

## Ireland Atlantic Margin: a new era in a frontier basin

Richard Wrigley<sup>1</sup>, Anongporn Intawong<sup>1</sup> and Karyna Rodriguez<sup>1\*</sup> review the prospectivity of the Rockall basin offshore Ireland.

The Atlantic Margin offshore west of Ireland is one of the few remaining, largely unexplored, frontier exploration areas in Europe. The Irish Atlantic Margin Basins share similarities to prolific Atlantic Margin hydrocarbon basins in the UK and Norway where commercial discoveries are being developed. Irish offshore exploration began in 1970 with the first well and over the past 44 years key petroleum system elements have been proven in several Atlantic Margin basins. There are several hydrocarbon discoveries, but commercial success has so far been elusive. The lack of success to date is related to fully understanding the key geological controls within the basins.

In this article we review prospectivity in the Rockall Basin; the largest of the Atlantic Margin basins, based on interpretation of 2D seismic reprocessed by Spectrum in 2014 (Figure 1).

The acquisition of modern seismic data, the improvement in seismic data quality, increased regional knowledge and

attractive fiscal terms have led to renewed industry interest in the Atlantic Margin Basins, reflected in the attendance at the recent Atlantic Ireland conference in Dublin. With reported undiscovered resources of 5bboe (PAD, 2006) the Rockall basin provides an exciting new venture opportunity.

In June 2014 the Minister of Natural Resources announced the Atlantic Margin Licensing Round with an application deadline of 16 September 2015. The large tracts of attractive unexplored open acreage combined with the announcement of the 2015 Atlantic Margin Licensing Round heralds a new era of exploration that may lead to the first commercial discovery.

### Exploration history

The first Irish offshore well (48/25-1) was drilled in the North Celtic Sea Basin in 1970 and the first discovery well was drilled in the Kinsale Head gas field in 1971. The First Licensing Round in 1975 resulted in the award of several licences west of

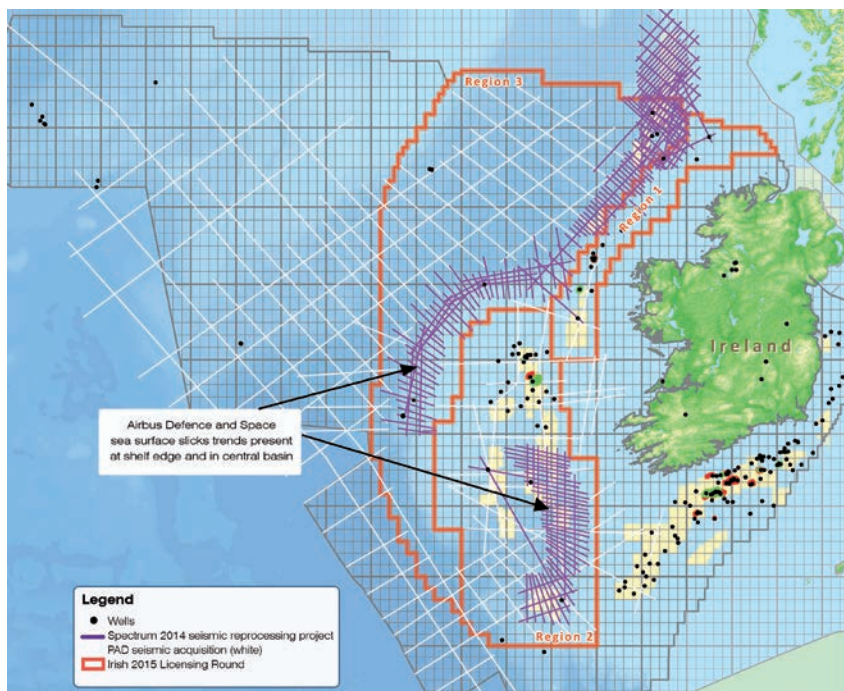


Figure 1 Ireland Atlantic Margin seismic database and 2015 Licence Round Blocks.

