI Research Centres Programme and is co-funded under the European Regional Development Fund and by PIPCO RSG and its member companies

Multiphase deformation history of the Porcupine Basin, offshore west Ireland

Mudasar Saqab, M.[1], Childs, C.[1,2], Walsh, J.[1,2], Delogkos, S.[2]

[1]*Irish Centre for Research in Applied Geosciences (iCRAG), School of Earth Sciences, University College Dublin*

[2]*Fault Analysis Group, School of Earth Sciences, University College Dublin*

The Porcupine Basin is a large underexplored sedimentary basin located in the offshore west of Ireland. It is a part of the structurally complex European North Atlantic Margin. The basin has evolved through multiple Jurassic-Recent phases of deformation. Although the overall plate tectonic context of the margin is well-documented, many uncertainties regarding phases of tectonic activity, strain distribution and fault kinematics persist. This study aims to better understand the nature and evolution of fault systems in the Porcupine Basin based on analysis of large volumes of 2D and 3D seismic data. Various fault systems are observed and genetically classified into non-tectonic and tectonic faults. The non-tectonic faults occur within specific stratigraphic intervals suggesting a compactional/gravitationally driven origin, i.e. basinward dipping normal faults within a Paleocene-early Eocene deltaic sequence, and polygonal faults within late Eocene and Neogene strata. In addition, three distinct phases of tectonically induced extensional faulting are recognised, they are: (i) Jurassic north-south trending syn-rift faults, (ii) Cretaceous east-west trending normal faults, and (iii) Mid Eocene-Oligocene north-south trending faults. The later phase of structuration coincides with the onset of spreading between Europe and Greenland (Atlantic spreading) and a period of rapid subsidence in the Porcupine Basin. It also resulted in reactivation of some of the Jurassic faults. The Mid Eocene-Oligocene faults are strongly segmented and focused along the basin margin, above the underlying Jurassic faults. The linkage of Cretaceous and younger faults with the underlying Jurassic syn-rift faults is controlled by: (i) relative position and orientation of different fault sets, (ii) fault size, and (iii) thickness of the intervening layer (decoupling zone).

iCRAG is funded under the SFI Research Centres Programme and is co-funded under the European Regional Development Fund and by PIPCO RSG and its member companies.

A new TOC, Rock-Eval and carbon isotope record of Lower Jurassic age from the Slyne Basin, offshore Ireland

Silva, R.L.[1], Carlisle, C.[1], Wach, G.[1]

[1]*Basin and Reservoir Laboratory, Dept. of Earth Sciences, Dalhousie University, Halifax, NS, Canada*

This presentation summarises the main findings of a manuscript currently under review where we presented a novel total organic carbon, Rock-Eval pyrolysis, and carbonate and kerogen $\delta^{13}C$ record of Upper Sinemurian–Aalenian age from the Slyne Basin (well 18/25-1 from the Corrib Gas Field), offshore Ireland.

Total organic carbon and Rock-Eval pyrolysis data highlights the Lower Toarcian as mature source rock dominated by type II kerogens. The $\delta^{13}C$ record is remarkably similar to contemporaneous datasets from several locations along the Atlantic margins: a positive carbon isotope excursion during the Upper Sinemurian; a negative carbon isotope excursion followed by a positive carbon isotope excursion during the uppermost Sinemurian–Lower Pliensbachian; and the negative carbon isotope excursion linked with the Toarcian Oceanic Anoxic Event.

This new dataset, especially the recognition of the Sinemurian and Lower Pliensbachian carbon isotope excursions, is a new addition to the understanding of the paleoenvironmental dynamics during the Lower

Jurassic, the extent and causes of the secular events that ultimately led to the T-OAE, and opens new possibilities for hydrocarbon exploration in Ireland's offshore.

This project is funded by the Petroleum Infrastructure Programme (PIP).

