

Irish sills and the Palaeocene-Eocene Thermal Maximum

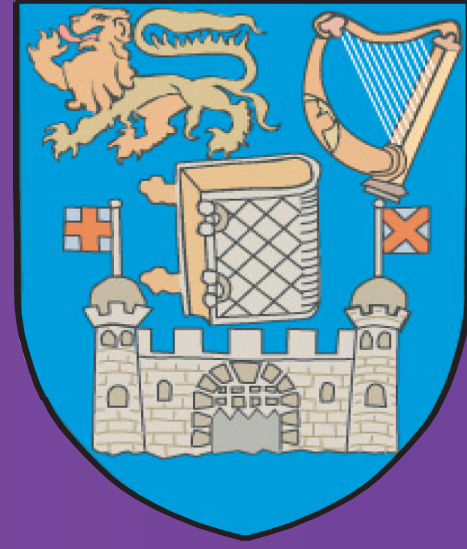


K. Fernandes¹, S. M. Jones¹, R. Hardy¹, G. Clayton² and R. Goodhue²

¹ Seismic and Basin Analysis Group, Department of Geology, Trinity College Dublin, Ireland

² Palynology and Organic Petrology Research Group, Department of Geology, Trinity College Dublin, Ireland

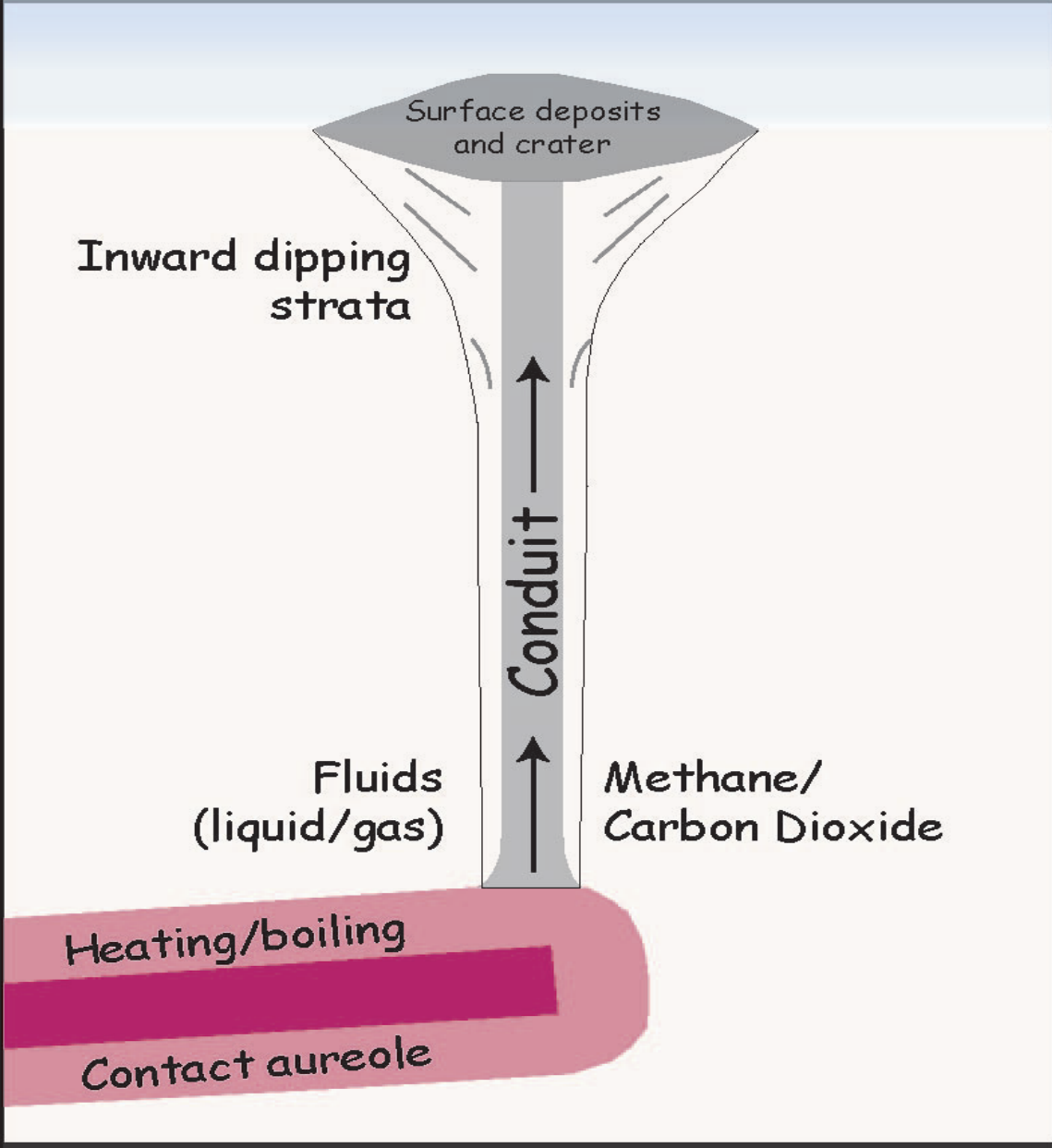
Contact: fernandk@tcd.ie



1. Introduction

A proposal by Svensen *et al.* (2004) suggests that the intrusion of the North Atlantic Igneous Province (NAIP) sills may have influenced, or perhaps even triggered or the Palaeocene-Eocene Thermal Maximum (PETM) global warming event. Sills may heat organic-rich host sediments generating carbon dioxide and methane, greenhouse gases which may then escape to the atmosphere, for example through a hydrothermal vent. (Figure 1).

Figure 1. Schematic illustration of greenhouse gas and hydrothermal vent formation. Vents may form when pressurised pore fluids in the host rock are heated by the intruding sill. Adapted from Svensen *et al.* 2004.



4. Results To Date

The preliminary methane potential calculations for the Irish sector are based on the area of continental shelf covered by 2D seismic surveys only (Figure 3A). Though the Irish sector covers a greater area of continental shelf than the Norwegian sector, (Table 1), the estimated Irish methane budget is considerably lower than the Norwegian budget (Figure 4).

Location	Shelf Area km ²	Sill Area km ²	Aureole Volume (200m) km ³	Sill Thickness km
Irish Basins	212747	14288	2717	0.013
Norway	78341	85000	17000	0.217

Table 1. Comparison of basin area, sill area, sill aureole volume and sill thickness in the Irish basins and Norwegian sector. Sill thickness is considerably lower in the Irish basins.