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## Petroleum Geology and Basins

Ireland and numerous wells were drilled in the following years. The Second Licensing Round in 1981 saw more awards to new companies and from 1975 to 1985 73 wells were drilled but no further commercial discoveries were made. In the early 1990s exploration success in UK and Norway focused attention on the Atlantic Margin with the first of three Frontier Licence Rounds in 1994. Drilling in the Slyne Basin resulted in discovery of the Corrib Field while several wells drilled in the Porcupine basin flowed oil but were non-commercial. In recent years exploration focus has returned west to the Porcupine and Rockall basins with the Rockall Frontier Licensing Round in 2009 and the Atlantic Margin Licensing Round in 2011.

In 2013 Exxon drilled the Dunquin (44/23-1) deepwater exploration well in the Porcupine basin and proved the presence of a thick, over-pressured Early Cretaceous carbonate reservoir. Although announced dry, the presence of a potential residual oil column may indicate hydrocarbons have subsequently leaked. Similar style prospects have thicker top seal and no fluid escape structures, suggesting trap is intact providing encouragement for the play. In 2013-2014 PAD in conjunction with ENI acquired 16,800 km of regional full fold 2D seismic data, gravity and magnetic data across the frontier areas of Rockall and Porcupine basins.

In 2014 Spectrum has been reprocessing and interpreting 14,587 km of 2D seismic data as shown in Figure 1.

### Atlantic Margin hydrocarbon potential

The Atlantic Margin basins have seen relatively few wells drilled; however, several have proven the presence of key petroleum play elements. The Rockall basin is the largest, least explored of the offshore Ireland basins with exploration limited by the scarcity of seismic data. The recent availability of the PAD-ENI 2013/14 seismic/gravity survey and the Spectrum reprocessed seismic surveys (Figure 1) has provided a modern regional data set for evaluating the basin potential in greater detail. The Spectrum reprocessed ISROCK96 2D seismic survey is regionally important as its strategic location on the eastern flank of the Rockall basin provides an important link between the Porcupine basin and the 2013/2014 PAD-ENI regional 2D seismic data (Figure 1). The ISROCK96 2D reprocessed seismic has significantly improved the image of the Mesozoic syn-rift graben and half-graben structures, particularly in the slope and basin floor setting.

Exploration drilling in the Atlantic Margin indicates the key hydrocarbon play elements are present with several hydrocarbon discoveries. The four main plays proposed for the Atlantic Margin basins are summarized in Figure 2.

The identification of direct hydrocarbon indicators (DHIs) observed within the Ireland Atlantic margin, such as the Airbus oil slicks dataset, seabed mud volcanoes and gas chimneys, adds further support to the presence of effective