Excess Pressure & Reservoir Compartmentalisation in the Porcupine Basin (Ireland) and Sable Sub-Basin (Nova Scotia, Canada)

Skinner, C.H.[1], Silva, R.L.[1], Richards, B.[1], Watson, N.[2], Wach, G.[1]

[1]*Basin and Reservoir Lab, Department of Earth Sciences, Dalhousie University, Halifax, NS B3H 4R2*

[2]*Atlantic Petrophysics Ltd., Halifax, NS*

Pressures in pore spaces of rocks are crucial for petroleum exploration and production. However, the sudden onset of excess pressure when drilling is potentially dangerous if not properly identified, understood, and managed. Increased understanding of the geological context and contributing factors to excess pressure in pressure cells or compartments can reduce drilling and environmental risks, and financial costs during exploration and development of offshore resources. Excess pressure has been identified as a poorly understood risk element in the Porcupine Basin, with limited previous study.

The distribution and dissipation of pressure in the Porcupine Basin is controlled by reservoir connectivity, which is ultimately dependent on the permeability and a result of the relationship between regional basin morphology, stratigraphy, and seal integrity. Excess pressure - depth plots were generated to enable comparison of the excess pressure to depth for observable correlations and trends, with the data classified by flow units. Plots demonstrated that there are two general increases in excess pressure, at approximately -2900 m TVDSS and -3700 m TVDSS.

In order to more fully understand pore pressures, formation mechanisms, and basin plumbing, studies must investigate what happens in three dimensions. Future work should focus on developing geometrical models populated with petrofacies, permeability data, pressure data, and hydrocarbon contacts. This would enable analysis of the calculated pore space and the permeability product in the reservoir overlap area along fault planes, and investigation into possible links with rates of fluid and reservoir pressure migration. The model created for this study is a two dimensional static model; a dynamic model would better serve to recreate and better predict excess pressure in undrilled sections of the region. Thermal modelling of wells would provide further insight on the thermal and maturation history of the region, which in turn could increase knowledge surrounding excess pressure mechanisms in the Porcupine Basin.

This project funded by the Petroleum Infrastructure Program (PIP).

Hierarchical characterisation of submarine channels: insights from 3D seismic data from the Taranaki Basin, offshore New Zealand

Soni, K.[1, 2], Manzocchi, T.[1, 2], Haughton, P.D.W.[1, 3]

[1] *Irish Centre for Research in Applied Geosciences (iCRAG), School of Earth Sciences, University College Dublin, Ireland*

[2] *Fault Analysis Group, School of Earth Sciences, University College Dublin, Ireland*

[3] *Marine and Petroleum Geology Group, School of Earth Sciences, University College Dublin, Ireland*

Submarine channels are major conduits of sediment transport from the shelf to the basin floor. They preferentially erode along the slope and deposit along the basin floor. Classification schemes for defining the structure of submarine channel systems must consider the size, connectivity, fill type and stacking of elements deposited at different hierarchical scales and deposited with different levels of confinement. This work focuses upon defining and parameterising a hierarchical classification scheme for these systems, which will subsequently be used to define flexible reservoir modelling approaches capable of capturing a wide range of depositional geometries honouring realistic hierarchical scales of reservoir heterogeneity and connectivity.

Preliminary results presented in the poster derive from analysis of 3D seismic data from the Taranaki Basin, offshore West New Zealand, and by compiling observations published in the wider literature. Seismic analysis has focused on a well imaged channel-lobe system from the Late Miocene-early Pliocene Mangaa Formation deposited in a local topographic low bounded by the syn-sedimentary Cape Egmont and Parihaka faults. Two hierarchical levels are evident in the dataset: discrete channel elements within a channel complex within a moderately-significantly confined topography. RGB blending of dominant frequencies brighten subtle features such as meander cut-offs, channel belt edges and active paleo-channels, which guide in channel boundary interpretation along with information on thickness of channel fills. Quantitative analysis has centred on measuring connectivity between channel elements using the amalgamation ratios, volumes fractions of different hierarchical elements, and lateral migration and vertical aggradation of channels, with a focus on how these parameters vary as a function of confinement and the gradient of the slope on which they were deposited. The literature analysis is used to place the measurements from this particular system within a wider context, and to consider likely character of sub-seismic hierarchical levels. The ultimate aim is to constrain input to object-based modelling workflows able to reproduce main characteristics of different channelised systems at different hierarchical levels.

iCRAG is funded under the SFI Research Centres Programme and is co-funded under the European Regional Development Fund and by PIPCO RSG and its member companies.

