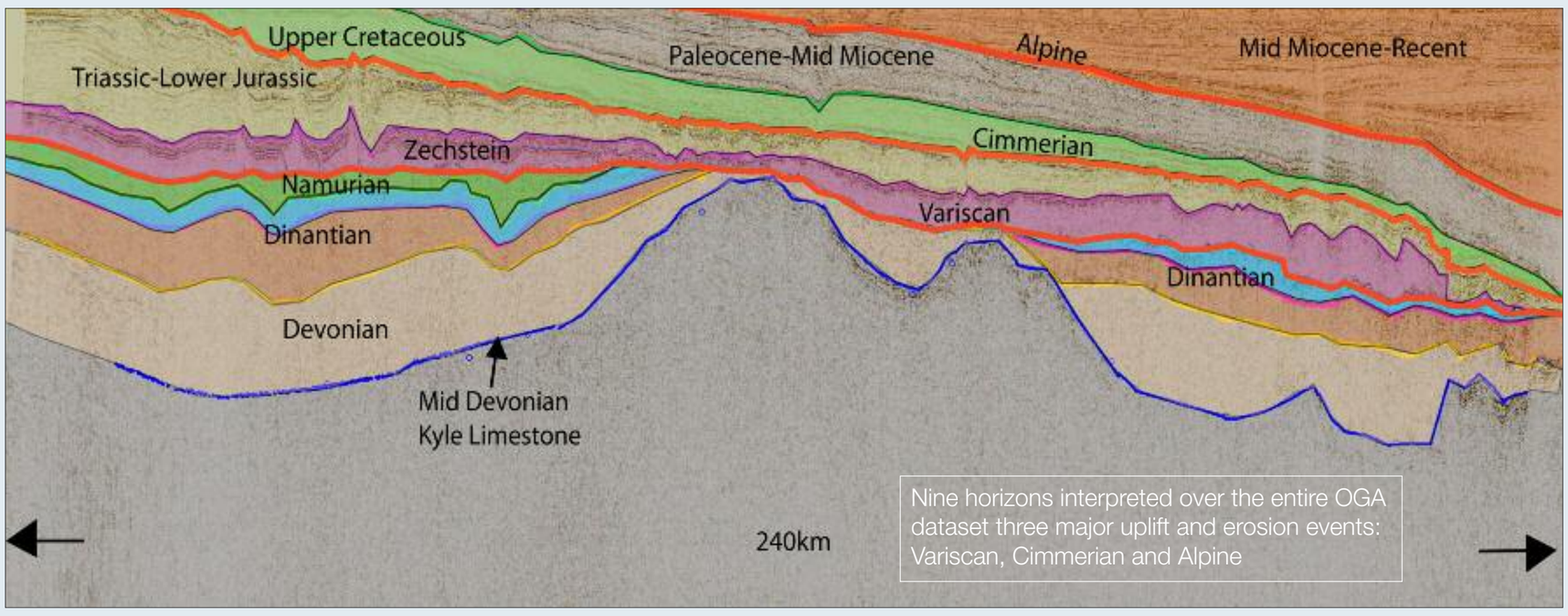
GWL
www.geoscience-wales.co.uk

a recognised centre of geoscience excellence

SOURCE ROCKS OF THE MID NORTH SEA HIGH: AN INTEGRATED SEISMIC AND BASIN MODELLING STUDY

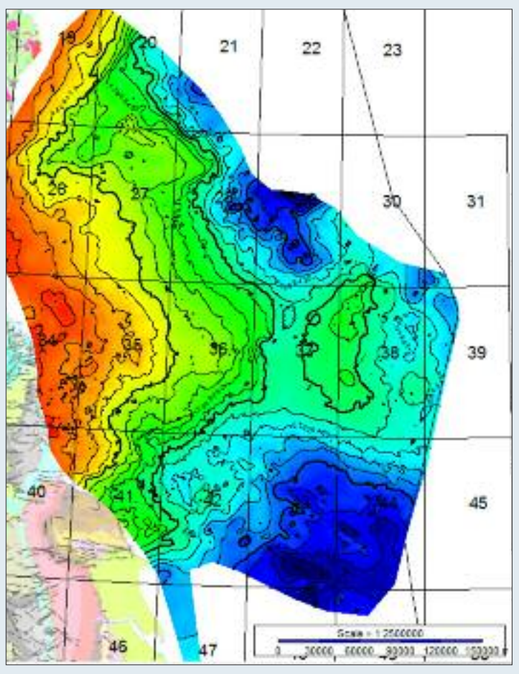
Stephen Corfield, Julian Moore, Maurice Bamford, Andrew Barnwell and Patrick Barnard.

