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

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  – www.pip.ie

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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

Porcupine Volcanic Ridge System

BASE TERTIARY

Porcupine Median Volcanic Ridge

BASE CRETACEOUS

‘STEERS HEAD’ BASIN GEOMETRY

Courtesy PAD
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

Key

- BOREHOLE INVENTORY
- KEY EXPLORATION WELL
- STUDY AREA
- BASIN
- PETROLEUM AUTHORIZATION AREAS

Offshore West of Ireland Porcupine Basin
LOWER CRETACEOUS CARBONATE
STUDY AREA
PMVR - Carbonate Play

Interpreted Isolated Carbonate Platform Complex

Porcupine Median Volcanic Ridge

Courtesy PAD
Hyper-Extensional Environment

Main Porcupine Basin
Beta ~ 1.3

South Porcupine Basin
Beta ~ 6.0

Iapetus Suture
Variscan Front

After Kimbell et al. BGS
Irish Petroleum Infrastructure Programme
PMVR Genesis Theories

- Volcanic
  - Magmatic Systems

- Sedimentary
  - Detached Fault Blocks

- Metamorphic
  - Serpentinitic Mud Mound

Hyper-Extension is the “Smoking Gun”

After O’Sullivan et al. 2009
Pacific Ocean Serpentine Mounds
POTENTIAL FIELD DATA
Regional Gravity Anomaly
Regional Magnetic Anomaly

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

Readman et al. 2005
Potential Field Observations

• Gravity Data
  – Lack of significant gravity anomaly
    • Sedimentary Block – Good Fit
    • Serpentinitic Mound – (?Composition)
    • Volcanic (?Interbedded w/Sediments)

• Magnetic Data
  – Lack of significant magnetic anomaly
    • Sedimentary Block – Good Fit
    • Serpentinitic Mound – (?Composition)
    • Volcanic – Low Susceptibility
LONG OFFSET SEISMIC DATA

Reflection & Refraction
Porcupine Median Volcanic Ridge

After O’Sullivan et al. 2010 (in prep)
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?

Deep HPHT Multi-TCF Gas Plays

Shallow re-migrated gas plays
SUMMARY
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BIG BASIN – BIG BOYS - BIG GAS?

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