PIP project IS13/18

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. 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, where a large underplating body has been identified (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 large scale 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 by means of tectonic heat flow modelling.

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.

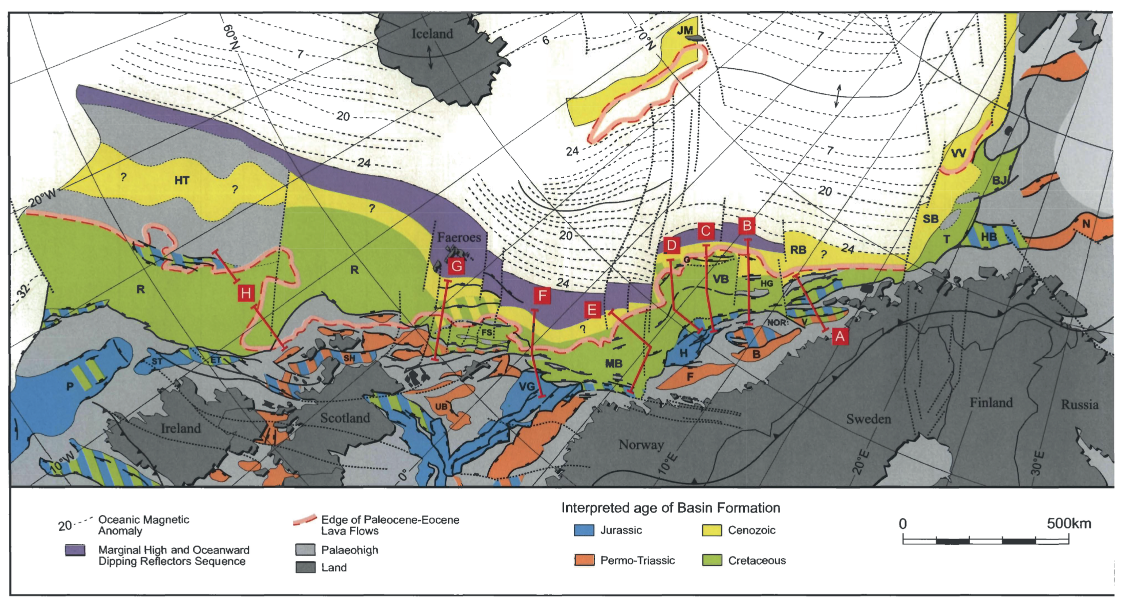

Figure 1: *Tectonic elements map of the northwest European Atlantic margin (Dore et al., 1999).*
B: Brønnøysund Basin, BJ: Bjørnøya Basin, ET: Erris Trough, F: Froan Basin, FS: Faeroe-Shetland Basin, G: Gjallar Ridge, H: Halten Terrace, HB: Hammerfest Basin, HG: Hel Graben, HT: Hatton Trough, JM: Jan Mayen, MB: Møre Basin, N: Nordkapp Basin, NOR: Nordland Ridge, P: Porcupine Basin, R: Rockall Trough, RB: Røst Basin, SB: Sørvestnaget Basin, ST: Slyne Trough, T: Tromsø Basin, UB: Unst Basin, VB: Vøring Basin, VG: Viking Graben, VV: Vestbakken Volcanic Province.

Vitrinite Reflectance (VR) database on the Atlantic Margin

VR data is a key element in identifying heat anomalies and vertical movements that have affected a sedimentary basin. VR data from wells located in the Porcupine Basin, Slyne-Erris Basin, and Donegal Basin has been collected.

46 wells in the Irish Atlantic margin have been identified. 35 of these wells contain VR data obtained from original drilling data, research publications, and reports. A detailed assessment of the quality of these values and their overall reliability and the number of VR values per wells, has been undertaken with a view to developing a robust database that for the purpose of heat flow modelling. Table 1 lists the wells with VR data shown on Figure 2.

The quality of the VR data is the key element in the well selection process, as this provides the calibration required to assess the results obtains with the tectonic-heat flow modelling.