1. Seismic interpretation and regional mapping

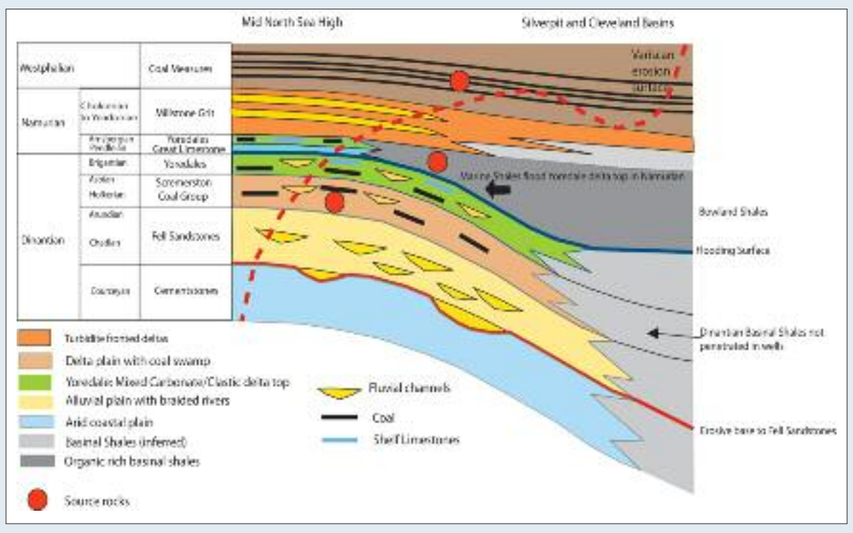


Nine horizons interpreted over the entire OGA dataset three major uplift and erosion events: Variscan, Cimmerian and Alpine

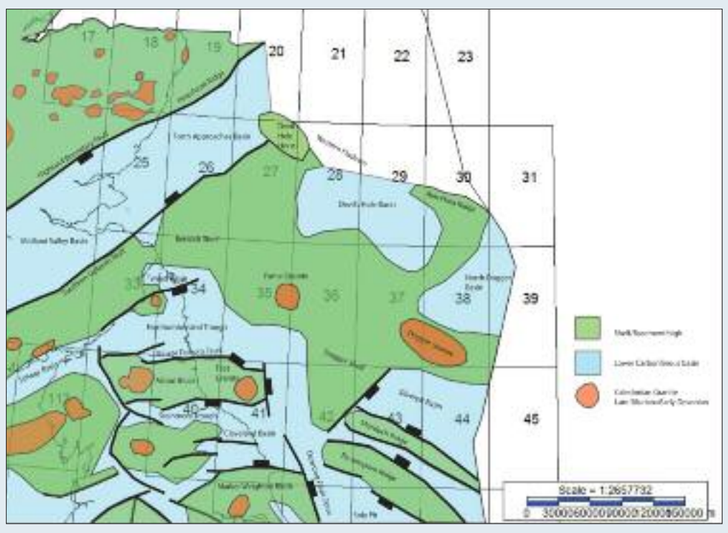
Base Zechstein depth map



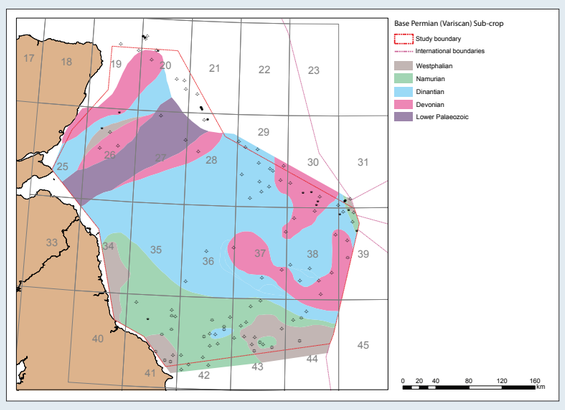
Dinantian to westphalian stratigraphy of the Mid North Sea High and the Silverpit and Cleveland Basins