Quaternary stratigraphy on the nearshore continental shelf of the Celtic Sea, SE Ireland

Tóth, Z.[1,2], Wheeler, A.J.[1,2], McCarron, S.G.[1,3], Murphy, P.[2,4], Coughlan, M.[4], Monteys, X.[5]

[1]*iCRAG – Irish Centre for Research in Applied Geosciences, Ireland;*

[2]*School of Biological, Earth and Environmental Sciences, University College Cork, Cork;*

[3]*Maynooth University, Dublin;*

[4]*Gaelectic Developments Ltd., Dublin;*

[5]*Geological Survey of Ireland, Dublin, Ireland*

The objective of this study is to define a Quaternary stratigraphic framework in the nearshore shelf to enable desktop evaluations and de-risk building offshore infrastructure such as the deployment of seabed infrastructure (pipelines, cables, wind turbines, etc.). This requires an understanding of recent sediments and their geotechnical properties. The stratigraphic model will also help to reconstruct the evolution and dynamic behaviour of the southern Irish part of the British-Irish Ice Sheet (BIIS) that drives the stratigraphy.

In recent years, a more extensive last Irish ice sheet has been proposed based on new sedimentological and chronological constraints on Ireland's south coast stratigraphy. Coastal exposures of Pleistocene sequences in SE Ireland suggest that the northern Celtic Sea was not only glaciated, but likely experienced ice-marginal oscillations and multiple phases of ice cover from different sources of the British-Irish Ice Sheet. Evidence from sediment cores also indicates that a grounded ice stream likely extended across the Celtic Sea to the continental shelf edge. However, little is known about the nearshore Quaternary sedimentary record that was heavily influenced by ice advances and retreats. We analysed an extensive seismo-acoustic data set that images the recent glacial and post-glacial deposits at the south coast of Ireland as the first phase of this project.

The coastal area in the Celtic Sea between Dungarvan and Waterford Harbour was mapped using acoustic Sparker and Pinger data, and the multibeam bathymetry data produced by the INFOMAR programme. The acoustic data reveal evidence of glacial activity in the area: major structural features include several valleys and large depressions cut into the bedrock, a buried esker-like ridge and N-S oriented linear ridges at the seafloor. In total, six seismostratigraphic units were identified based on their seismic reflection pattern, reflection attributes, and bounding reflections. The seismostratigraphic interpretation suggests a complex Quaternary history offshore southern Ireland with the presence of a grounded ice sheet, a halt in its retreat and a short existence of an ice-dammed lake or glaciomarine conditions.

iCRAG is funded under the SFI Research Centres Programme and is co-funded under the European Regional Development Fund and by PIPCO RSG and its member companies.

Thermal history modelling in an extensional basin

Tunwal M.[1,2], Mulchrone K.F.[2], Meere P.A.[1]

[1]*School of B.E.E.S., UCC, Distillery Fields, North Mall, Cork*

[2]*Department of Applied Mathematics, UCC, Western Gateway Building, Western Road, Cork*

Temperature plays an important role in many geological phenomena. In sedimentary basins, maturation of hydrocarbon source rocks depends on the temperature history after deposition. Sedimentation rate, geothermal gradient and duration of sedimentation are therefore key parameters controlling the thermal

evolution. The McKenzie model is a widely accepted model for extensional basin formation which can be used for estimating post-rift subsidence and rate of sedimentation.

In this work a numerical model in 1D has been implemented based on McKenzie's model and allows the estimation of the thermal evolution of post-rift sediments. The finite difference method is used to solve the heat equation in the sediments, crust and upper mantle. At each time step, subsidence due to thermal relaxation is calculated and added to the system and in this way the generalised moving boundary thermal diffusion problem is solved. Heat generated due to radioactivity can also be taken into account in this model. This model provides better accuracy and an estimate of the thermal profile of post-rift sediments as a function of time.

