Integrated geophysical and geological studies in the Porcupine Basin

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Introduction

A new research project, funded by the Irish Petroleum Infrastructure Programme (PIP) will investigate and re-evaluate the crustal structure of the Porcupine Basin using wide-angle seismic data not hitherto comprehensively analysed.

The Porcupine Basin is a good sedimentary basin to investigate the processes involved in hyperextension (Whitmarsh et al. 2001) within the North Atlantic region, where the crust becomes severely thinned during basin formation.

Crustal-scale tectonic processes that lead to hyperextension are poorly understood, but are important in controlling deep-water petroleum systems. The Porcupine Basin, part of the frontier petroleum exploration province west of Ireland, is underlain by thin to ultra-thin continental crust (O'Reilly et al. 2006) and is therefore an excellent natural field laboratory in which to investigate these processes.

This basin may provide important insights into these processes because the degree of crustal extension is known to increase dramatically from north to south in the basin. The project will investigate basin structure from the Mesozoic to Cenozoic basin-fill sediments to deeper levels in the crust and upper mantle.

It will re-evaluate the crustal structure of the Porcupine Basin using wide-angle seismic data gathered in a collaboration between the Dublin Institute for Advanced Studies (DIAS) and the Helmholtz Centre for Ocean Research Kiel (GEOMAR).

Scientific Approach

This will be accomplished by quantifying variations in crustal geometry and seismic properties both along the basin axis and across the basin towards mainland Ireland, using various geophysical and geological methods. The project will determine the stratigraphic response to varying amounts of tectonic extension and its potential impact on petroleum systems.

An integrated crustal model for the region will be produced (including gravity, magnetic and seismic stratigraphic data from industry and government sources) as well as previous results from PIP-funded projects in this sedimentary basin, as well as other studies (Reston et al. 2004; Readman et al. 2005; O'Reilly et al. 2006).

The study will interrogate the formation and thermal history of the Porcupine Basin as an analogue for failed and successful rifts elsewhere. The thermal history of the lithosphere is likely to be very different to settings where a significant amount of magmatism occurs, with important implications for hydrocarbon source rock maturation.

It will also help de-risk further exploration activity in the basin by providing a better understanding of how hyperextension evolves in the continental lithosphere.

The project began in September 2014 and is funded by the Irish Shelf Programme Study Group (ISPSG) of the Petroleum Infrastructure Programme (PIP).

Potential Outcomes

1 The results will be of importance in understanding the interaction between the Earths hydrosphere and lithosphere and for heat flow modelling studies for petroleum generation in similar tectonically hyperextended settings.

2 The research proposed here will address a large and critically important gap in understanding of geological/geophysical processes in this region of the North Atlantic west of Ireland.

3 It will have significant impact on the broader issues of hydrocarbon prospectivity and exploration de-risking and will also pave the way for future initiatives in the Porcupine Seabight Basin as planned in **ISPSG Project ISO9/06** (O'Reilly *et al*. 2010).

4 On a regional North Atlantic scale the Porcupine Basin is crucial in understanding the kinematics of early Mesozoic basin development and plate tectonic linkages with conjugate eastern Canadian basins that are part of a frontier hydrocarbon province (Welford et al. 2012).

5 The outcome of this study and the information provided by it will be important in assisting the development of future seismic acquisition plans (O'Reilly *et al*. 2012) designed to refine regional "plate"reconstructions of these conjugate basins (Figure 3) at a more basin-sized scale.