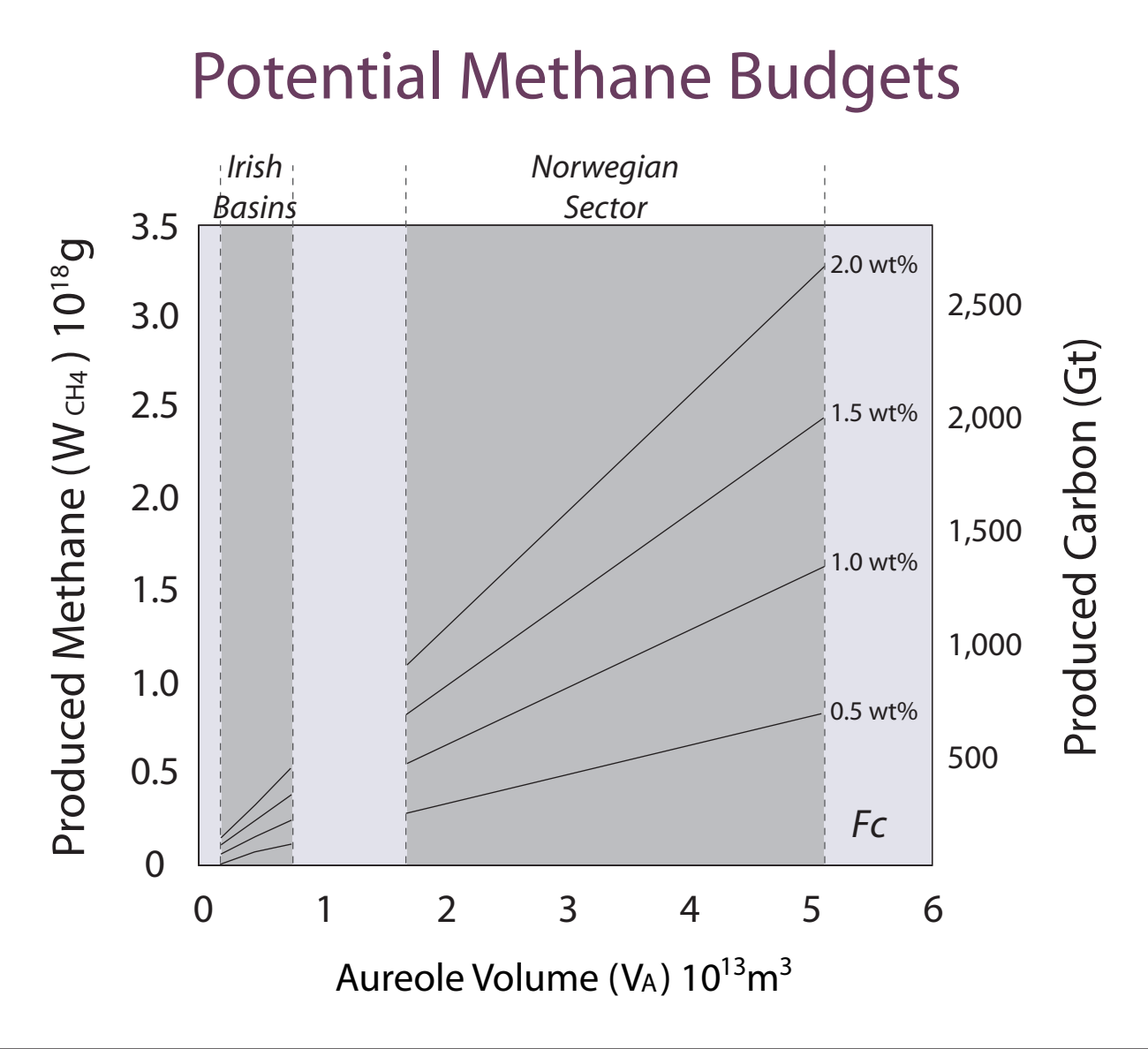