This project is funded by the Petroleum Infrastructure Programme (PIP).

Hydrocarbon-related research at the Irish Centre for Research in Applied Geosciences (iCRAG)

Walsh, J.J.[1]

[1]*Irish Centre for Research in Applied Geosciences, School of Earth Sciences, University College Dublin*

iCRAG is a recently established national centre for applied geoscience research in Ireland, performing research which is linked to a broad range of application areas and industries. The Centre's research programme consists of four cohesive topics or 'spokes' in the areas of groundwater, hydrocarbons, marine geoscience and raw materials, which are built around four enabling technology and equipment based 'platforms' which focus on geophysical sensing and imaging, geochemistry, 3D geological modelling and public perception and understanding. This poster focuses on our hydrocarbons research 'spoke', outlining the 18 projects that are currently underway or that have recently commenced on the broad range of topics linked to offshore hydrocarbons. Whilst the research will be conducted in several so-called Targeted Projects, the research programme will be multi-disciplinary in nature, promoting the development of across-spoke and inter-project technical linkages.

Hydrocarbon-related research is conducted within five main Targeted Projects:

(i) Sediment tracking: investigating provenance tracers, modern sand dispersal and mixing, sediment volumes, partitioning and recycling, and implications for reservoir quality. (ii) Basin evolution and petroleum systems: involving the investigation of early rift architecture, structural evolution and traps, stratigraphic onlaps and traps, hyperextended basins and their fills, stratigraphic evolution at continental-oceanic transition and thermal history/migration modelling. (iii) Reservoir modelling and software development: involving reservoir modelling and imaging, including stratigraphic modelling, well/seismic conditioning and reservoir monitoring, (iv) Unconventional hydrocarbons and (v) Global Subsurface Training Centre in Clare.

iCRAG is funded under the SFI Research Centres Programme and is co-funded under the European Regional Development Fund and by PIPCO RSG and its member companies.

Irish Centre for Research in Applied Geosciences (iCRAG)

Walsh, J.J.[1]

[1]*Irish Centre for Research in Applied Geosciences (iCRAG), UCD School of Earth Sciences, University College Dublin*

iCRAG is a recently established national research centre which will transform applied geoscience research in Ireland, performing research which is designed to deliver economic impact for a broad range of application areas and industries. The Centre brings together Ireland's leading geoscience experts focusing on a range of issues all of which underpin economic development - from safe and secure groundwater supplies through to the discovery of mineral/aggregate deposits, and from the de-risking of oil and gas exploration to ensuring that the Irish public is educated and informed on these issues. Supported by Science Foundation Ireland and industry partners for the next six years, iCRAG is one of only 12 SFI Research centres, and the first national geosciences initiative to be supported by SFI's flagship funding scheme. iCRAG is a collaboration between 150 researchers within UCD, TCD, NUIG, UCC, NUIM and DIAS and more than 50 industry partners who will work in partnership with government agencies involved in the geosciences sector.

iCRAG's research programme consists of four cohesive topics or 'spokes' in the areas of raw materials, marine geoscience, groundwater and hydrocarbons which are built around four enabling technology and equipment based 'platforms' which focus on geophysical sensing and imaging, geochemistry, 3D geological modelling and public perception and understanding. It will capitalise on Ireland's unique geological resources, including its world-class base metal deposits, its unusually extensive and highly prospective offshore basins and its world-class lowland karst and fractured bedrock aquifers. The principal goal is to embed the outcomes of high quality research within industry practice in Ireland and overseas.

Instead of outlining the full range of iCRAG research, this poster describes some of the research conducted outside of the hydrocarbons spoke which is pertinent to technical issues confronted by the petroleum industry. This includes our marine-related research involving three main Targeted Projects: (i) Marine Acoustics, (ii) Enhancing knowledge and understanding of Ireland's seabed and (iii) Marine remote sensing applications. The broad range of research topics linked to offshore hydrocarbons is the subject of a separate poster. In total there are currently 39 projects either currently underway or recently commenced with a further 18 directly related to hydrocarbons.

iCRAG is funded under the SFI Research Centres Programme and is co-funded under the European Regional Development Fund and by PIPCO RSG and its member companies.