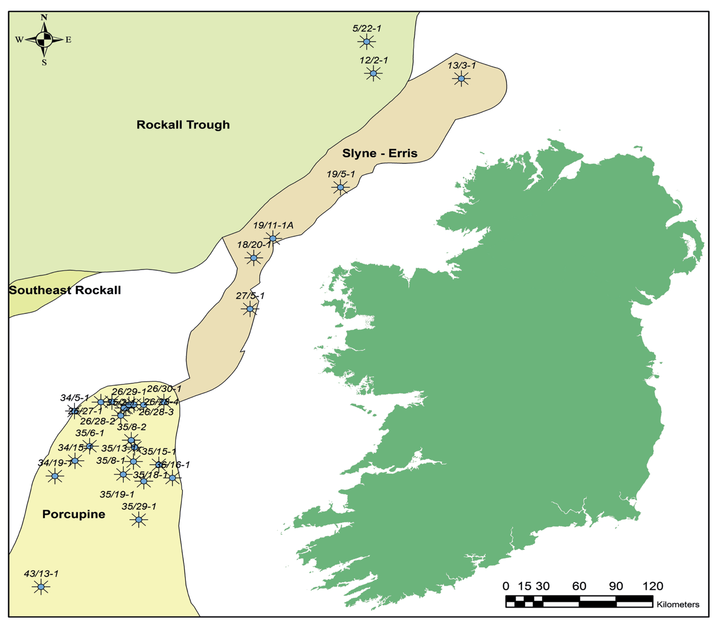

Figure 2: *Location of the available wells with VR values in the Irish Atlantic Margin*

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)*

Modelling methodology

The modelling relies on two major factors:

- the description of the sedimentary layers (present and eroded)
- the definition of the major geological events during the lifetime of the basin

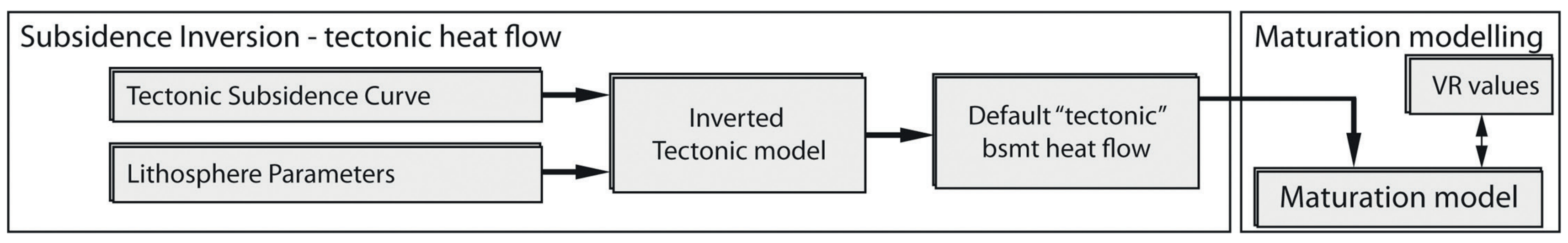

Figure 3: *General workflow adopted in the modelling approach (modified after van Wees et al., 2009). VR values: Vitrinite Reflectance values*

For each 1D location the following information is required and has been collected in the wells considered in this work:

- the sedimentary layers still in place and the eroded layers
- timing of deposition and erosion described in the well reports
- lithological description of the remaining or eroded layers.
- description of the major layers in the lithosphere
- description of the major geodynamic phases that have impacted the basin

Using these parameters, a heat model is generated that allows the maturation modelling to be undertaken

Preliminary results: example of the well 26/28-1 north of the Porcupine Basin

Tectonic subsidence

The first results of the modelling show that the modelled tectonic subsidence (Figure 4) can be compared with the described depositional and erosional phases from the well. Correlation is good and the major phases are distinctively modelled.

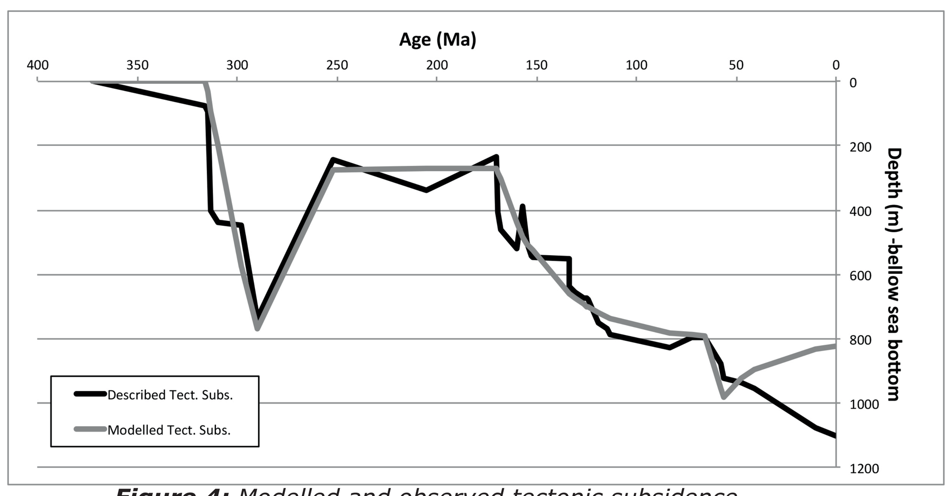

Figure 4: *Modelled and observed tectonic subsidence*

Five main geodynamic steps have been identified:

- Intrusion in the crust at shallow depth (>10km thick at 1300°C) during the late Carboniferous (Late Wesphalian/Stephanian)
- Uplift phase with intense erosion during Permian
- 1st extension phase at Middle/Late Jurassic
- 2nd extension phase at Early Cretaceous
- Uplift due at the Paleocene due to the Iceland Plume (?)