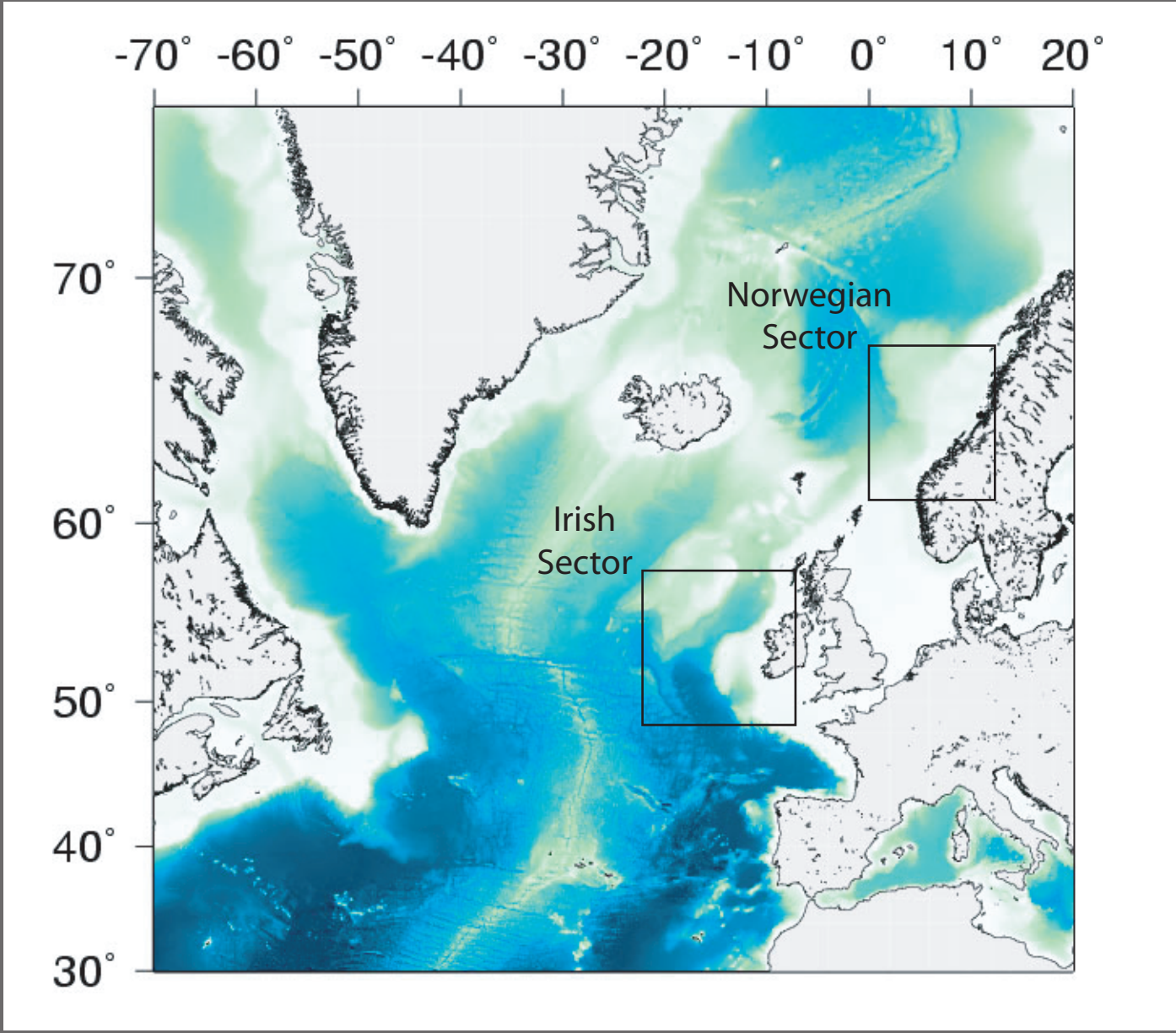