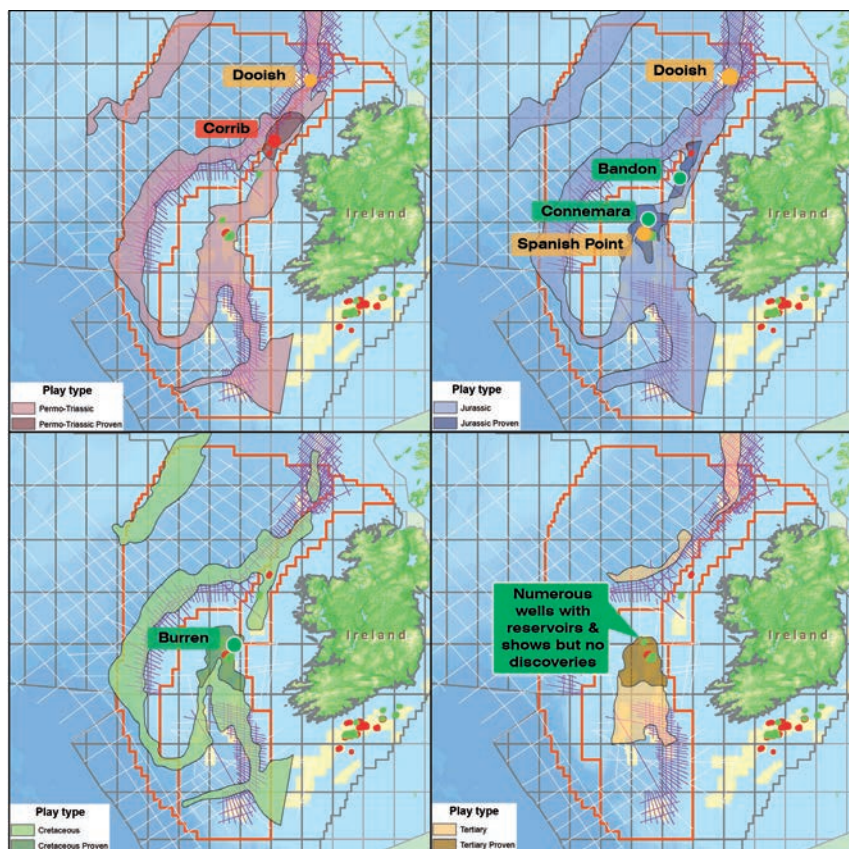


Figure 2 Four main plays in the Ireland Atlantic Margin (Modified from PAD/Ternan, 2006).



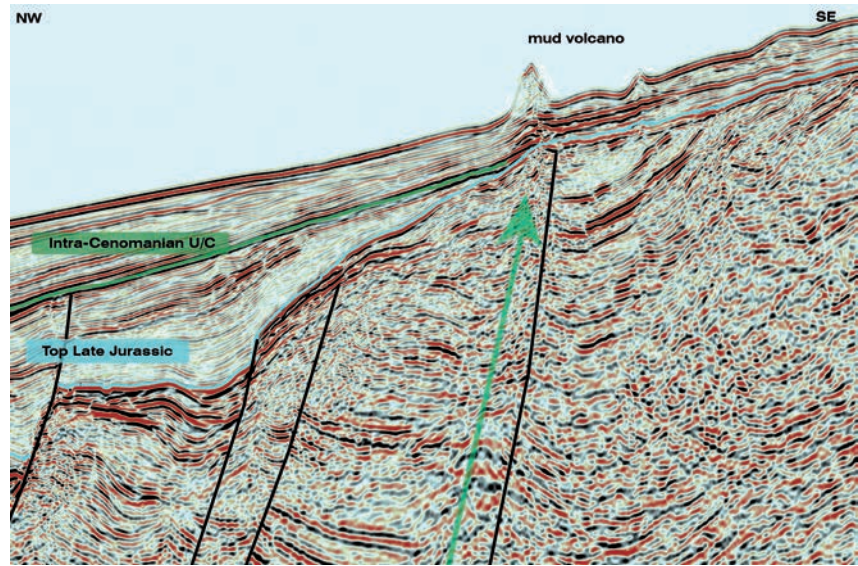


Figure 3 ISROCK96 2D reprocessed seismic data shows mud volcanoes developed above an extensional fault; an indication of fluid flow from the Jurassic half-graben to the seabed via the fault.

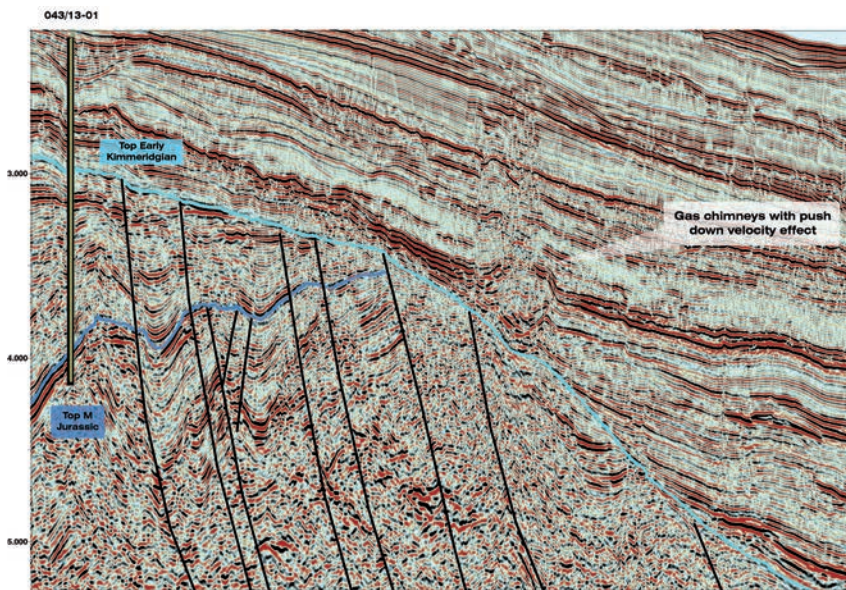


Figure 4 An example of gas chimney observed in PORC97 2D reprocessed seismic data showing push down velocity effect.

hydrocarbon source kitchens along the margin. Several seabed mud volcanoes indicating gas escapes are observed on seismic sections in the Rockall basin. Figure 3 illustrates an example of a mud volcano located above a major extensional fault indicating that the fault is or has been acting as a fluid migration pathway. In the Porcupine Basin, numerous gas chimneys are seen on reprocessed seismic sections; an example of a gas chimney with push down velocity effect in the western flank of the basin is illustrated in Figure 4.