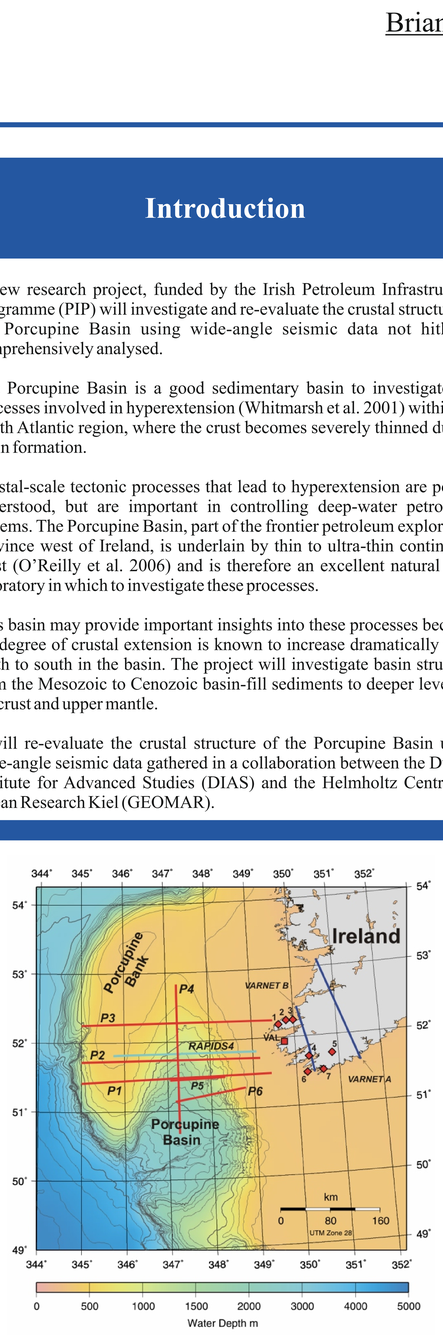

Figure 1: Location map showing the wide-ange seismic profiles across the Porcupine Basin (red lines lablelled P1 to P6). Also shown are the onshore refraction profiles VARNET96 Lines A and B, as well as the offshore seismic wide-angle profile RAPIDS4. The red symbols are onshore stations, deployed to record energy from the marine profiled at large offsets to determine crustal structure along the shelf and platform region of the basin margins.

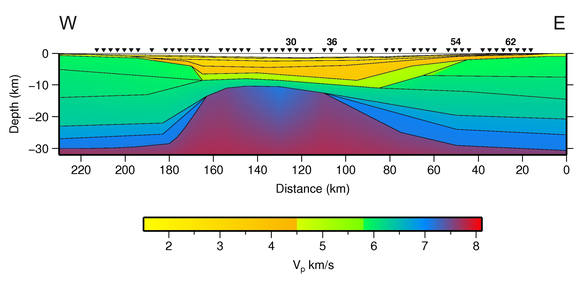

Figure 2: Crustal and sedimentary structure across the Porcupine Basin into southwest Ireland along the RAPIDS4 profile from Hauser et al. (2010). For location see Figure 1. Vertical exaggeration is 1:1.6. Triangles are ocean bottom seismometer locations used to record wide-angle seismic energy from airgun sources at long offsets. Seismic velocities are indicated by bar scale: yellow tones are potential hydrocarbon rich sedimentary deposits, overlying highly thinned crust (green to blue tones). Central blue-purple region is interpreted serpentinised mantle lithosphere.

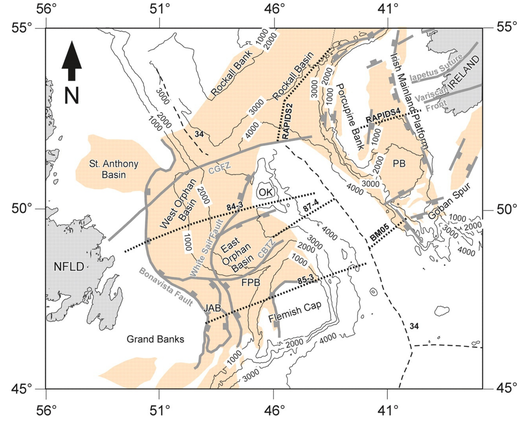

Figure 3: Preliminary plate tectonic reconstruction of the Irish and Newfoundland continental margins and basins at late Cretaceous geological time, showing the regional tectonic setting of the Porcupine Basin within this conjugate margin system.. The reconstruction is based primarily on the results of gravity field studies and also the results of deep-crustal seismic profiling on both sides of the Atlantic. (see Welford et al. 2012 for details). The grey lines represent the major fault systems those activity controlled the formation of the major Mesozoic sedimentary systems, the extent of which are marked in pale orange.

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Acknowledgements

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