Basin Modelling of the Porcupine Basin, Offshore Ireland

Gagnevin D.[1], Haughton P.D.W.[1], Shannon P.M.[1], Whiting L.[1], Schmid D.W.[2] and Rüpke L.H.[3]

1. iCRAG, UCD School of Earth Sciences, University College Dublin, Belfield, Dublin 4, Ireland
2. GeoModelling Solutions GmbH, Hardturmstrasse 120, 8005 Zurich, Switzerland;
3. GEOMAR Helmholtz Centre for Ocean Research Kiel, Dynamics of the Ocean Floor, Wischhofstr. 1-3 DE-24148 Kiel, Germany

1. Introduction

The Porcupine Basin (PB) is part of a chain of elongated **hyperextended basins** extending along the north-western Atlantic margin (Fig. 1). Key questions remain regarding its geological and thermal evolution, especially in undrilled areas in the south of the basin, which is the focus of current exploration interest. Jurassic serpentinisation (e.g., O'Reilly *et al.*, 2006) and widespread early Cenozoic igneous activity (Gagnevin *et al.*, 2017) have been proposed based on a wide range of data (P-wave velocity; gravity; geochemistry; seismic interpretations). In this project we aim to **reconstruct the evolution of the basin evaluating critical elements** (stretching factors, maturity, heat-flow, etc) and **testing different scenarios** (serpentinisation; igneous activity) using the TecMod basin modelling software.

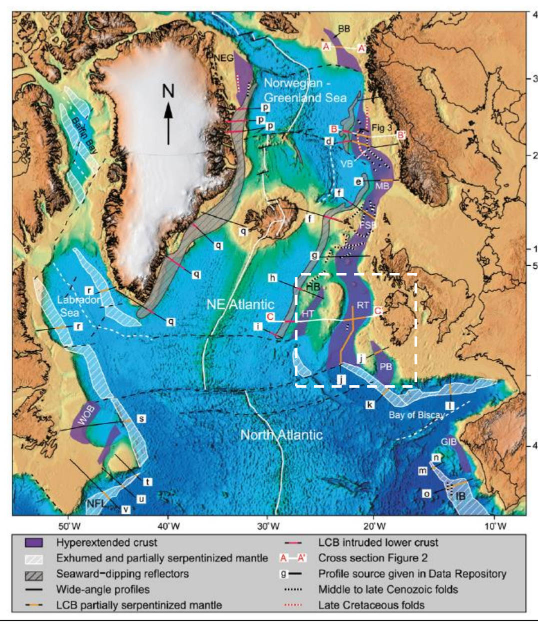


Fig. 1: map of the North Atlantic region with hyperextended crust highlighted (Doré et al., 1999).

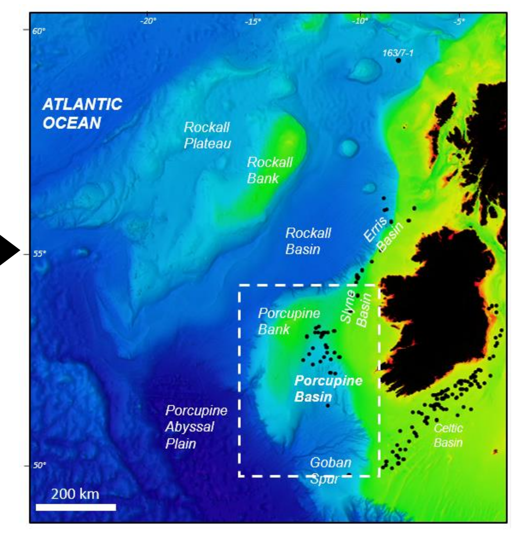


Fig. 2: Bathymetry map showing location of the Porcupine Basin in relation to other basins offshore Ireland.

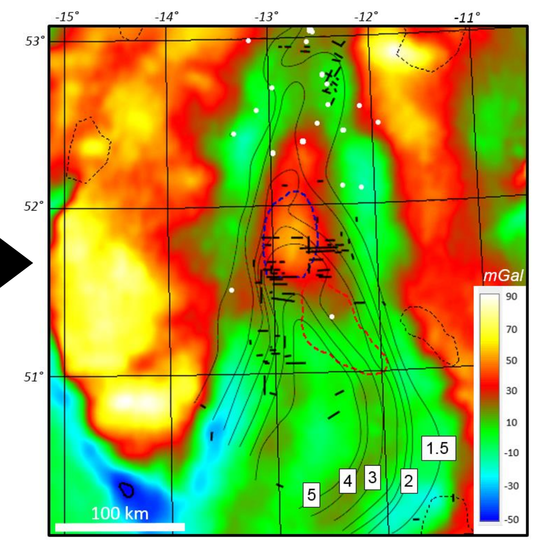
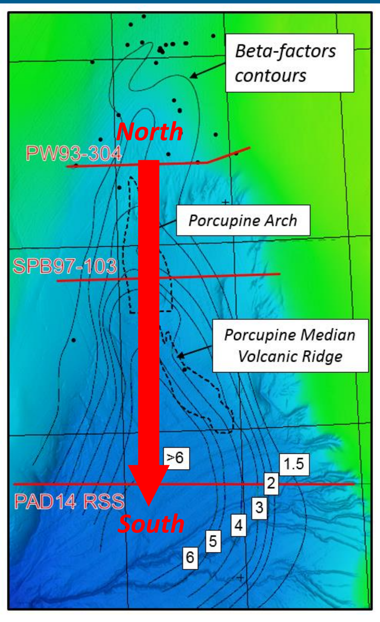