A new workflow for generating low amalgamation, high net:gross geomodels constrained to well data

Walsh, D.A.[1,2], Manzocchi, T.[1,2]

[1]*Irish Centre for Research in Applied Geosciences (iCRAG),School of Earth Sciences, University College Dublin*

[2]*Fault Analysis Group, School of Earth Sciences, University College Dublin*

The ability to generate geologically realistic reservoir models that honour the available well and seismic data is an important step in predicting reservoir production behaviour. Many deep marine turbidite reservoirs are often characterised by poorly amalgamated sand bodies interbedded with low permeability shales. Although these systems often have high net:gross ratios, the low connectivity of the sandstones has a strong control on reservoir performance but is often poorly reproduced in reservoir geomodels.

A new class of object-based model uses a so-called “compression” method in order to reproduce poorly amalgamated but high net:gross ratio sequence typical of many lobe reservoirs. The compression method allows the net:gross and amalgamation ratios to be separate inputs into the modelling workflow, but is based on conventional object based methods which are notoriously difficult to condition to well data. The recently-developed multiple-point statistics approach is pixel-based so models can be easily conditioned, and uses a training image to recreate the desired geological architecture. We have developed a new workflow that combines the compression algorithm with the multiple-point statistics method in order to create geologically realistic models that have realistic levels of sand amalgamation yet honour the available well data.

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Generating long-term records of seabed environmental conditions in support of drill-operation EIAs and other iCRAG Marine Spoke projects

Wheeler, A.J.[1,2], Power, K.[1,2], Crowley, Q.[1,3], Georgiopoulou, A.[1,4], Bean, C.[1,6], Croot, P.[1,5], McCarthy, T.[1,7], Cahalane, C.[1,7], Nicholas, S.[1,5], Tóth, Z.[1,2], Walsh, D.[1,7]

[1]*Irish Centre for Research in Applied Geosciences (iCRAG)*

[2]*Geology, School of Biological, Earth & Environmental Sciences, University College Cork, Cork, Ireland.*

[3]*Geology, School of Natural Sciences, Trinity College Dublin, Dublin*

[4] *School of Earth Sciences, University College Dublin, Dublin*

[5]*Earth & Ocean Sciences, National University of Ireland – Galway, Galway*

[6]*Geophysics, School of Cosmic Physics, Dublin Institute of Advances Sciences, Dublin*

[7]*National Centre for Geocomputation, National University of Ireland – Maynooth*

An outline of marine spoke projects is provided, namely:

- The development of cold-water coral biochemical environmental seabed archives
- The use of passive acoustics to generate a better picture of offshore wave-climates,
- Developing shallow sub-seabed seismic stratigraphic models and databases to assist infrastructure installations
- Remotely sensed natural and anthropogenic oil slick mapping linked to cloud based software tools
- Influence of natural biogeochemical controls on primary productivity on the optical properties of surface seawater with a focus on the use of cold-water corals as archives of changes on the seabed environment.

The oil industry needs to drill. The impact of drilling can be localised and may even be beneficial to some organisms but responsible operations requires an assessment of the nature and extent of the impact on the seabed environment which usually translates as the impact on marine organisms. Responsible environmental practice should involve an assessment of impact – a before, (during) and after assessment. However, deep sea seabed environments are dynamics and poorly understood. Natural negative changes can be erroneously and unfairly blamed on industrial intervention.

It is in the interest of the industry to not just take snapshots to determine what is there but to understand the natural dynamics in an environment. Monitoring is expensive and requires a long run-in to realistically determine natural dynamics and cannot determine processes that manifest over decades.

