

Geodynamic Assessment of Maturity in the Irish Offshore

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Introduction

The basins of the Atlantic Margin in Northern Europe extend from Norway to southern Ireland. The inner basins of the Irish Atlantic Margin have complex histories with phases of inversion (Corcoran and Clayton, 2001). The timing of these basin inversions has controlled to some extent the accumulation of gas resources. There are similarities in this respect to the Norwegian Vøring basin, for example (Wengen et al., 2011), where a large underplating body has been identified (Wangen et al., 2011 and Fjeldskaar et al, 2003) as having a great influence on the source rock maturation. In the Irish Atlantic Margin, there is ample evidence of magmatic activity on a number of scales.

The GAMIO project aims to understand the impact of geodynamic variations and magmatism on maturation by assessing the geodynamic evolution of the inner basins on the Irish Atlantic Margin (Porcupine, Erris and Slyne) at the lithospheric scale

The inner basins of the Irish Atlantic Margin

The model generally accepted for the opening of the North Atlantic involves multiphase rifting culminating in Early Eocene crustal separation of Greenland and Europe. The result of this opening is a North West European continental shelf 300-500 km wide with a complex structure composed of several basins developed from the late Paleozoic to the Cenozoic. The basins can be divided into two major groups (see Figure 1). The inner basins of Jurassic age include the Erris and Slyne Troughs and the Porcupine Basin in the Irish Margin and the Halten Terrace and Viking Graben in the Norwegian Margin. The Cretaceous to Tertiary outer basins include the Rockall and Hatton Troughs to the south and the Møre, Vøring and Lofoten Margins to the North.

The Porcupine Basin is the largest of the three inner basins of the Irish Atlantic Margin, with a length of c. 250 km and a width of up to 65 km. Its crustal thickness varies, and is thinnest in the south, reaching a value as low as c.6-8 km (Readman et al, 2005). There are up to 10 km of preserved sediments in other areas (Shannon & Naylor 1998). The Erris and Slyne Troughs are 'perched' basins with an average crustal thickness for their inner position of c. 20-25 km. The sedimentation in both has a thickness of c. 3-4 km.

Magmatism in the Atlantic Margin

Igneous bodies occur as lava flows, sills, dykes, igneous centre sand stocks, through much of the Atlantic Margin region. In the basins of the Irish Atlantic Margin, two major magmatic elements can be observed: sills on one side and deep large-scale intrusion on the other. The dissemination of the sills is quite extensive (figure 2) and relates to the Porcupine and Slyne basins as well as the eastern edge of the Rockall Trough (Fernandes, 2011). The emplacement of these sills has been constrained to the Paleocene and Eocene. The thickness of the sills range between 50-300m and transgress an average of 500 m in the Porcupine Basin and 1300 m in the Slyne-Erris. The Porcupine Median Volcanic Ridge (PMVR) is a large buried extrusion beneath Early Cretaceous sediments; it has a thickness of 2 to 5.2 km with an average length of 80 km and width of 20 km. The origins of the ridge are disputed however. Some authors suggest an amagmatic origin, which would have far reaching implications for hydrocarbon maturation.

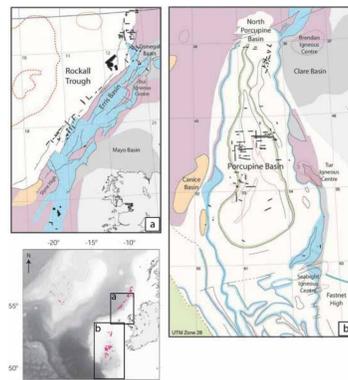


Figure 2: Sills plotted on geostructural maps (copyright DCENR, 2008 & Ordnance Survey of Ireland No. EN 0047208, and PAD 2001). Source: Fernandes (2011)

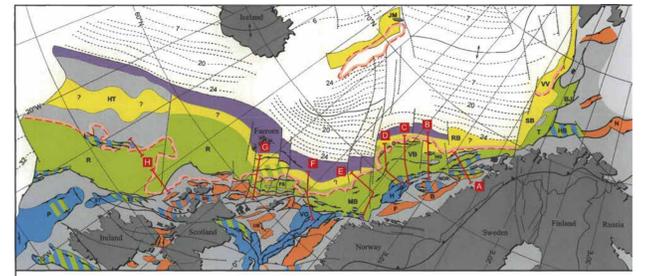


Figure 1: Tectonic elements map of the northwest European Atlantic margin (Dore et al., 1999). B: Bannafund Basin, B1: Bjornoya Basin, ET: Erris Trough, F: Froan Basin, FS: Faerøe-Shetland Basin, G: Gjaljar Ridge, H: Halten Terrace, HB: Hammerfest Basin, HC: Hel Graben, HT: Hatton Trough, JM: Jan Mayen, MB: Møre Basin, N: Nordkapp Basin, NOR: Nordland Ridge, P: Porcupine Basin, R: Rockall Trough, RB: Rest Basin, SB: Servetnaet Basin, ST: Slyne Trough, T: Tromsø Basin, UB: Ust Basin, VB: Vøring Basin, VG: Viking Graben, VV: Vestbakken Volcanic Province.