Fig. 3: Free-air gravity anomaly map with outline of the Porcupine Arch, wells, sill distribution, and regional beta-factor variations (Gagnevin et al., 2017).

2. TecMod (2D) modelling results



- **2D basin modelling** has been carried out using TecMod (Rükpe *et al.*, 2008; 2010; 2013) along three seismic lines across the basin (north to south).
- **Automatic lithospheric and basin reconstruction** through coupling of thermotectonostratigraphic forward model to inverse scheme (full inversion).
- **Quality of the model** checked against well data (temperature and vitrinite reflectance data).
- **Possibility of modelling of igneous and serpentinisation processes** (Rükpe *et al.*, 2010; 2013).
- **wide ranges of outputs**: crustal structure, sediment infill, heat flow model, stretching factors, temperature evolution, water depth, subsidence, density, conductivity, porosity, permeability, sedimentation rate, petroleum generation, volumetrics etc.

Figs. 4: Results of TecMod modelling in the northern (PW93-304 line), central (SPB97-103 line) and southern (PAD14 RSS line) parts of the Porcupine Basin.

North → **South**

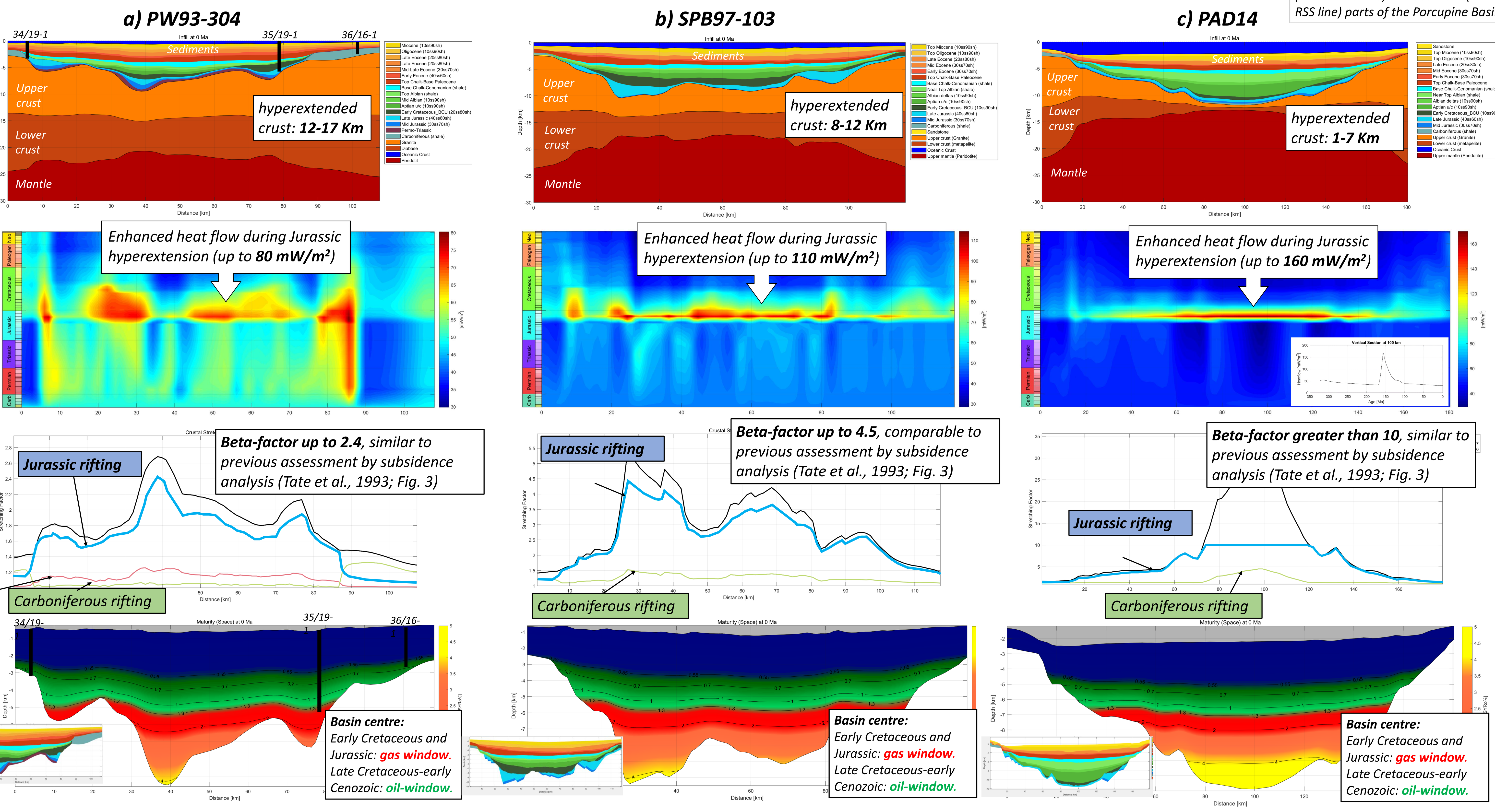
a) PW93-304 | *b) SPB97-103* | *c) PAD14*