In the Rockall basin, confirmation of a working Jurassic hydrocarbon play is based on seismic and well penetration. Located in the NW of the Rockall basin, the Dooish discovery well (12/2-1z) encountered 187 m of gas and condensate in Permian to Middle Jurassic sandstone reservoir. With an average porosity of 14% and average permeability of 10 mD

the Jurassic fluvial sandstones provide a quality reservoir target and confirm the presence of Jurassic strata in the basin. Although the image quality of the original DGER96 seismic is poor, the section still indicates the development of a series of Jurassic half-grabens downdip from the Dooish well where mature Jurassic source rocks have generated and expelled hydrocarbons (Figure 5). The reprocessed version is expected to deliver a significant improvement in data quality.

In 1999 five shallow boreholes were drilled on the eastern flank of the South Rockall basin as part of the PIP Rockall Studies Group confirming the presence of a Jurassic section in the basin. These wells have been tied to the ISROCK96 reprocessed seismic data and illustrate the development of Jurassic tilted fault blocks on the eastern flank of the Rockall basin (Figures 6 and 7).



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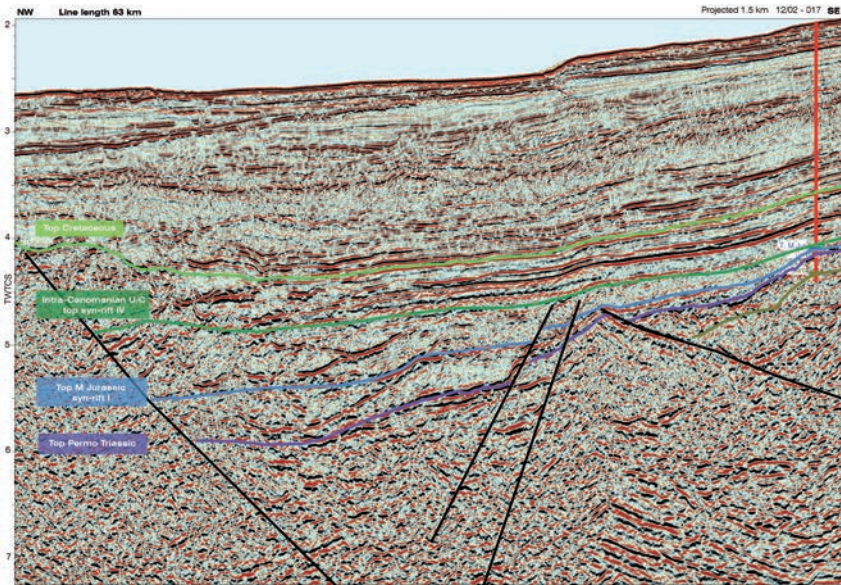


Figure 5 Original seismic line illustrating Jurassic basin west of the Dooish discovery well.