We present a method for accessing archives of environmental change on seasonal to decadal timescales stored in *Lophelia pertusa* and *Desmophyllum dianthis* cold-water corals. Geochemical elemental assessment from coral growth rings (Li, Mg, Ca, Sr, Ba, Cd, Nd, U and REE) generates proxies for changes in temperature and nutrient flux. A highly dynamic canyon head environment (Porcupine Bank Canyon) within the Porcupine Bank "area of sensitivity" overlying the South Bróna Basin is studied and sampled. Extensive areas of cold-water coral exist benefiting from an intensification of currents activity on the steep canyon head topography. Strong currents also provide exposures of bedrock that are imaged but have proved hard to sample. Preliminary coral geochemical data shows high seasonal variability and a trend of ocean warming.

iCRAG is funded under the SFI Research Centres Programme and is co-funded under the European Regional Development Fund and by PIPCO RSG and its member companies.

Post-rift evolution of hyperextended basins: Lower Cretaceous tectono-stratigraphy of the Porcupine Basin

Whiting, L.[1], Haughton, P. H.[1]., Shannon, P. M.[1]

[1]*Irish Centre for Research in Applied Geosciences (iCRAG), UCD School of Earth Sciences, University College Dublin, Ireland*

The Porcupine Basin is unusual in that it displays a strong north-to-south lateral strain gradient along with evidence for hyperextension and a central ridge that has been variously interpreted as volcanic, a buried fault block or a serpentinite diapir/extrusion. Mid-Late Jurassic fault-controlled half graben were followed by a protracted phase of thermal subsidence during the Cretaceous. However, a feature of the post-rift Cretaceous stratigraphy is the presence in different parts of the basin of prominent unconformities that cap relatively thin but deeply eroded and structurally-rotated lowermost Cretaceous successions. Curiously, the latter are mainly preserved perched on the flanks of the main basin and are passively overstepped by the younger Lower Cretaceous infill. These earlier erosional remnants are important as they may give clues to the evolution from normal to hyperextension prior to major thermally-controlled subsidence focused along the basin axis.

The present study uses a combination of 2D and 3D seismic data to identify and examine the character, distribution and significance of the remnant early post-rift successions. Dense 2D and 3D seismic coverage in the NE Porcupine (Moling sub-basin) and ties to exploration wells 35/19-1 and 35/30-1 indicate the early post-rift here ranges from Berriasian to Aptian in age and is a mud-dominated marine sequence within minor interbedded carbonates and local turbidite sandstones. These sequences, which variably thicken and thin and locally appear to converge and onlap towards what became the later axial depocentre are truncated by an unconformity with high relief (200-500 ms TWT) referred to as the 'Intra-Aptian' unconformity. Similar unconformity-bound early post-rift packages are also recognised in the southern Porcupine Basin where they are even more strongly rotated towards the younger axial depocentre and are overstepped by the younger basin fill including a prominent continuous high-reflectivity sequence. In the southwest, the toe of a wedge-shape package which dips and thins towards the younger depocentre appears to have been rotationally overstepped and to have gravitationally failed to form a mass transport complex >10 km across. Axial correlations linking the northern and southern sectors of the basin suggest the 'Intra-Aptian' unconformity passes laterally into the aforementioned high-

reflectivity sequence and the rotation and development of the unconformity and onlap surface in the southern Porcupine could be older.

The character of the remnant early syn-rift successions challenges the notion that fault-controlled extension led directly to unfilled deep bathymetry. The syn-rift graben were largely filled during the syn-rift phase with the early post-rift tapering towards an axial uplift or arch that subsequently collapsed (earlier in the south Porcupine than in the north) rotating earlier marginal depocentres.

iCRAG is funded under the SFI Research Centres Programme and is co-funded under the European Regional Development Fund and by PIPCO RSG and its member companies.