Output example 1: *modelled crustal structure and sediment infill through time.*

Output example 2: *heat-flow variations in time and space*

Output example 3: *stretching-factors for all rifting events*

Output example 4: *source rock maturity evolution in space and time*

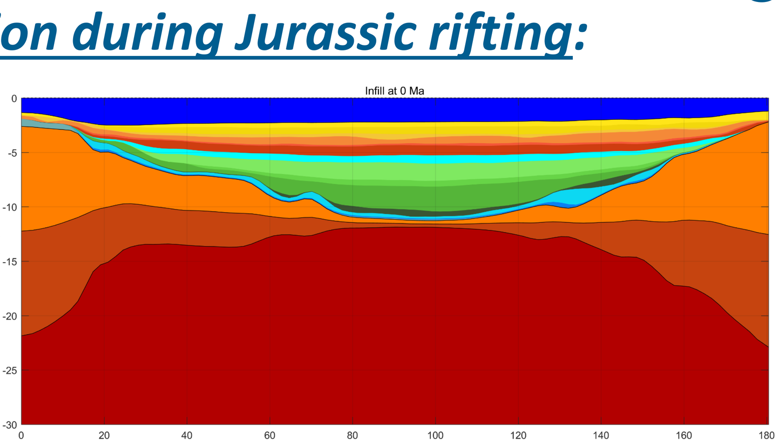


3. Testing thermal and geological scenarios

Figs. 5: Evaluation of Jurassic serpentinisation and Cenozoic magma underplating in the Porcupine Basin.

Mantle serpentinisation during Jurassic rifting:

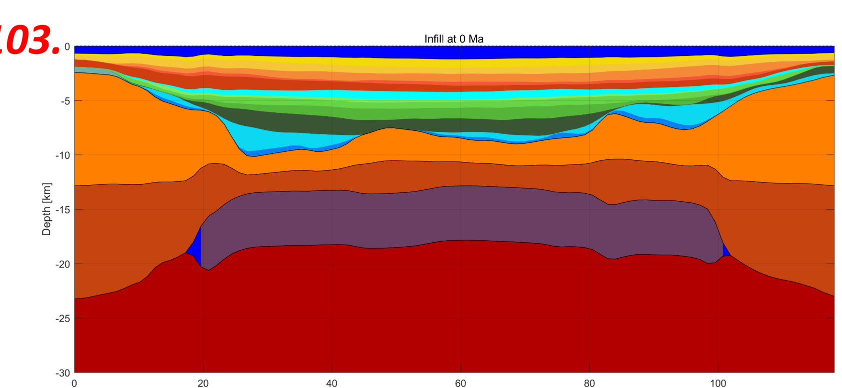
Model based on ***PAD14 RSS*** *(i.e. greatest extent of crustal stretching and thinning)*