Carboniferous structural elements



Pre-Permian subcrop

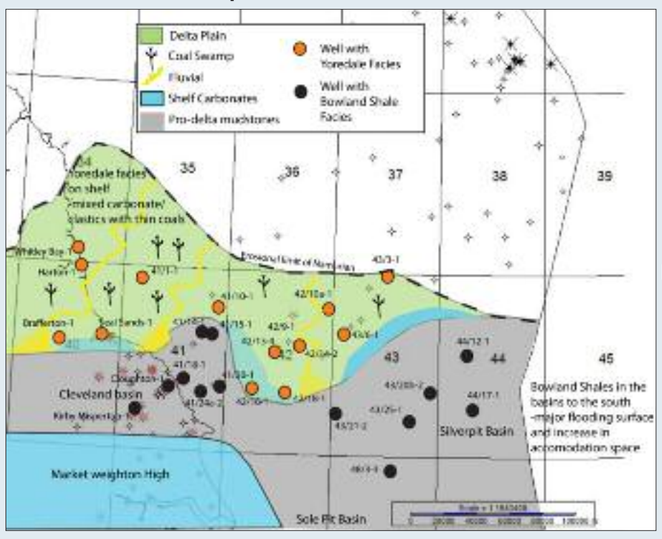


- The Upper Carboniferous is restricted to the southern part of the study area
- Dinantian sediments are found over the central and northern parts

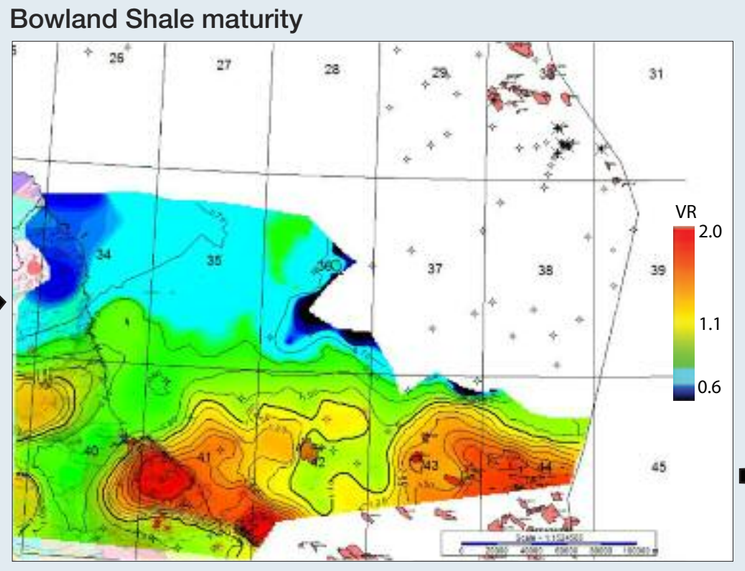
2. Source rocks and 3D basin modelling

Source rocks: Westphalian Coals are restricted in distribution (see subcrop map) and are largely immature for gas generation in the study area.
The two main source rocks are the Lower Namurian Bowland Shales and Dinantian Scremerston Coal Group