List of Delegates

Name	Organisation
Ian Burdis	AGR Petroleum Services
Laurie Phillips	AGR Petroleum Services
Nick Chilcott	AGR Petroleum Services
Nick Ingrassia	6 Point Energy
James Massey	AECOM
Chris Rayburn	AGR
Nick Chilcott	AGR
Colin Cross	Aker Solutions Ltd
Marcus Jenkins	Anadarko Petroleum Corporation
Rob Nelson	Anadarko Petroleum Corporation
Peter O'Connor	APEX Geoservices
Helen Kerr	APT (UK) Ltd
Patrick Barnard	APT (UK) Ltd
Brendan O'Connor	AQUAFACT
Cathal Jones	Ardilaun Energy Ltd
Eoin Ryan	Ardilaun Energy Ltd
John Mc Keon	Ardilaun Energy Ltd
Mark Pearson	Ardilaun Energy Ltd
David Bolger	Austinbridgeporth
Simon Mamouney	Australian Embassy
Bernie Wayne	AzEire Petroleum Ltd
David Sturt	AzEire Petroleum Ltd
Diz Mackewn	AzEire Petroleum Ltd
Robert Murphy	AzEire Petroleum Ltd
Tom Villiers	AzEire Petroleum Ltd
Alcide Thebault	BeicipFranlab
Jean-Marie Laigle	BeicipFranlab
Samuel Piriou	BeicipFranlab
Thibaut Pichot	BeicipFranlab
Zhentao Hong	BGP Atlantic
Steve Callan	BGP Marine
William Lowry	Black Mountain Petroleum
Andrew Rawlinson	Bluestack Energy Ltd
Donal O'Driscoll	Bluestack Energy Ltd
John Robbins	Bluestack Energy Ltd
Amelia Tustin	BP
Erik Hulm	BP
Simon Grant	BP
John Ludden	British Geological Survey
Margaret Stewart	British Geological Survey
Chris Brown	Cairn Energy Plc
Ian Bulley	Cairn Energy Plc
Martin Dashwood	Cairn Energy Plc
Paul Gannon	Cairn Energy Plc
Richard Ember	Cairn Energy Plc
Simon Higgins	Cambridge Carbonates
Cameron Grant	CGG
Hari Krishna	CGG
John McKenzie	CGG
Paul Godwin	CGG
Phil Baxter	CGG GeoSpec
Alex Fowler	CGG Robertson
Alex Finlay	Chemostrat Ltd
John Lyle	Chevron
Bruce Gemmell	CODES
Ann McGarry	Commission for Energy Regulation (CER)
Ben Browne	Commission for Energy Regulation (CER)
Liam Murphy	Commission for Energy Regulation (CER)
Dave Ward	Commissioners of Irish Lights