Figure 4. Upper and lower bounds of the methane budgets established for the Irish basins and the Norwegian sector of the North Atlantic Igneous Province.

This estimate of the initial methane generating potential of the Irish sector is a preliminary calculation that will be refined using more accurate measures of TOC, host rock density and aureole thickness. The budget will also be expanded to account for the entire NAIP.

2. Objectives



Results from the study by Svensen *et al.* (2004) are based solely on data from the Norwegian sector of the NAIP. Using data from the Irish sector of the NAIP we wish to:

- Assess the impact of Irish sector sills on palaeo-climate change.
- Comment on the plausibility of the NAIP intrusive component triggering the PETM.

Figure 2. Location map of the Irish and Norwegian sectors of the North Atlantic Igneous Province.

3. Methodology

To calculate a potential greenhouse gas budget for the Norwegian sector the following framework was used (Svensen *et al.* 2004). This equation will be used to determine the greenhouse gas potential of the Irish sector.

$$W_{CH_4} = 1.34 F_C V_A p$$

1.34: The atomic weight conversion factor between carbon and methane

V_A : The volume of the metamorphic aureole. This is based on sill area (20104 km²) and thickness (200m, 400m, 600m) 4.0208 x 10¹² m³

p : Host rock density 2400 kg/m³

F_C : The amount of carbon available that can be used to generate methane. This estimate is based on the Total Organic Content (TOC) of the host rocks 0.5 - 2.0 wt %

Volume of the metamorphic aureole

Irish sector sills have been mapped using a comprehensive grid of 2D seismic data (Figure 3A). Preliminary volume calculations have been carried out by establishing the area of the sills using the regional sill map (Figure 3B), then multiplying each area by an averaged lower bound aureole width of 200m.