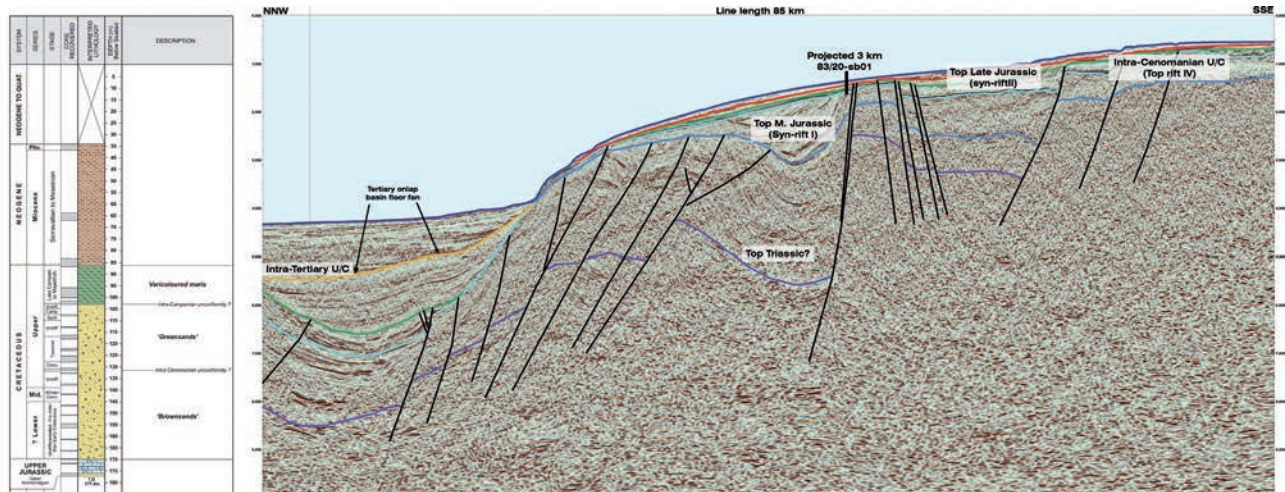


Figure 6 Seismic line with shallow borehole 83/20-sb01. Summary log of borehole 83/20-sb01 is modified from Stoker (1999).

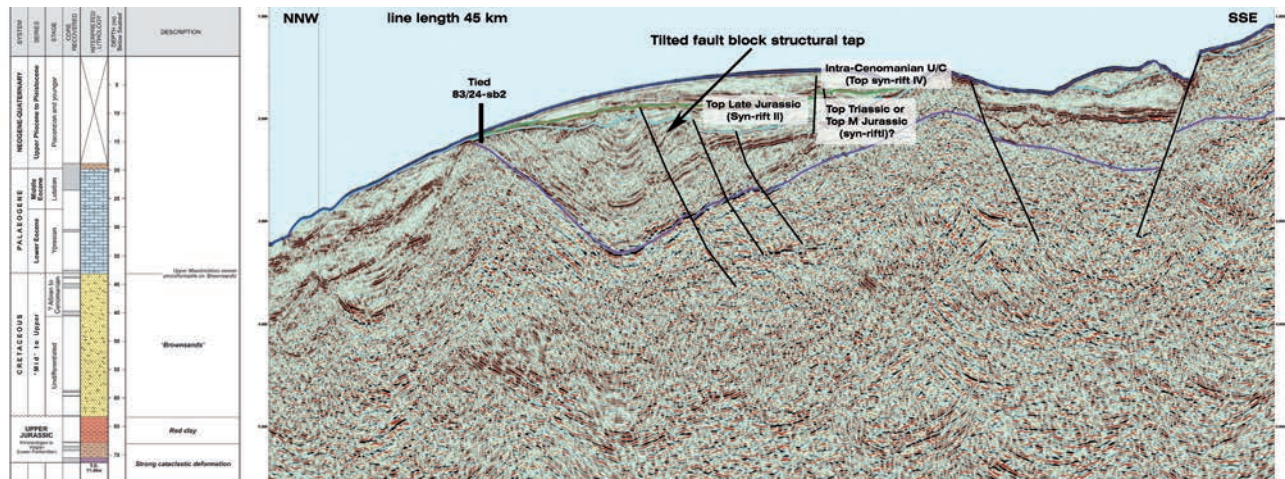
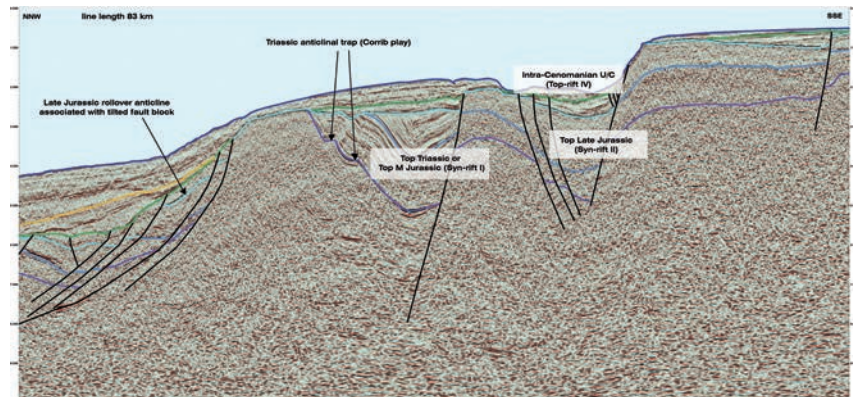


Figure 7 Seismic line with shallow borehole 83/24-sb02. Summary log of borehole 83/24-sb02 is modified from Stoker (1999).