Thermal results

Four thermal modelling scenarios are being tested based on the observation of the VR measurements and more precisely for the observed VR from the Carboniferous. These scenarios specifically test the presence (or not) of a large deep an underplating/intrusion that would have been emplaced at the Late Carboniferous and creating a thermal response in the basement heat flow (Figure 5) and the VR data (Figure 6) .

The 4 scenario are

- no intrusion
- 10km thick underplating @1300°C
- 10km thick intrusion in the middle of the crust @1300°C
- 10km thick intrusion just below the sediments @1300°C

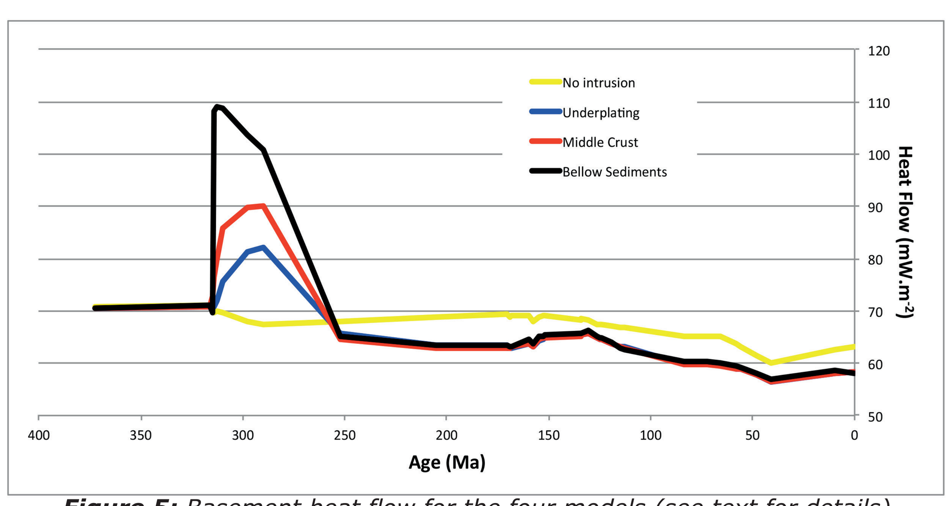

Figure 5: *Basement heat flow for the four models (see text for details)*

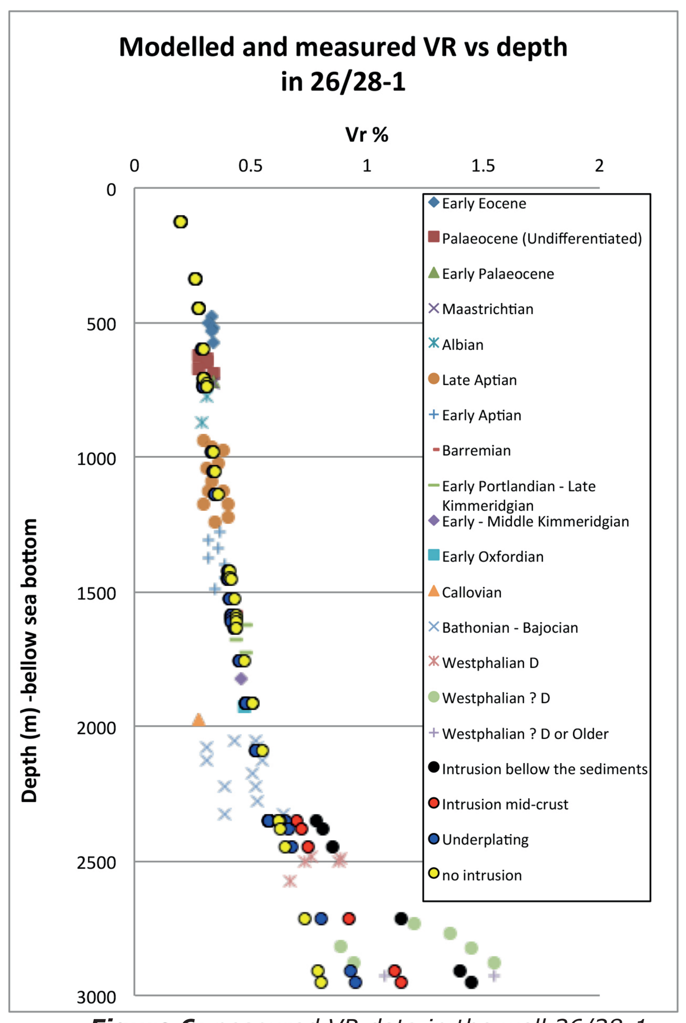

Figure 6: *neasured VR data in the well 26/28-1 vs modelled results (see text for details)*

Acknowledgement:

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