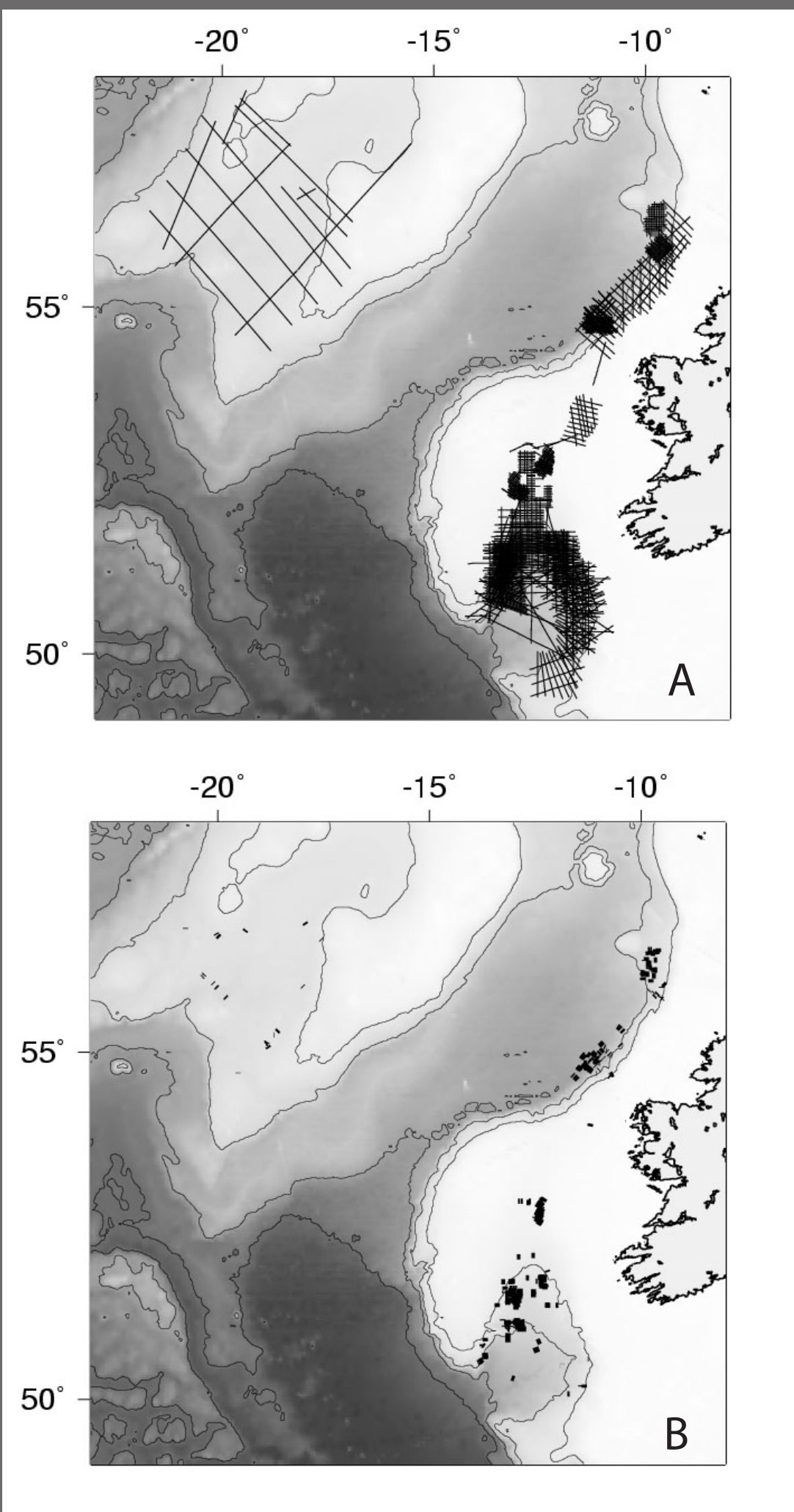
Host rock density

For these initial estimates the host rock density has been taken as 2.4 Mg m⁻³, a reasonable figure to represent sedimentary rocks.

Greenhouse gas potential

The volume of methane generated can be estimated using the TOC of the host rocks. For our initial calculations the value used has been taken from the Norwegian study.

Figure 3. (A) Density of 2D seismic data across the study basins of the Irish Sector of the NAIP. (B) Sill density in the Irish sector. Two 3D seismic surveys will be used to establish what influence 2D data distribution and quality has on the density of sills identified in the area and to refine the volume of sill aureole in the Irish sector.