**Figure 8** Series of Jurassic rotated fault blocks developed along eastern flank of the Rockall basin.

The Porcupine basin is better understood compared with the Rockall basin where the presence of Jurassic source rock was confirmed by several wells including the Connemara (26/28-1) and Spanish Point (35/8-2) oil discoveries.

In the adjacent Slyne basin the Corrib gas field (Block 18/20) has a Carboniferous hydrocarbon source and Triassic Sherwood Sandstone reservoir. This medium-sized gas field (~1TCF GIIP) will be developed as a subsea tie-back facility connected by pipeline to an onshore processing terminal. Other wells drilled in the basin have hydrocarbon shows; well 27/5-1 encountered heavily oil stained Middle Jurassic sandstones in a horst block structure, well 27/13-1 encountered a Lower Jurassic section with Liassic source rock intervals in the Portree and Pabba Shale and oil shows in Middle Jurassic (Bajocian) sandstones (Dancer et al., 2005).

### Rockall Basin exploration potential

The integration of the Spectrum reprocessed 2D seismic on the eastern margin of the Rockall Basin with the well data and regional synthesis has identified Jurassic rift structure potential. This new reprocessed seismic was performed on zero phase at the seafloor and shows less noise throughout the section (Figures 6, 7 and 8). It has clearly improved amplitude continuities of high amplitude reflectors within the Jurassic tilted fault blocks and fault geometry has also been enhanced. This increases confidence of the seismic interpretation and leads to mapping in the Rockall Basin with several Mesozoic and Palaeogene leads identified on the south Rockall reprocessed seismic data (Figure 9).

The series of Jurassic rotated fault blocks developed along the eastern flank of the Rockall basin are clearly enhanced, particularly in the deeper section both in the slope and basin floor setting (Figures 6, 7 and 8). Several tilted fault block structural traps have been identified within the new reprocessed data (Figure 6, 7 and 8). A Triassic anticlinal trap similar to Corrib play is recognised on a dip-oriented line south of the basin and towards the northwest Late-Jurassic rollover plays are developed in deeper slope setting (Figure 8). Mid-Jurassic tilted fault block play (Dooish) have also

been identified (Figure 6). These structural plays are associated with rifted Jurassic tilted fault blocks and have mature Jurassic source rock deposited downdip of the structures.

In the deep-water basin, stratigraphic traps with high amplitude reflectors, have been identified within the Palaeogene interval (Figure 6). These may be a basin floor fan onlapping on an intra-Palaeogene unconformity.

### Porcupine basin exploration potential

Early exploration drilling in the Porcupine basin proved the presence of effective source rock and reservoir, but proven resources have been small. Reprocessed line PORC9-60 illustrates a series of tilted fault blocks with gas chimneys connected to a deep mature source rock basin located downdip from well 43/13-1 (Figure 10). Oil shows were encountered in early Kimmeridgian section from 3500 m to 3600 m MD and the Late-Jurassic section was correspondingly thicker than the prognosis. The reprocessed PORC97 seismic survey has improved definition of the Mesozoic interval, fault block structures and details of the post-rift section.

The Dunquin well proved the presence of an Early Cretaceous carbonate play concept within a large structure with hydrocarbon shows that appears to have been breached. There are similar undrilled 'Dunquin' style prospects with thicker top seal seen on the PORC97 reprocessed seismic survey. With a proven reservoir and hydrocarbon source basin, the challenge for the 2015 Licence Round is to use the new seismic data to define large hydrocarbon charged structures for drilling.

