Unconventional Hydrocarbon Potential of the Weald Basin, Southern England, United Kingdom*

Francesco Palci[1], Alastair Fraser[1], Martin Carles[1], Martin Neumaier[1], Stephen Sanderson[2], and Rob Wallace[2]

Search and Discovery Article #11100 (2018)**
Posted July 30, 2018

*Adapted from oral presentation given at 2018 AAPG Annual Convention & Exhibition, Salt Lake City, Utah, May 20-23, 2018

[1]Earth Science and Engineering, Imperial College London, London, United Kingdom (francesco.palci14@imperial.ac.uk)
[2]UKOG, Guilford, United Kingdom

Abstract

Petroleum in the Weald Basin has been produced since the late 19th century from conventional sandstone and carbonate reservoirs sourced from Jurassic marine source rocks. These source rocks include the Kimmeridge Clay, the Lower Oxford Clay, and the Liassic Shale intervals. To date 13 small oil fields have been discovered and all of them are located on the basin margins, while only gas shows and seeps have been recorded in the basin centre. The exploration success and production have undergone a major downturn in the last 30 years as existing production has declined and exploration has ceased. Our view of the Weald Basin hydrocarbon potential changed radically in 2014 following the Horse Hill 1 oil discovery. This well successfully tested two previously unknown naturally fractured Kimmeridge Limestone horizons. Dry-oil flowing at rate of around 400 and 900 bopd were recorded from the Lower and the Upper Kimmeridge Limestone horizons respectively.

In this study a regional 3D basin and petroleum systems model has been built using 70 available boreholes data and composite 2D seismic lines. The research is focused on gaining a better understanding of how the Weald Basin petroleum system has developed through time, taking into account its complex tectonic evolution and erosion/uplift history. Furthermore, some of the outcomes of the model are used to address some key questions, such as: why are the conventional oil fields limited to the basin margins? Why do we find only gas shows in the basin centre? Is there a basin centre petroleum system preserved in tight rocks?

Selected References

Andrews, I.J., 2014, The Jurassic shales of the Weald Basin: geology and shale oil and shale gas resource estimation: British Geological Survey for Department of Energy and Climate Change, London, UK.

Hawkes, P.W., A.J. Fraser, and C.C.G. Einchcomb, 1998, The tectono-stratigraphic development and exploration history of the Weald and Wessex basins, Southern England, UK: Geological Society London Special Publications, v. 133/1, p. 39-65.

Unconventional hydrocarbon potential of the Weald Basin, Southern England, UK

Francesco Palci[1], Alastair Fraser[1], Martin Carles[1], Martin Neumaier[1]
Stephen Sanderson[2], