

# **Geological Modelling of the Porcupine Median Ridge: Implications for the Hydrocarbon Prospectivity of North Atlantic Hyper-Extensional Basin and Margin Systems\***

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## **Abstract**

The Porcupine Median Ridge (PMR) is located in the frontier deepwater South Porcupine Basin some 200 km off the southwestern coast of Ireland. The PMR is important because it forms the edifice for the Lower Cretaceous Dunquin carbonate platform exploration prospect, which is considered one of the largest undrilled exploration targets offshore NW Europe. The composition of the PMR remains unknown and previous workers have suggested that it is composed of volcanic, sedimentary or metamorphic (serpentinitic) rock. Here, we analyse recently acquired potential field data and two dimensional long offset seismic reflection data over the PMR to provide new insights into the PMR geology. The results of gravity and magnetic data modelling are presented and integrated with interpretations of both the new 2D seismic reflection data as well as published regional deep seismic refraction profiles. Published basin modelling studies have demonstrated that the South Porcupine Basin underwent hyperextension during the Jurassic and Cretaceous periods with beta factor (total strain) estimates of more than 6.0. We describe how basin hyperextension played a key in PMR genesis as well as on petroleum system elements, such as regional thermal regime, timing of trap formation and source maturation, and reservoir development. Of wider interest are the implications for the Lower Cretaceous play systems that have recently proved prolific elsewhere in the Atlantic Basins, such as offshore Brazil and along the West African Transform Margin. The PMR may provide a Rosetta Stone in our understanding of the petroleum geology of these Atlantic hyper-extensional basinal systems, which are of renewed focus in the context of deepwater NW European oil and gas exploration.

## **Selected References**

Naylor, D., P. Shannon, and N. Murphy, 2002, Porcupione-Goban region – a standard structural nomenclature system: Petroleum Affairs Division, Special Publication, v. 1/2, 65 p.

Readman, P.W., B.M. O'Reilly, P.M. Shannon, and D. Naylor, 2005, The deep structure of the Porcupione Basin, offshore Ireland, from gravity and magnetic studies: *Geology of Northwest Europe Proceedings of the Conference*, v. 6, p. 1047-1056.

# **GEOLOGICAL MODELLING OF THE PORCUPINE MEDIAN RIDGE: IMPLICATIONS FOR THE HYDROCARBON PROSPECTIVITY OF NORTH ATLANTIC HYPER-EXTENSIONAL BASIN AND MARGIN SYSTEMS**

**AAPG Annual Convention & Exhibition 2010  
New Orleans  
Wednesday 14<sup>th</sup> April 2010**

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# Acknowledgements

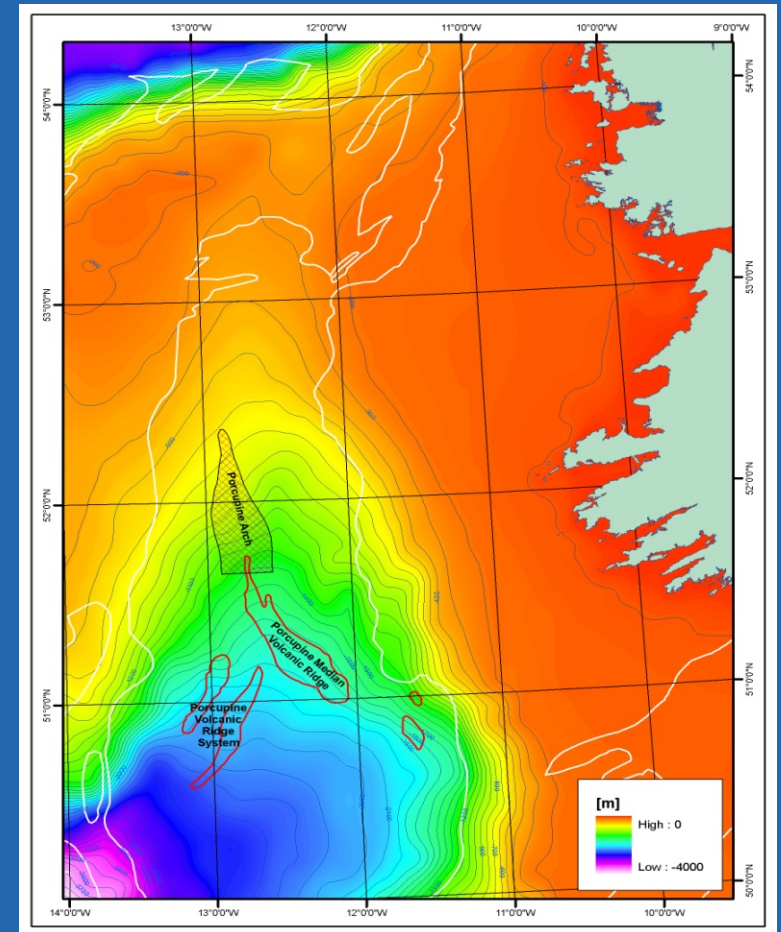
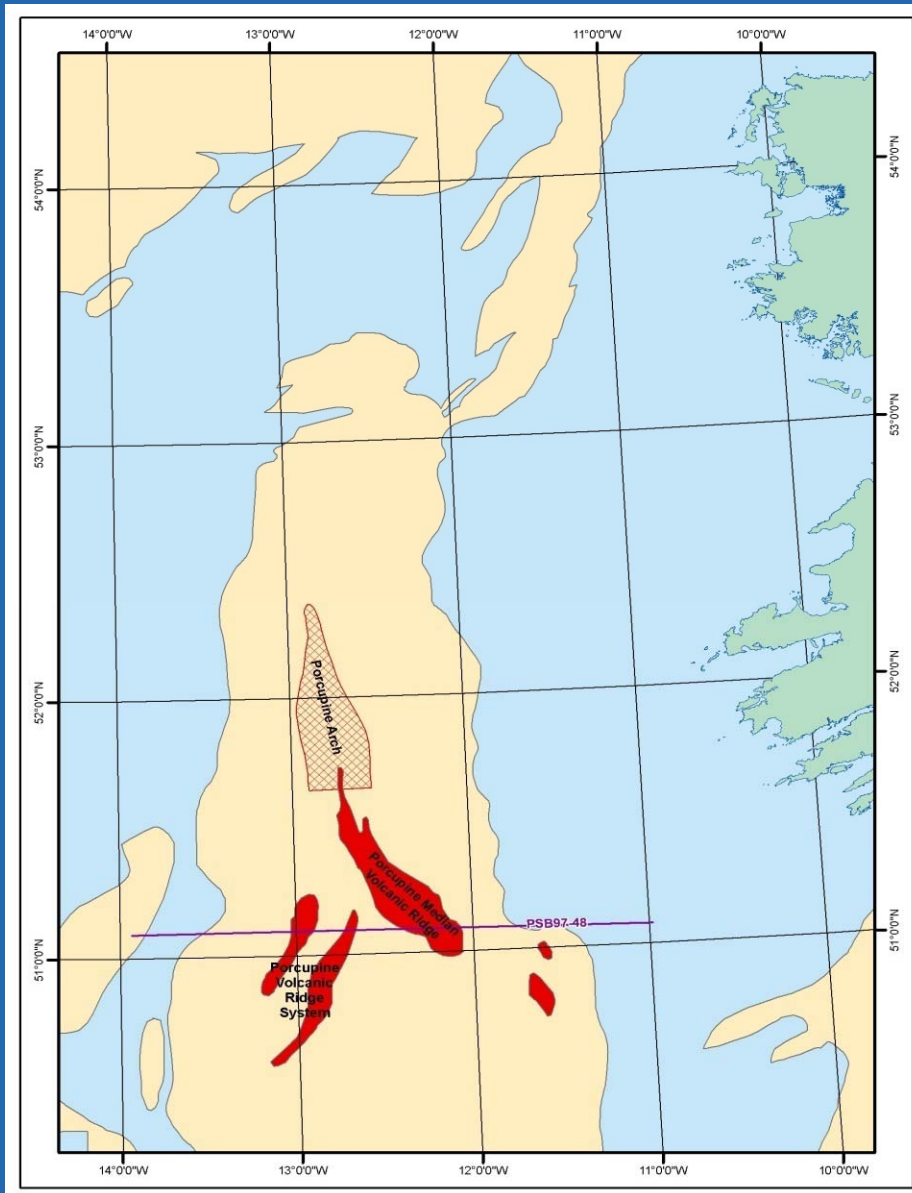
- Frontier Exploration Licence 3/04 Partners
  - ExxonMobil Exploration and Production (Offshore) Ireland Limited, ENI Ireland BV, **Providence Resources plc** & Sosina Exploration Limited
- Petroleum Affairs Division, Department of Communications, Energy & Natural Resources, Ireland
- The Irish Petroleum Infrastructure Programme
  - [www.pip.ie](http://www.pip.ie)
- FUGRO-GEOTEAM & TGS NOPEC

# Executive Summary

- **Potential field data over the undrilled Porcupine Median Volcanic Ridge and Porcupine Volcanic Ridge System in the South Porcupine Basin show no significant associated anomalies**
  - **Is the South Porcupine Basin a magmatic/amagmatic basinal system?**
  - **What are the implications for hydrocarbon exploration?**
- **Newly integrated 2D long offset seismic reflection and refraction data support an amagmatic basin origin with a potential sedimentary origin for the ridges – Little evidence of mantle exhumation in the South Porcupine Basin**
- **A sedimentary origin for the South Porcupine Basin ridges has important positive implications for the development of deep Mesozoic petroleum systems in the frontier South Porcupine Basin and potentially for other similar hyper-extensional Mesozoic North Atlantic basinal systems**

# INTRODUCTION

# South Porcupine “Volcanic” Ridges

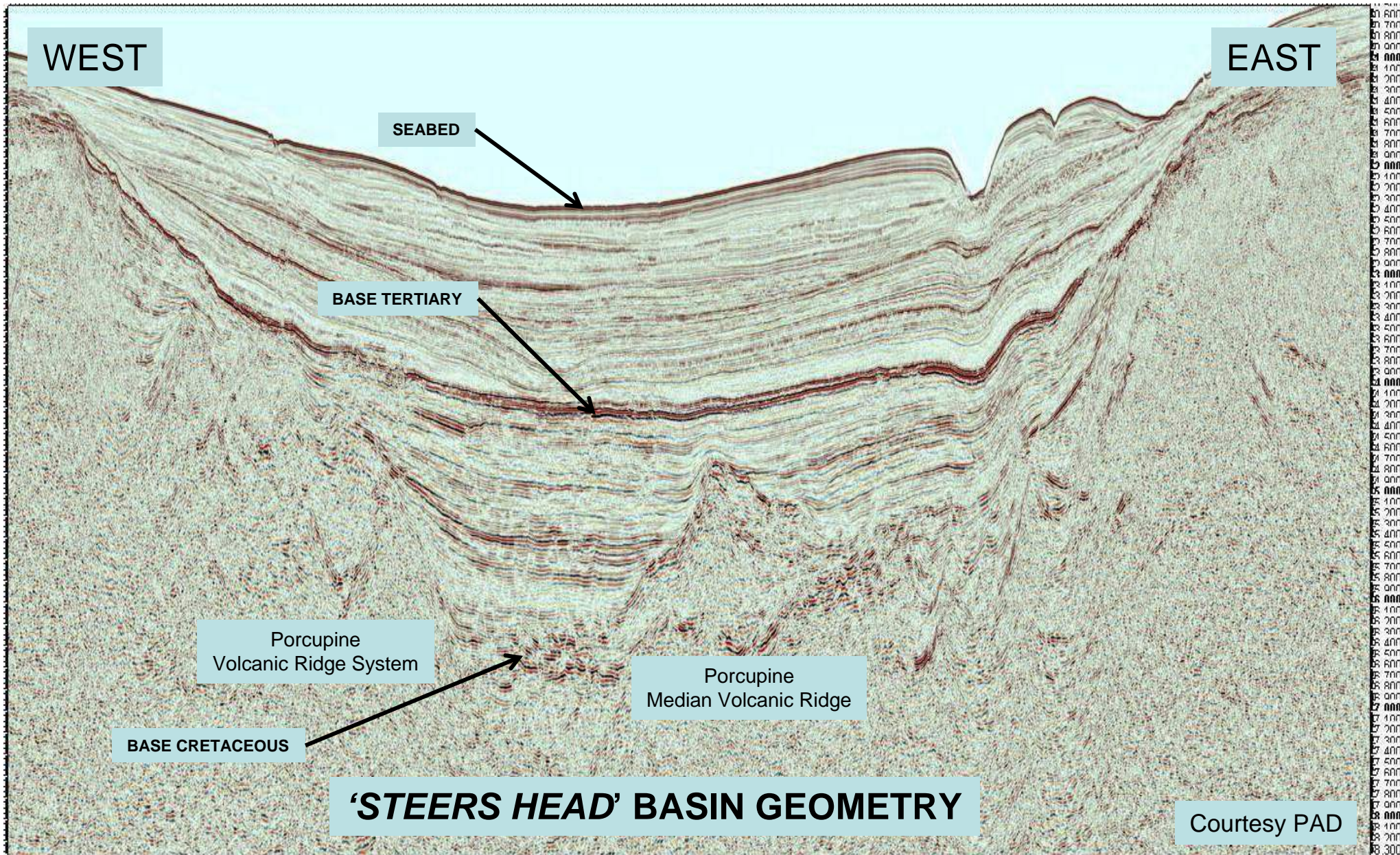


- Porcupine Median Volcanic Ridge
- Porcupine Volcanic Ridge System

after Naylor *et al.* 2002



# Regional Seismic Section

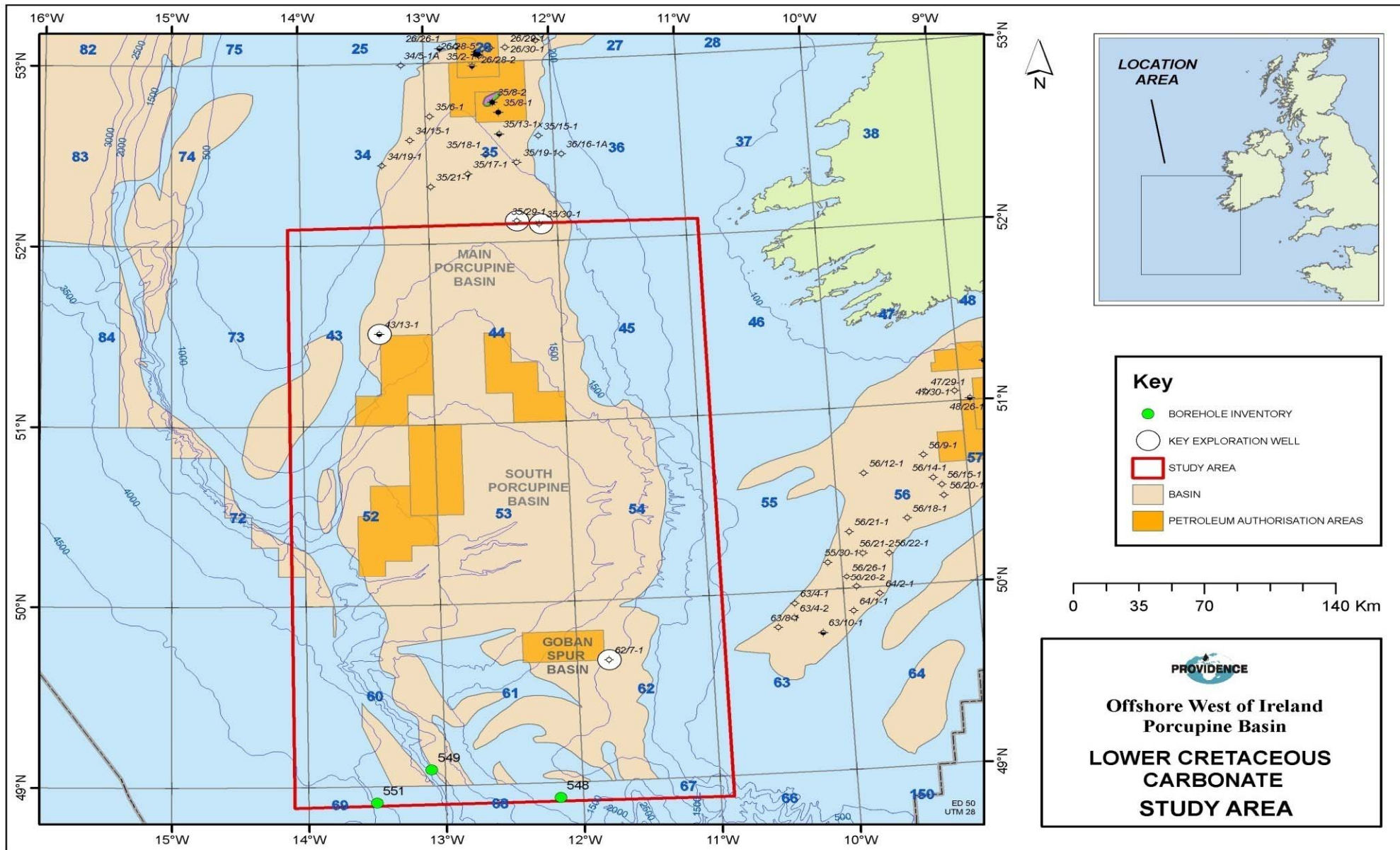




# Generalised Geological History

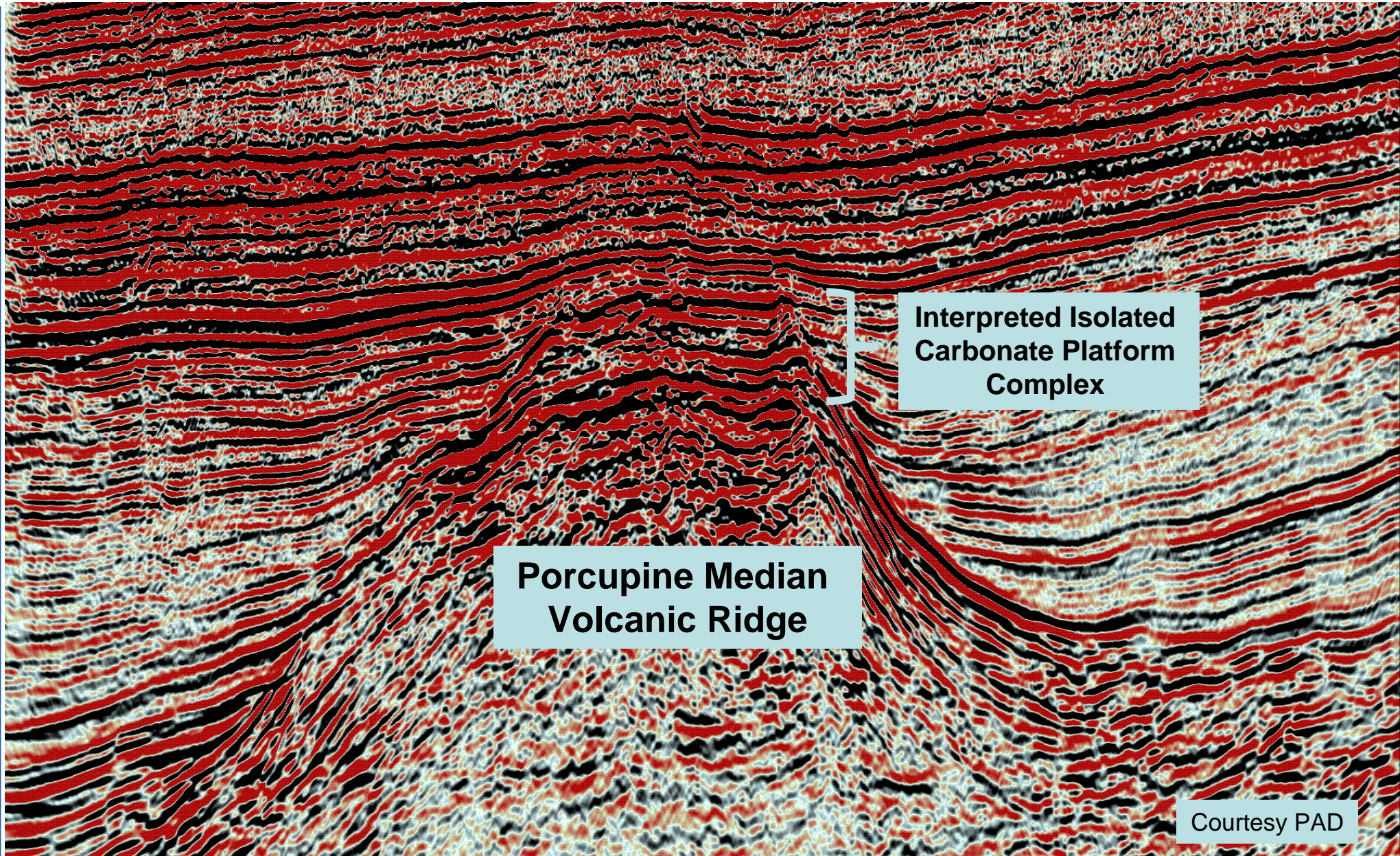
- Incipient Permo-Triassic rifting
  - Continental clastic & evaporite deposition
- Major Jurassic & Lower Cretaceous extensional phases
  - LK Clastics in Main Porcupine Basin
  - LK Carbonates in South Porcupine Basin
- Upper Cretaceous Chalks
- Cenozoic regional uplift & thermal sag
  - Associated igneous intrusives

# Petroleum Exploration Activity





# PMVR - Carbonate Play

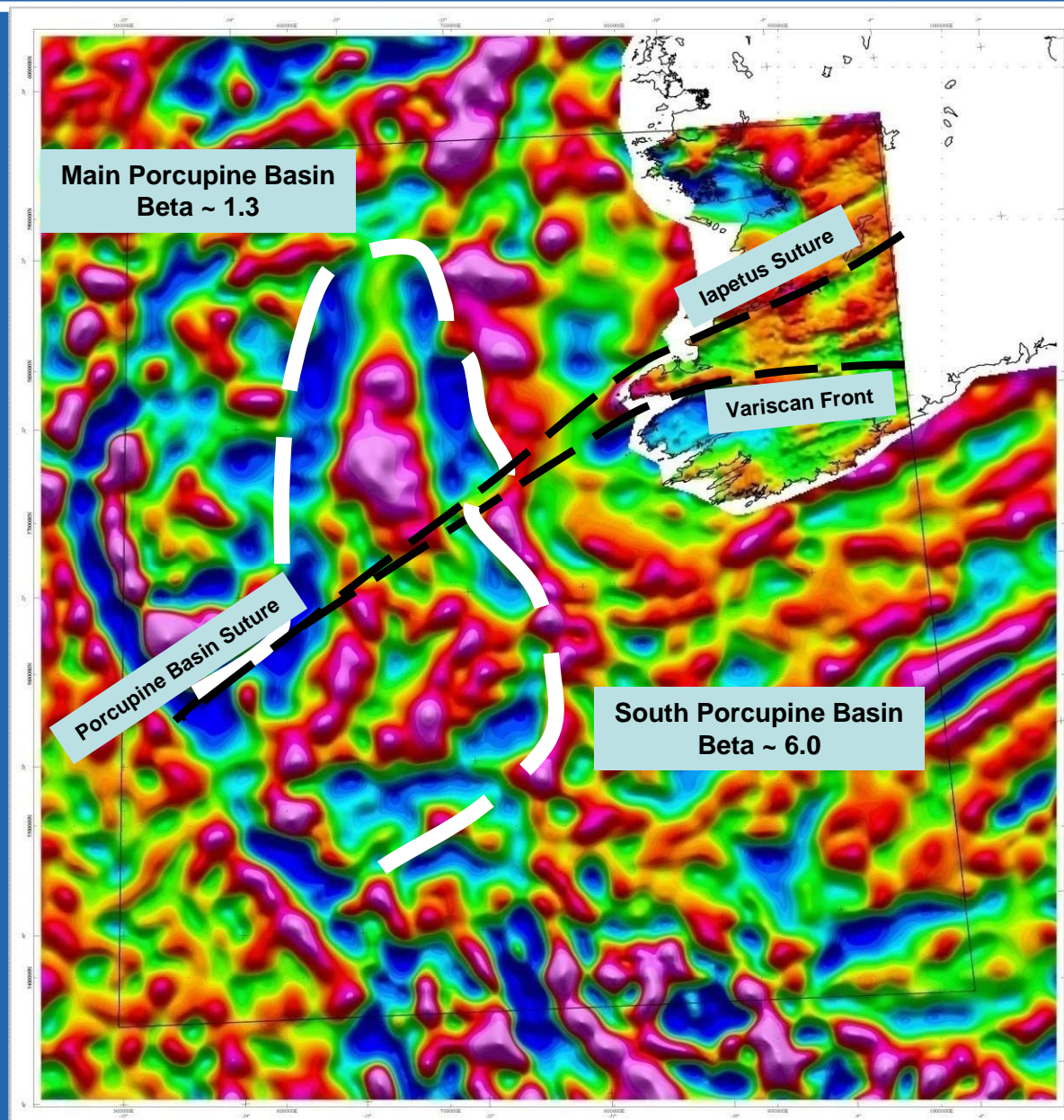


Interpreted Isolated  
Carbonate Platform  
Complex

Porcupine Median  
Volcanic Ridge



# Hyper-Extensional Environment



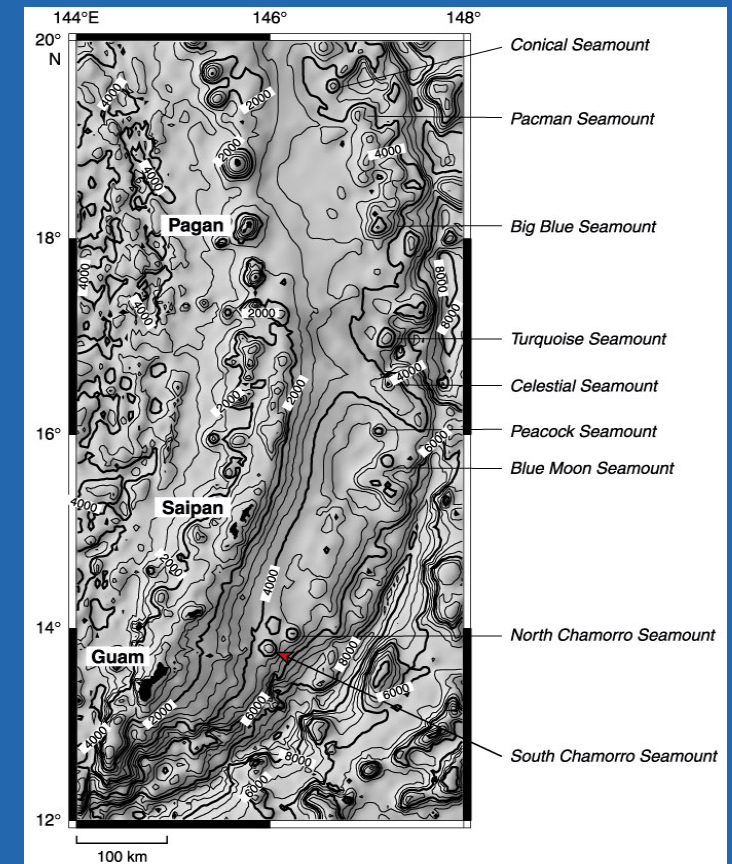
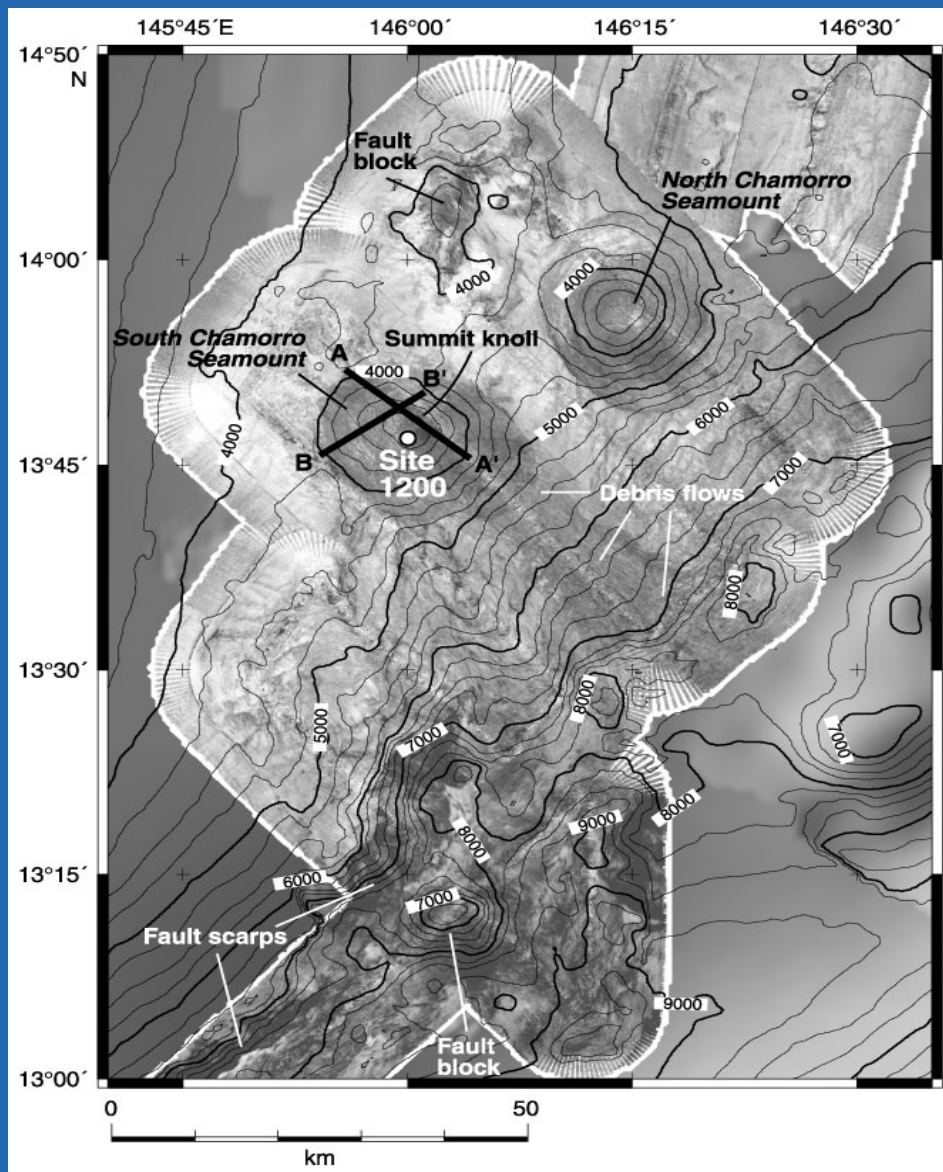


# PMVR Genesis Theories

- Volcanic
  - Magmatic Systems
- Sedimentary
  - Detached Fault Blocks
- Metamorphic
  - Serpentinitic Mud Mound

Hyper-Extension  
is the  
“Smoking  
Gun”

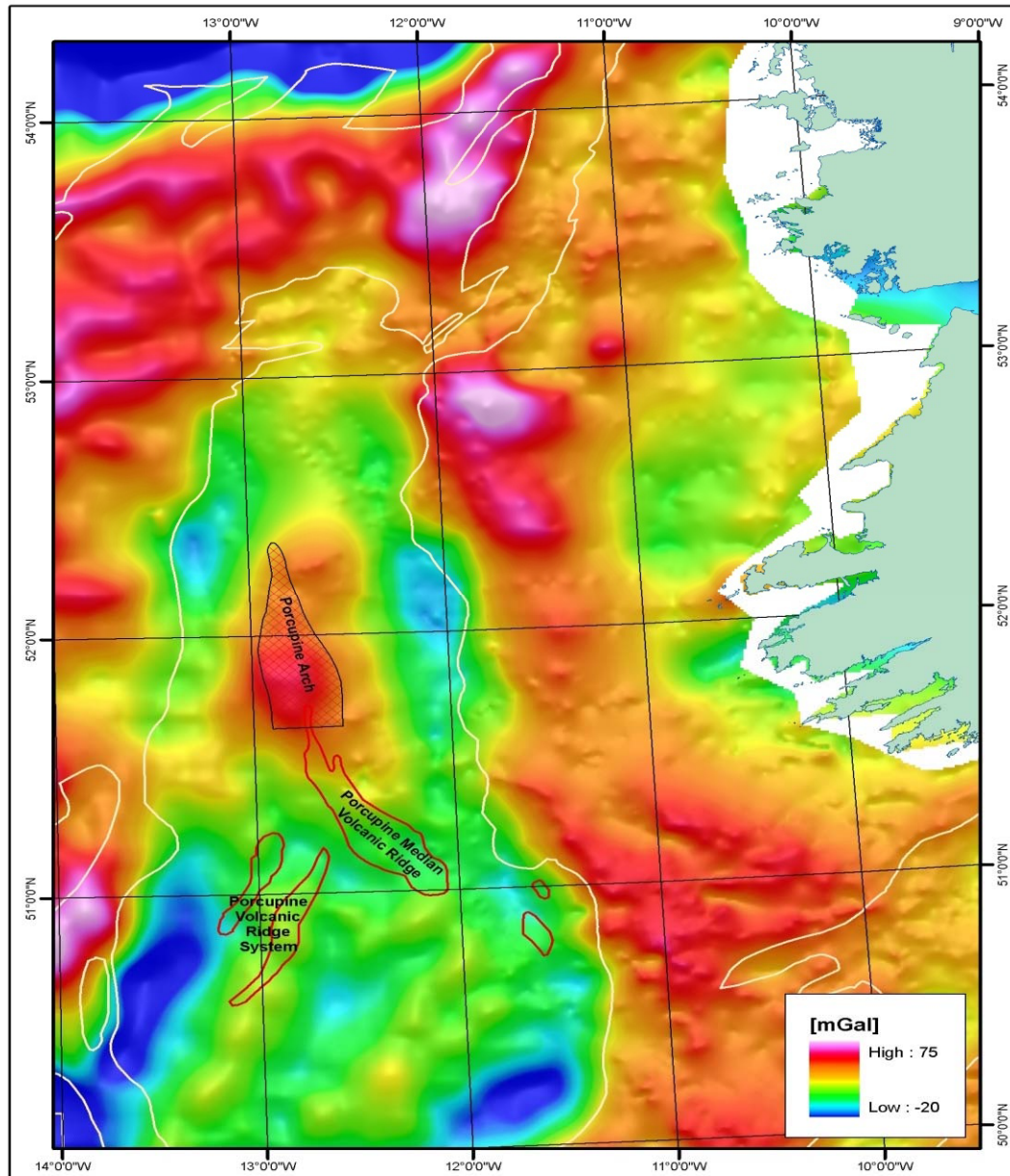
# Pacific Ocean Serpentinite Mounds



Courtesy ODP, Leg 1200

# POTENTIAL FIELD DATA

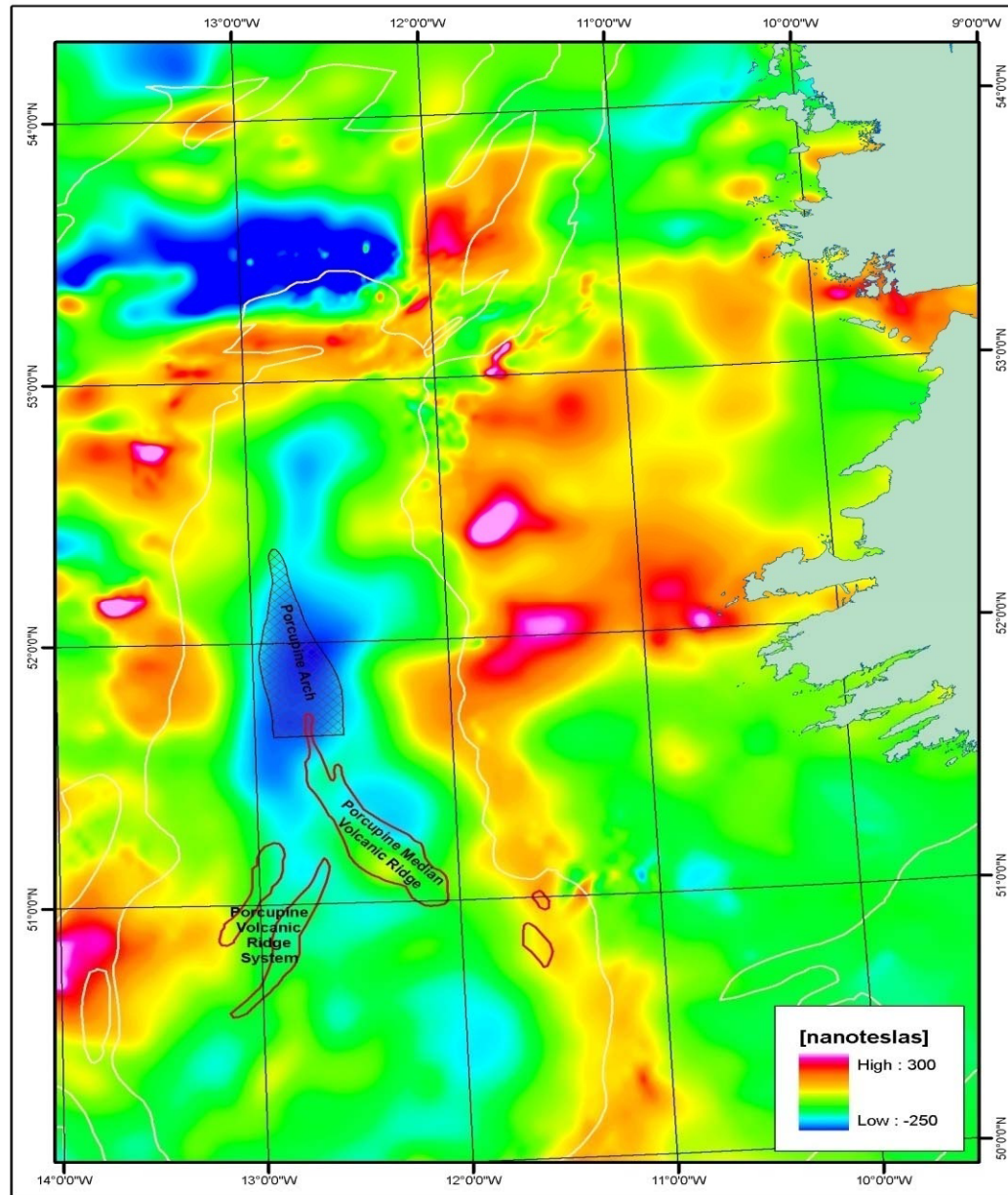
# Regional Gravity Anomaly



After Kimbell *et al.* BGS & Naylor *et al.* 2002  
Irish Petroleum Infrastructure Programme

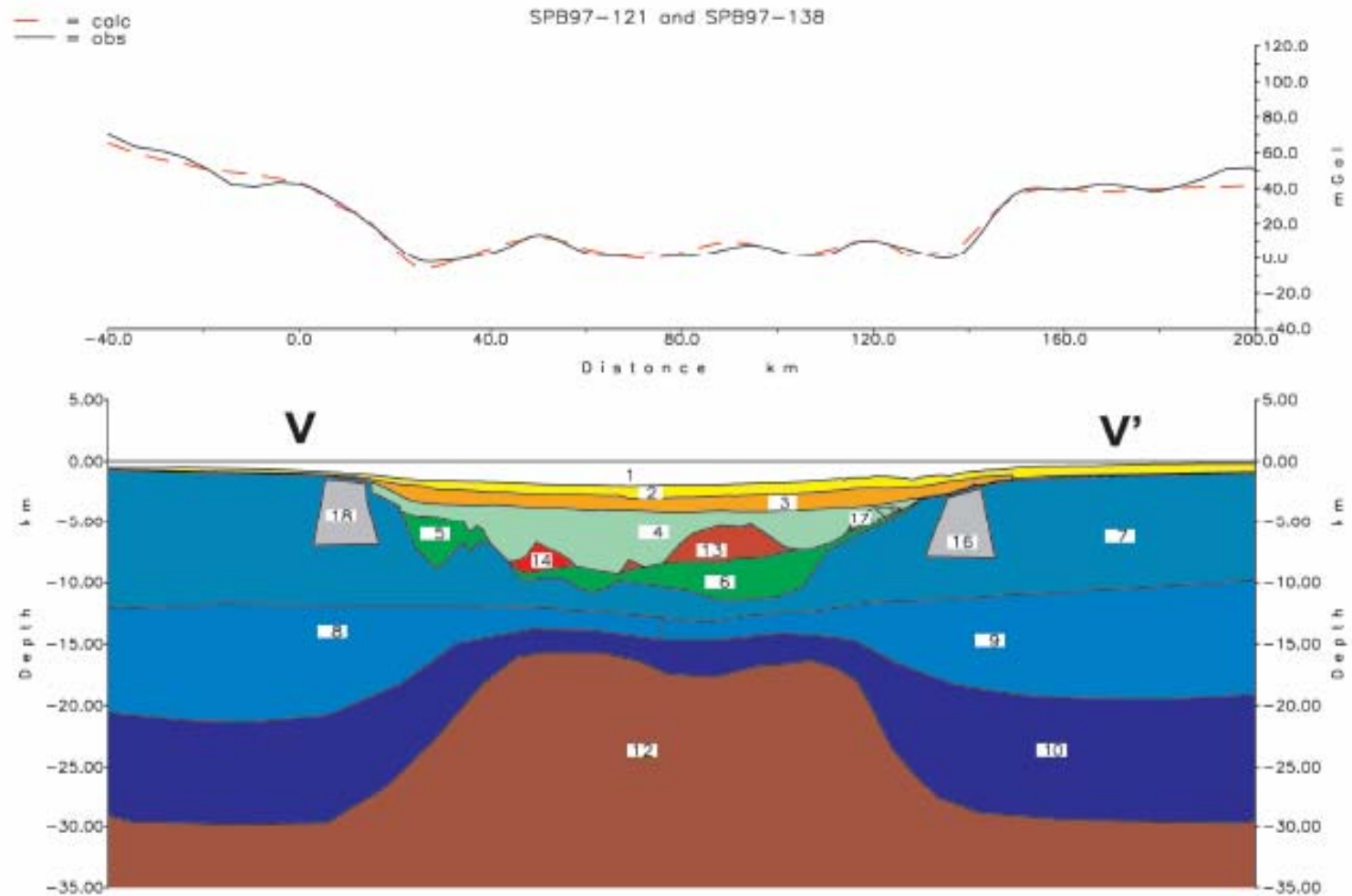


# Regional Magnetic Anomaly



After Kimbell *et al.* BGS & Naylor *et al.* 2002  
Irish Petroleum Infrastructure Programme

# Gravity Modelling



# Potential Field Observations

- Gravity Data

- Lack of significant gravity anomaly
  - Sedimentary Block – Good Fit
  - Serpentinic Mound – (?Composition)
  - Volcanic (?Interbedded w/Sediments)

- Magnetic Data

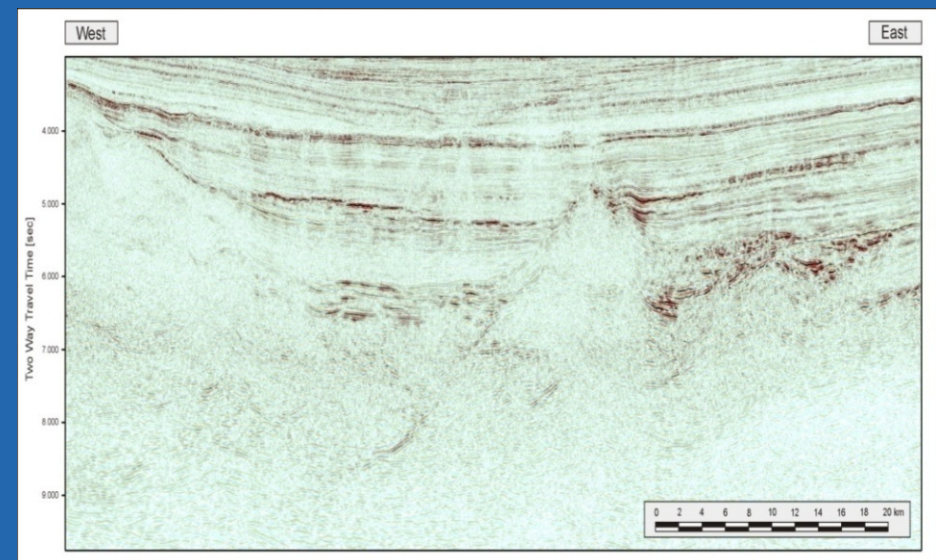
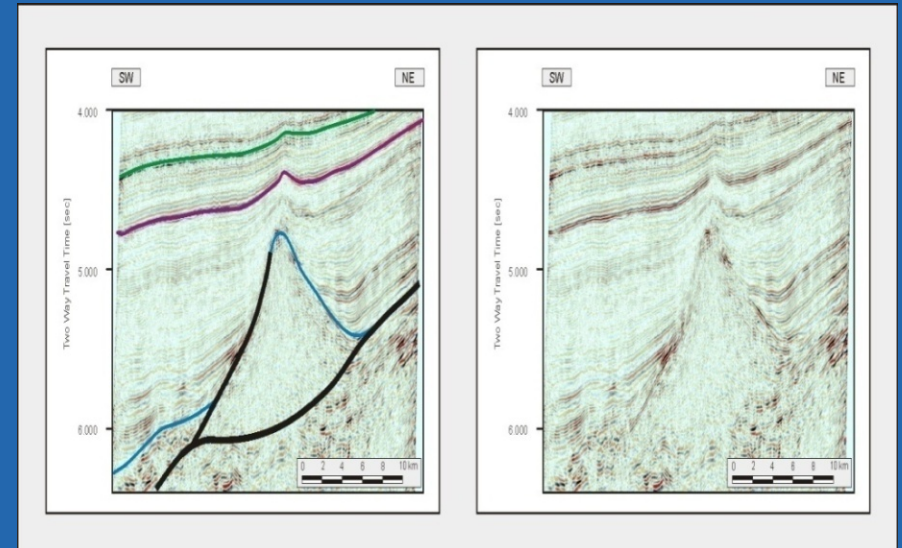
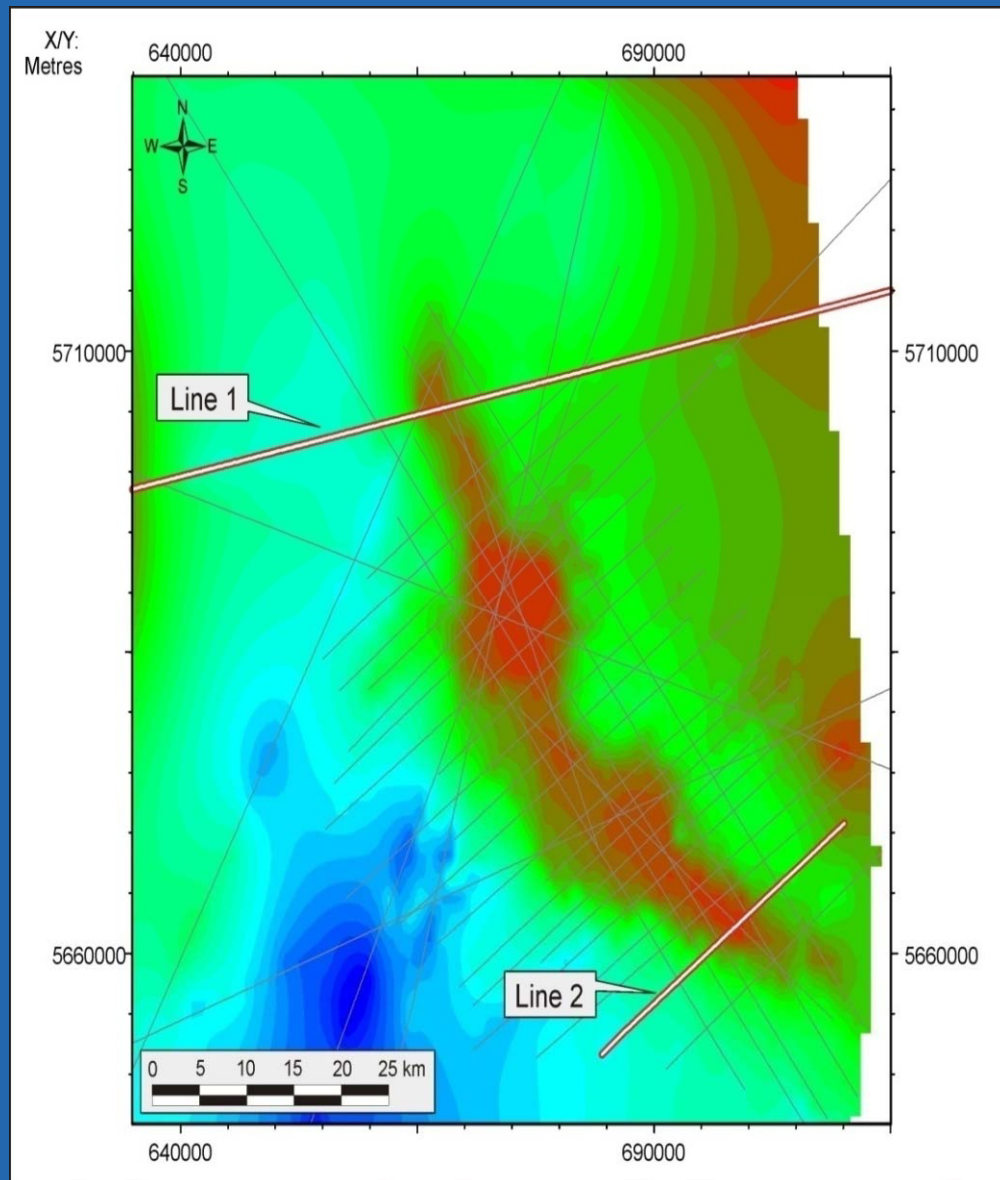
- Lack of significant magnetic anomaly
  - Sedimentary Block – Good Fit
  - Serpentinic Mound – (?Composition)
  - Volcanic – Low Susceptibility