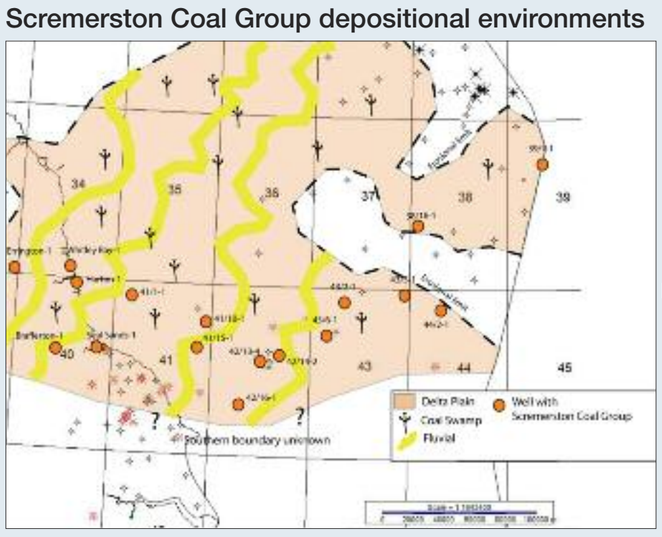
Bowland Shale depositional environments



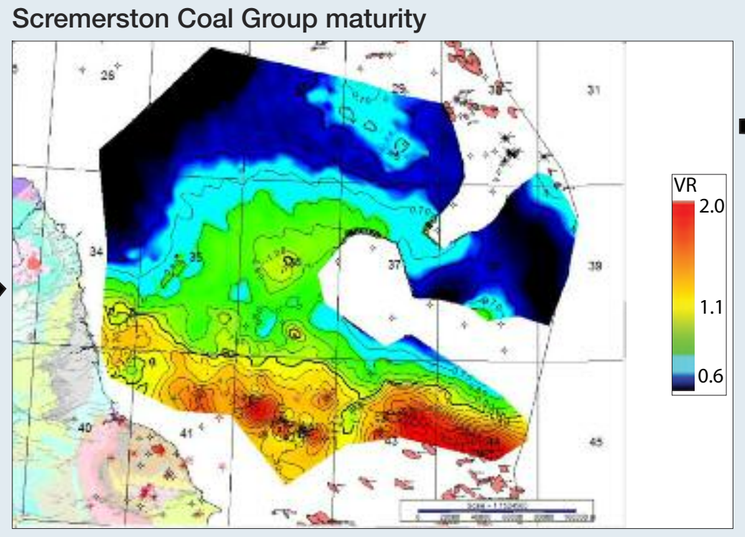
Bowland Shale maturity



Scremerston Coal Group depositional environments



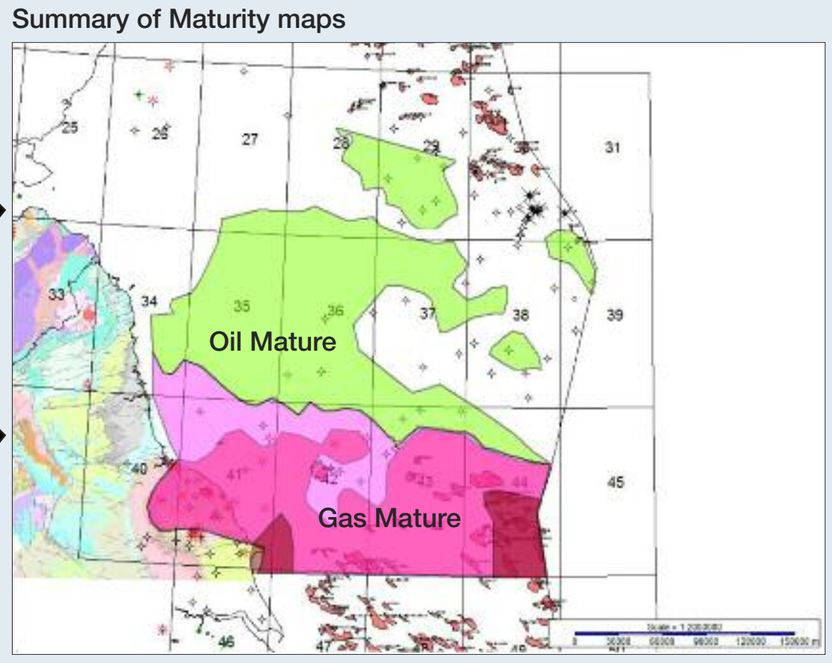
Scremerston Coal Group maturity



Inputs to Trinity software to build 3D model

- nine depth depth grids of key horizons
- three major uplift and erosion events
- restoration of missing section
- crustal thickness and heat flow
- maturity data

Summary of Maturity maps



- Scremerston Coal Group oil mature
- Scremerston Coal Group gas mature
- Bowland Shales gas mature
- Westphalian gas mature

Final Study Report

Petroleum Systems of the Mid North Sea High

Reference No: TRN010/03/2016

Submitted by:

Geoscience Wales Ltd
9 Connaught House
Riverside Business Park
Benarth Road
Conwy
LL32 8UB
Wales