### Conclusion

Advances in seismic acquisition and visualisation are helping to unlock the hydrocarbon potential of the large, unexplored basins of the Irish Atlantic Margin. The integration of reprocessed seismic data, well data and seep data supports several play concepts with several active hydrocarbon source rocks. The Rockall and Porcupine basins offer exciting new venture opportunities; the current study has identified significant exploration potential with numerous leads of various styles. Significant advances of floating production systems, sub-sea

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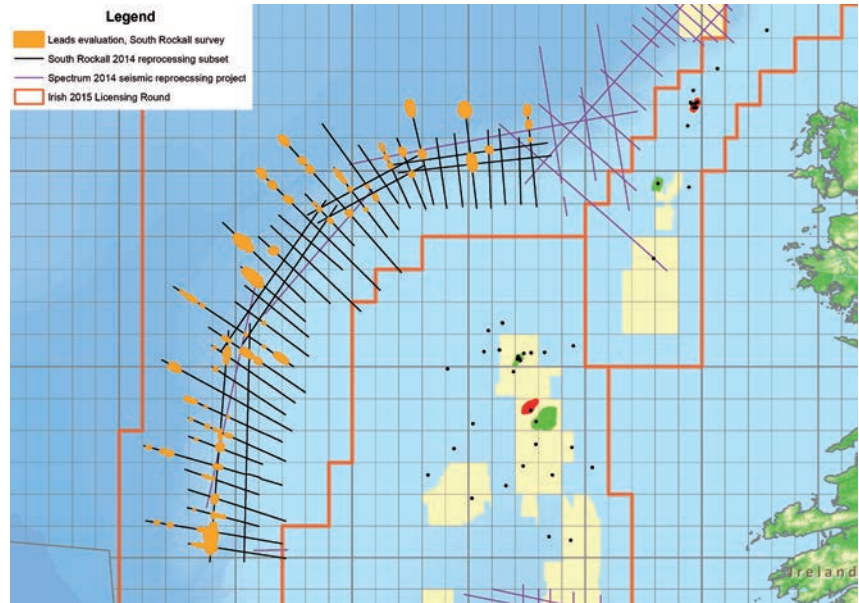


Figure 9 Mesozoic and Palaeogene lead map based on the Rockall reprocessed seismic data.

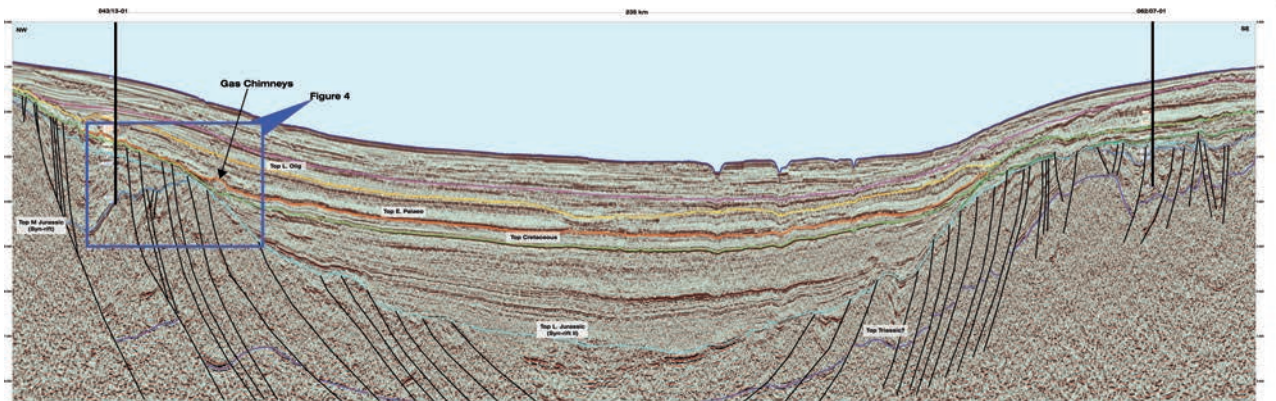


Figure 10 The reprocessed line illustrates a series of tilted fault blocks with gas chimneys connected to a deep mature source rock basin located downdip from well 43/13-1 on the western flank of the basin.

technology will positively impact the development of future Atlantic Margin discoveries. The availability of Spectrum reprocessed seismic and PAD 2013/14 seismic provide a modern dataset to evaluate the exploration potential in preparation for the 2015 Atlantic Margin Licensing Round.

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