# **LONG OFFSET SEISMIC DATA**

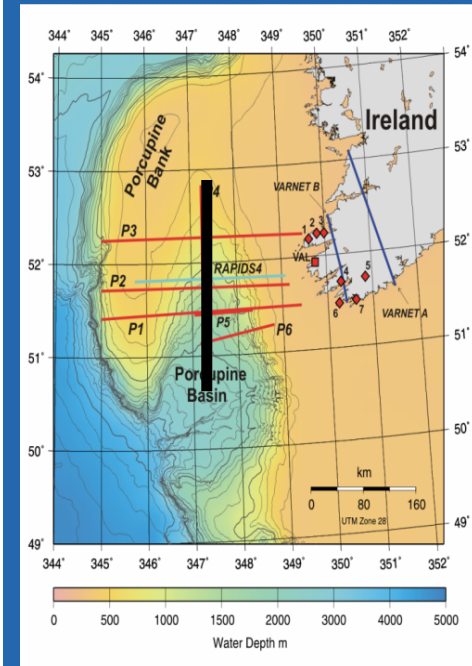
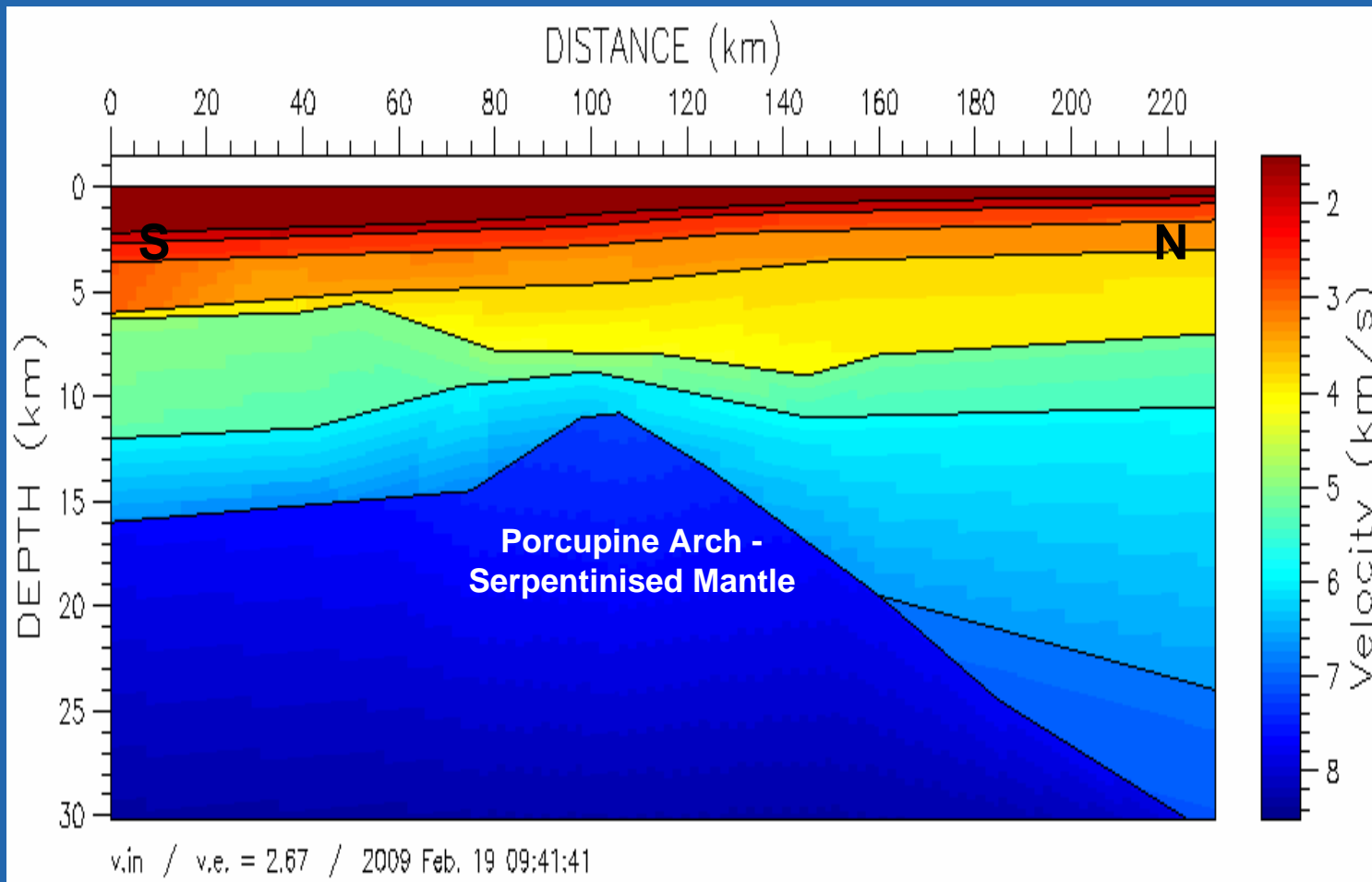
## **Reflection & Refraction**



# Porcupine Median Volcanic Ridge



# Seismic Refraction Studies



After Hauser & O'Reilly 2010  
Irish Petroleum Infrastructure Programme

# PETROLEUM SYSTEMS

# Petroleum Systems Analysis

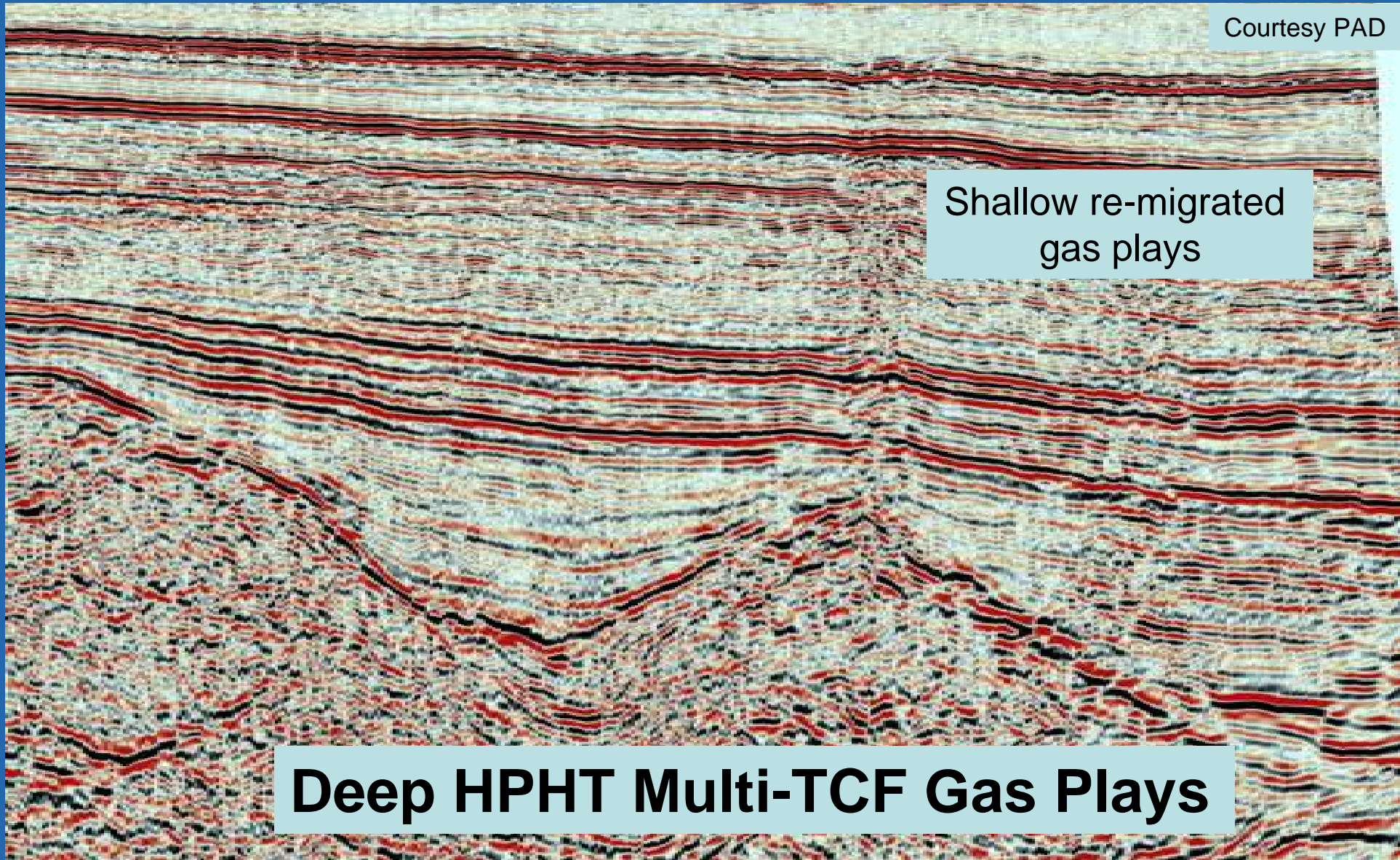
- Sedimentary Ridge System Origin
  - Low Heat Flow
    - Source Presence – More Likely & Well Developed
    - Source Maturation – Oil (Potential Deeper Source Potential)
    - Source Timing – Late (Top Seal Risk)
    - Source Access – Simple (More Direct)
    - Ridge Reservoir Potential (Likely)
- Volcanic/Metamorphic Ridge System Origin
  - High Heat Flow
    - Source Presence – Less Likely & More Discrete
    - Source Maturation – Gas (Deeper Sources Exhausted)
    - Source Timing – Early (Top Seal Risk)
    - Source Access – Tortuous (Less Direct)
    - Ridge Reservoir Potential (Unlikely)

# PVRS – Sedimentary or Volcanic?

Courtesy PAD

Shallow re-migrated  
gas plays

**Deep HPHT Multi-TCF Gas Plays**





# SUMMARY

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# BIG BASIN – BIG BOYS - BIG GAS?



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