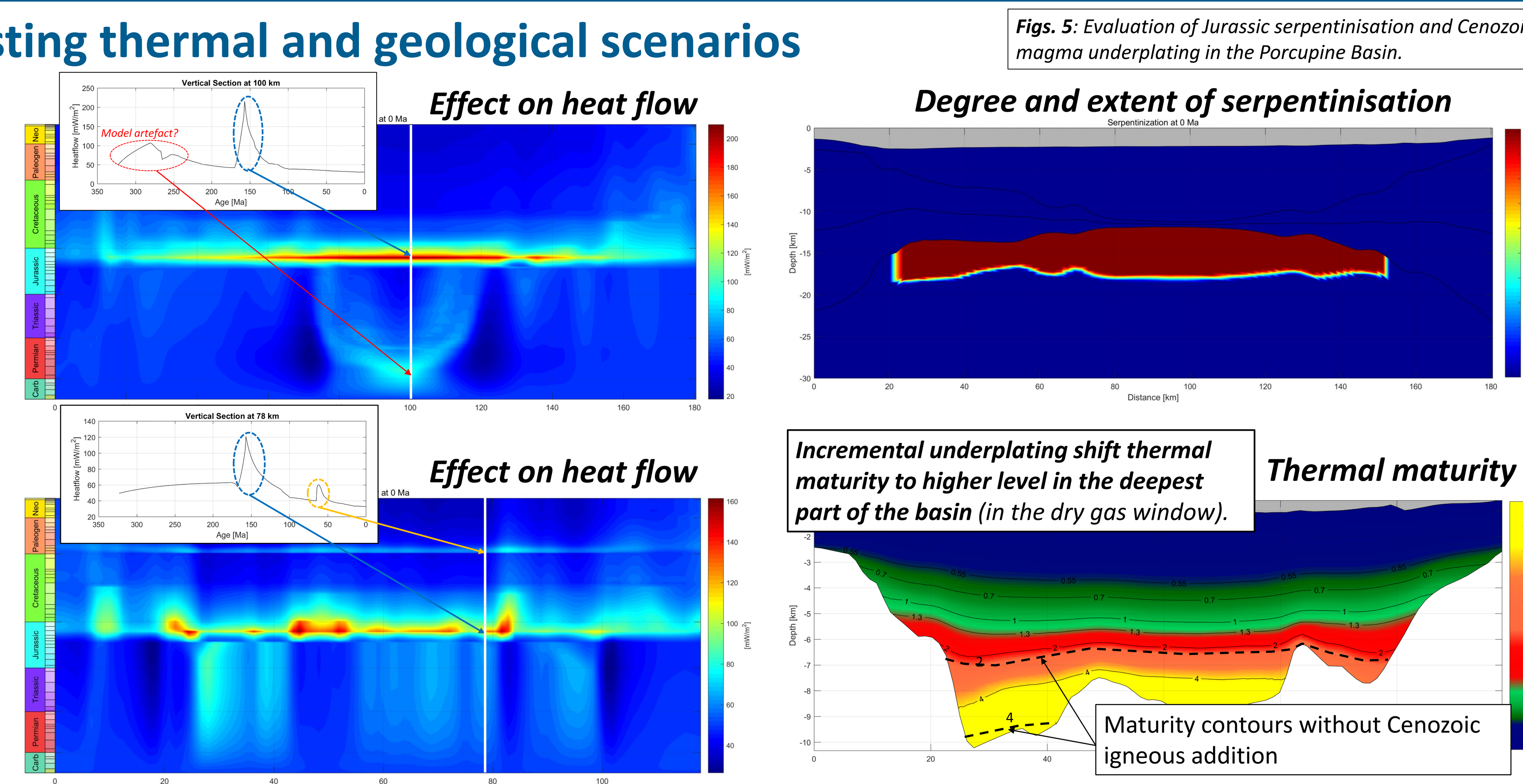


Early Cenozoic igneous underplating (Iceland-plume related):

Model based on SPB97-103.

Incremental magma addition over 5 Ma *(61-66 Ma) with 1 Km of magma added at each 1Ma increment.*





4. Conclusions and outstanding questions

- Preliminary basin modelling results along the three profiles on a North-to-South transect suggest that the Jurassic sedimentary section (main source rock) is systematically in the **wet/dry gas window in the basin centre** (hyperextended area), particularly in the central and southern parts of the Porcupine Basin. ***How extensive is the gas-prone domain in the Porcupine Basin?***
- Cretaceous source rocks may be more favourable for oil maturity and generation. ***Is there a good Cretaceous oil-prone source rock in the Porcupine Basin?*** So far not demonstrated from the well data….
- **The crustal thickness as derived from the modelling is highly variable across the basin**, i.e. >12 km, >8 km and >1 km the northern, central and southern parts of the Porcupine Basin, respectively. ***Does the south of the Porcupine Basin lie on top of oceanic crust?***
- **Modelled stretching-factors** are in broad agreement with earlier investigation (Tate *et al.,* 1993).
- **Jurassic serpentinisation** (e.g., Prada et al., 2017) can be modelled during the syn-rift stage in central and south Porcupine Basin based on **thermal and rheological grounds**, and has incidence on maturity and heat-flow. ***Presence of low-angle detachment fault?*** Highly dependant on seismic interpretation...
- **Early Cenozoic igneous activity** (e.g., Gagnevin *et al*., 2017) **may have incidence on source rock maturity** if this occurred over a protracted and repeated igneous emplacement, as opposed to a single and shorter event where no effect is observed (not shown). ***Type and duration of igneous activity across the basin?***

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