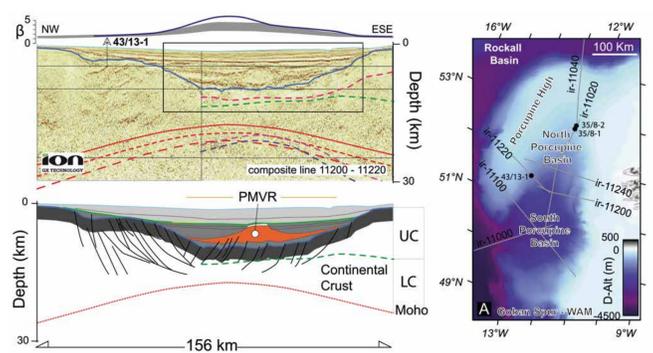


Figure 3: Composite W-E seismic reflection profile across the Porcupine Median Volcanic Ridge (see map to the right (A) for location). Source: Calvès et al (2012)

Modelling methodology

The methodology to be employed has previously been used to inverse model heat flow and quantify maturation in various basin settings (van Wees et al., 2009). The workflow for the modelling technique is shown in figure 4. Firstly, a backstripping analysis is performed, resulting in a tectonic subsidence curve for each well. A tectonic modelling inversion procedure at the lithospheric scale is then carried out in order to obtain the tectonic model that fits the backstripped tectonic subsidence curve. The forward modelling approach is based on the pure-shear lithosphere thinning model of McKenzie (1978) with variable amounts of thinning in the crust and lithospheric mantle (based on the work of Royden and Keen, 1980). The stretching also allows for underplating and intrusion in the crust (Hirsch et al., 2010). The thermal transfer in the lithosphere and sediment column is affected by conduction and also radiogenic input. The sediment layers are defined as fractional proportions of eight basic lithologies (sandstone, shale, siltstone, limestone, salt, coal, anhydrite and dolomite).

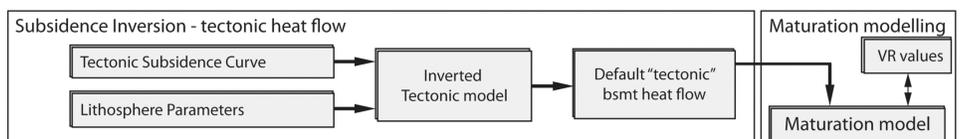


Figure 4: General workflow adopted in the modelling approach (modified after van Wees et al., 2009). VR values: Vitrinite Reflectance values

Vitrinite Reflectance (VR) Data for calibration

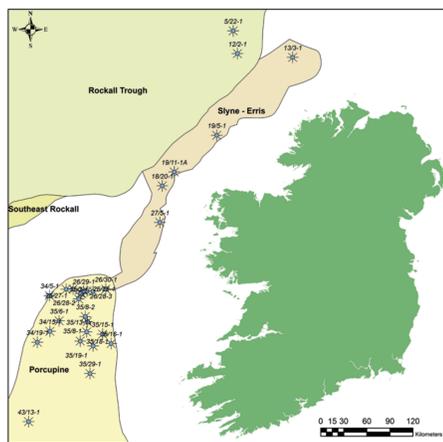


Figure 5: Localisation of the available wells with VR values in the Irish Atlantic Margin

Well ID	Basin	X Coord TM65	Y Coord TM65
26/27-1	Porcupine Basin	-116992.59	214588.33
26/28-1	Porcupine Basin	-105646.43	208668.2
34/5-1	Porcupine Basin	-147601.34	205885.55
35/2-1	Porcupine Basin	-109761.57	201597.68
35/6-1	Porcupine Basin	-135185.24	173078.49
35/8-1	Porcupine Basin	-98461.82	172018.9
35/8-2	Porcupine Basin	-101220.01	178639.23
34/15-1	Porcupine Basin	-147137.6	159416.36
34/19-1	Porcupine Basin	-163532.83	145206.23
35/13-1x	Porcupine Basin	-99378.3	158749.22
35/15-1	Porcupine Basin	-78639.11	155732.5
35/18-1	Porcupine Basin	-107713.87	146695.03
35/19-1	Porcupine Basin	-90927.94	140392.57
36/16-1	Porcupine Basin	-67499.88	143418.54
35/29-1	Porcupine Basin	-94995.77	104487.99
43/13-1	Porcupine Basin	-174952.3	41827.26
19/5-1	Erris Trough	69806.87	414580.74
26/26-1	Porcupine Basin	-125947.31	214209.16
26/28-2	Porcupine Basin	-107095.07	208671.06
26/28-3	Porcupine Basin	-103111.28	211788.88
26/28-4	Porcupine Basin	-98916.58	211868.06
26/29-1	Porcupine Basin	-91106.46	211546.16
26/30-1	Porcupine Basin	-74478.9	214359.22
13/3-1	Erris Trough	168620.28	515988.11
19/11-1a	Erris Trough	14606.43	366822.93
5/22-1	Rockall Trough	91276.92	550478.11
12/2-1	Rockall Trough	96744.66	520878.79
18/20-1	Slyne Trough	-1064.88	348720.51
27/5-1	Slyne Trough	-4109.03	301130.92

Table 1: Available wells with VR values in the Irish Atlantic Margin (as catalogued on the PAD website)

In order to validate our model some data are required for calibration. The VR values are a product of the maximum temperature and therefore allow comparison with the maximum modelled temperature. The selection of wells for our modelling will be determined by the availability of VR data. Vitrinite Reflectance data exist from multiple sources for some 29 wells in the Irish Atlantic Margin. These data are to be sourced from original drilling data, research publications and reports prepared by independent reports. The selection of wells to be used is being finalised on the basis of data quality and location. Table 1 lists the wells with VR data shown on Figure 5. Additional possible VR data sources are currently being considered and may be included in the final data selection process.

Acknowledgement:

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