Manus Weed	Commissioners of Irish Lights
Eamon Kelly	CONSUB Subsea Engineering
Fintan Convery	Consultant
John F Ryan	Consultant
Richard Duggan	Consultant
John Laing	Consultant Oil & Gas
Anne McAfee	Core Lab
Charlie Carlisle	Dalhousie University
Job Langbroek	Davy Research
Ferdia Marnell	Dept. of Arts, Heritage, Regional, Rural and Gaeltacht Affairs
Oliver Ó Cadhla	Dept. of Arts, Heritage, Regional, Rural and Gaeltacht Affairs
Bill Morrissey	Dept. of Communications, Climate Action & Environment
Ciarán Ó hÓbáin	Department of Communications, Climate Action & Environment
Clare Morgan	Department of Communications, Climate Action & Environment
Kara English	Department of Communications, Climate Action & Environment
Katie Hernon	Department of Communications, Climate Action & Environment
Matthew Collins	Department of Communications, Climate Action & Environment
Michael Hanrahan	Department of Communications, Climate Action & Environment
Nuala Free	Department of Communications, Climate Action & Environment
Oonagh O'Loughlin	Department of Communications, Climate Action & Environment
Orla Ryan	Department of Communications, Climate Action & Environment
Brian O'Reilly	DIAS
Chris Bean	DIAS
David Craig	DIAS
Florian Le Pape	DIAS
Giuseppe Maggio	DIAS
Javier Fullea	DIAS
Manel Prada	DIAS
Matteo Ravenna	DIAS
Nicolas Luca Celli	DIAS
Peter Readman	DIAS
Raffaele Bonadio	DIAS
Sergei Lebedev	DIAS
Thomas Farrell	DIAS
Julian Sherriff	DownUnder GeoSolutions
Marie Smyth	DownUnder GeoSolutions
Bruce Walker	Drilling Info
Jack Lee	Durham University
Jim Henderson	Durham University
Gavin Mcaulay	Earthworks Reservoir
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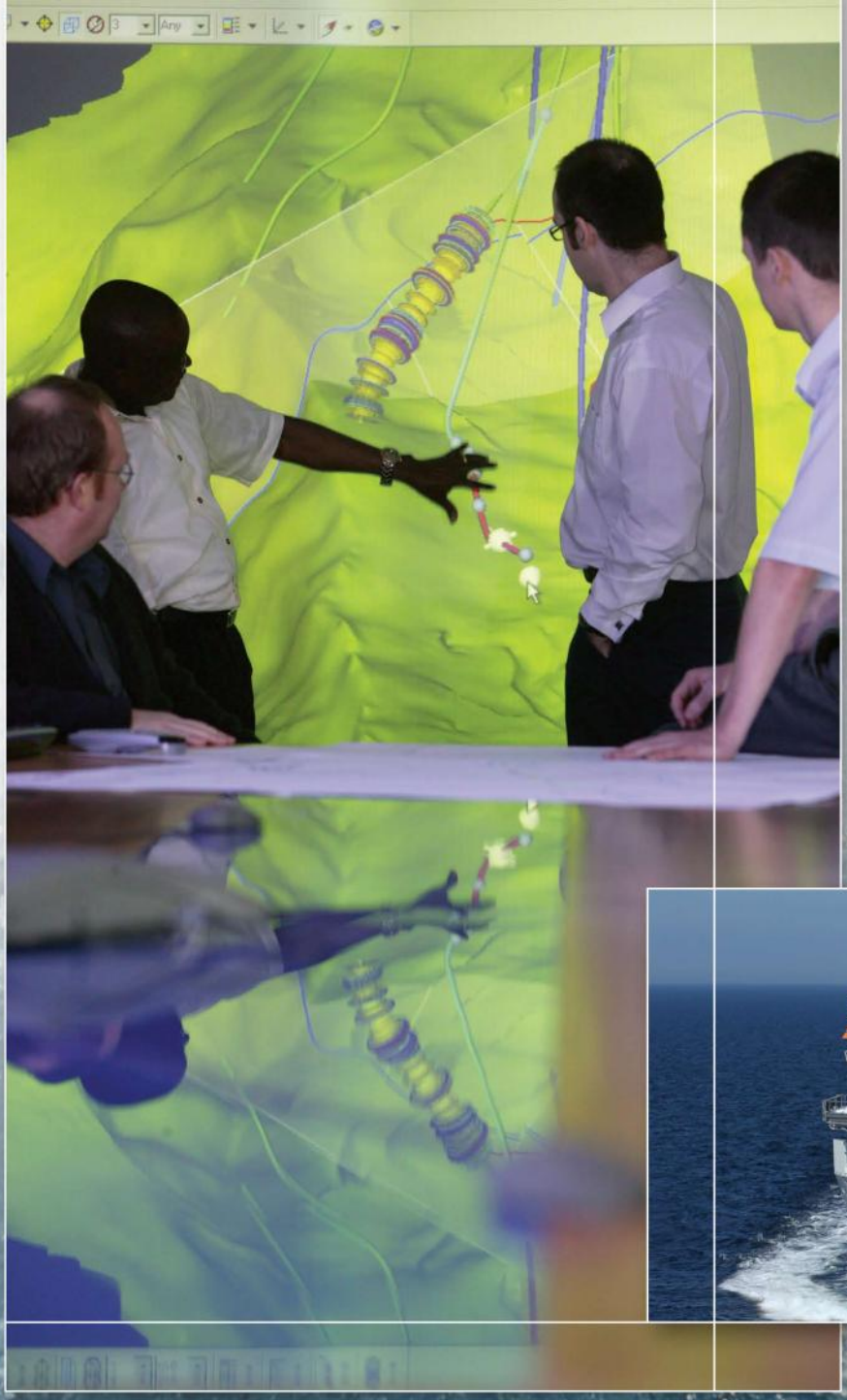

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7 Dundrum Business Park,
Windy Arbour, Dublin 14, Ireland
Tel: +353 1 296 4667, Fax: +353 1 296 4676

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