16th November 2016

Table of Contents

Executive Summary 2

Table of Contents 3

List of Tables 6

List of Figures 6

1. Introduction 13

2. Data Availability 14

2.1. Introduction 14
2.2. Seismic Data 14
2.3. Potential Fields Data 14
2.4. LAS Well Data 14
2.5. Well Data 14
2.6. Tops, Lithology and Shows Database 15
2.7. Geochemical Data 15

3. Geophysical Interpretation 23

3.1. Stratigraphy 23
3.2. Seismic Data Quality 23
3.2.1. Legacy 2D data 23
3.2.2. OGA 2015 survey 23
3.3. Horizons Interpreted 24
3.3.1. Post Carboniferous Stratigraphy 24
3.3.2. Pre-Permian Structure interpretation 25
3.4. Devonian-Carboniferous Basins of the MNSH 26
3.4.1. Dogger Granite, Dogger Shelf, North Dogger Basin and the Devil's Hole Basin 26
3.4.2. Northumberland Trough, Alston Block and Cleveland Basin 27
3.4.3. Midland Valley and the Forth Approaches Basin 27

4. Tectonic Development 69

4.1. Devonian to Early Carboniferous Rifting 69
4.2. Carboniferous Thermal Subsidence 70
4.3. Variscan Foreland Basin 70
4.4. Variscan Orogeny and Base Permian Thermal Doming 70
4.5. Permo-Triassic Basin Formation 71
4.6. 'Mid-Cimmerian' Uplift Event 71
4.7. Jurassic Rifting 71
4.8. Cretaceous to Tertiary Thermal Subsidence 71
4.9. Tertiary 'Alpine' Uplift and Erosion 72

4.9.1. Laramide Event (Latest Cretaceous – Palaeocene) *72*
4.9.2. Pyrenean Event (Eocene-Oligocene) *72*
4.9.3. 'Late' Alpine Event (~10 Ma) *73*

5. Gross Depositional Environments 78
5.1. Introduction 78
5.2. Methodology 78
5.3. Mid-Miocene to Holocene (Nordland Group) 79
5.4. Eocene (Stronsay Group) 80
5.5. Palaeocene (Moray and Montrose Groups) 80
5.6. Cretaceous 81
5.7. Jurassic 81
5.8. Triassic 82
5.9. Early Permian (Rotliegendes Group) 83
5.10. Late Permian (Zechstein Group) 83
5.11. Carboniferous 84
5.11.1. Fell Sandstone Formation *84*
5.11.2. Scremerston Coal Group *84*
5.11.3. Yoredale Formation *85*
5.11.4. Early Namurian Yoredale/Bowland Shales *85*

6. Petroleum Systems 128
6.1. Introduction 128
6.2. Source rocks 128
6.2.1. Well defined source rocks 128
6.2.2. Basins with poorly defined source rocks *130*
6.2.3. Undefined source rocks *131*
6.3. Distribution of Hydrocarbons 131
6.4. Basin & Petroleum System Modelling 132
6.4.1. Modelling Approach *132*
6.4.2. Source Rock Parameterisation *132*
6.4.3. Data Input *134*
6.4.3.1. Boundary Conditions *134*
6.4.4. Trinity Model Calibration / Genesis Integration *136*
6.4.5. Results & Discussion *136*
6.4.6. Basin and Petroleum Systems Summary *138*
..... 183

7. Plays and Common Risk Segment Maps 202
7.1. Introduction 202
7.2. Nordland Group Shallow Gas Play 202
7.2.1. Introduction *202*
7.2.2. Netherlands Analogues *203*

7.2.3. Shallow Gas Play in the MNSH study area *203*
7.3. Palaeocene to Eocene Heavy Oil Play 204
7.4. Upper Cretaceous - Chalk 205
7.5. Lower Cretaceous and Upper Jurassic Shallow Maine Play 205
7.6. Middle and Lower Jurassic 205
7.7. Triassic Aeolian Play 205
7.8. Zechstein Carbonate Play 206
7.9. Rotliegendes to Devonian 206
7.9.1. Rotliegendes *207*
7.9.2. Carboniferous *207*
7.9.3. Devonian *208*

8. Petroleum System Summary and Conclusion 222

9. References 223

Appendix 2. List of digital data included with the report 228

Appendix 6. 229
Appendix 6.1. 229
Appendix 6.2. 258
Appendix 6.3. 265