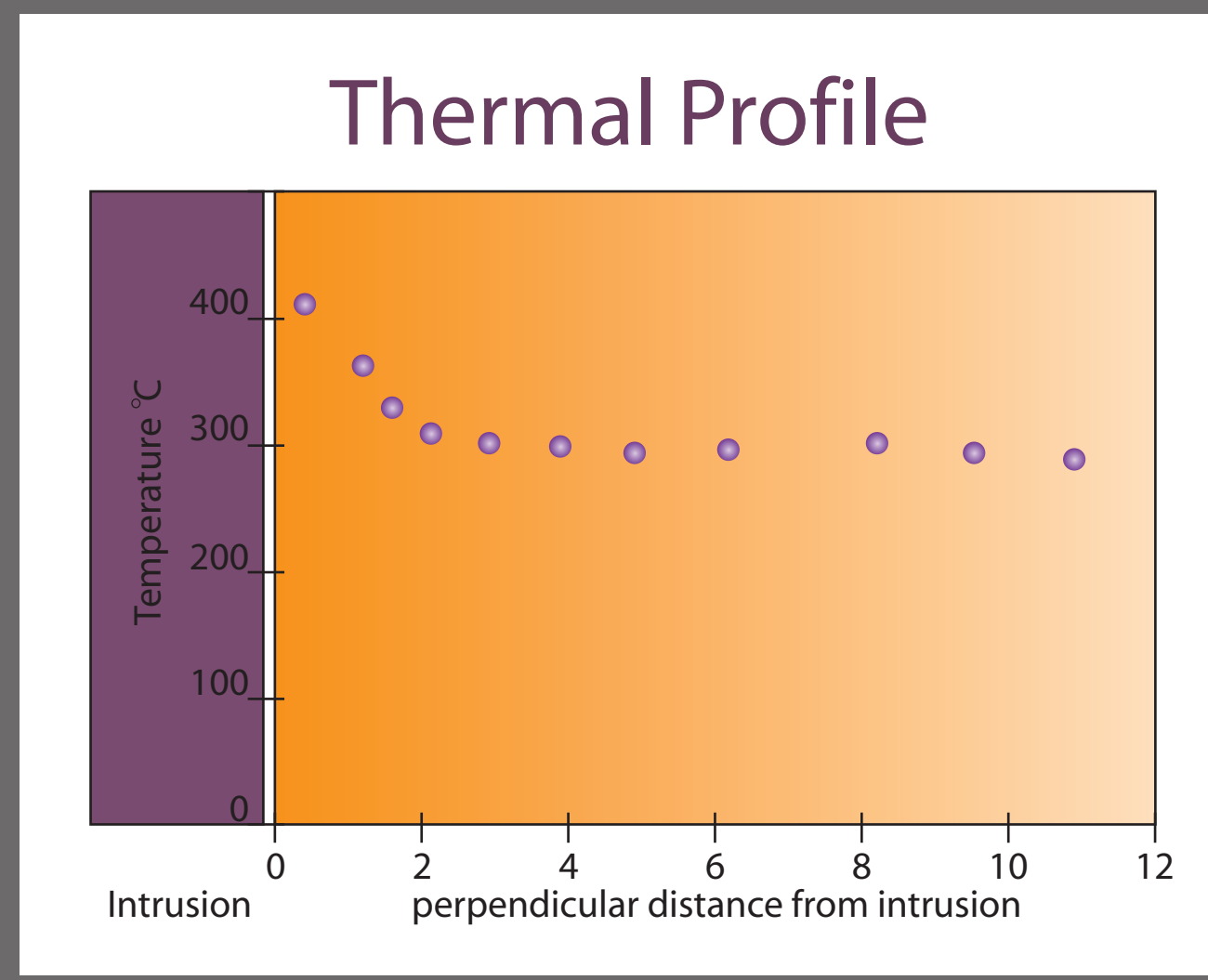


5. Future Work

Vitrinite Reflectance

To establish a more accurate estimate of the sill metamorphic aureole volume a vitrinite reflectance study of intrusion aureoles will be conducted (e.g. Figure 5). Intrusions suitable for sampling should intrude muddy host rocks and be individual/remote sills or dykes with no thermal overprint. Examples can be either drilled or located in the field.

Figure 5. Temperature profile of the ~4m wide North Star dyke, Ballycastle, intruding shales, using vitrinite reflectance data (Goodhue, R. 1996, PhD).



Total Organic Carbon

To establish more accurate greenhouse gas potential estimates, TOC values from Irish sector rocks will be used.

Estimates must be expanded to account for the entire Irish sector which represents quite a significant proportion of the entire area of the NAIP. Hatton basin lies closer to the active margin than the other basins yet less sills have been recorded here due to poor data coverage. These areas of poor or zero data coverage must be accounted for.

6. Discussion/Conclusion

- Preliminary results indicate that the potential greenhouse gas budget for the Irish sector of the NAIP is significantly lower than the budget calculated for the Norwegian sector (Figure 4).
- The lower gas volume calculated for the Irish sector reflects a lower volume of intruding magma. This emphasises the locations of the Irish and Norwegian sectors relative to the rift zone: the Irish sector is further from the NW Europe/Greenland continental break-up zone and the centre of the NAIP.
- The estimates for the Irish sector must be expanded to account for areas of poor or zero coverage.
- The Irish sector greenhouse gas budget will be refined using the following techniques:
 - 3D data (Figure 3) and vitrinite reflectance (Figure 5) to refine aureole volumes
 - TOC values to establish Irish sector greenhouse gas potential more accurately
- The timing of sill intrusion must be constrained as without accurate dating it is impossible to link the effects of the Irish sills with the PETM.
- Once Irish sector calculations are complete, the influence of the entire NAIP on the PETM can be estimated more accurately.

Acknowledgements & References

This presentation uses data and survey results acquired during a project undertaken on behalf of the Irish Shelf Petroleum Studies Group (ISPSG) of the Irish Petroleum Infrastructure Programme Group 4. Thanks to Jeanette Henssen of Shell, and Gianpiero Miglio and Andrew Howard of ENI for support and provision of 3D datasets, and Panorama Technologies for processing of synthetic data.

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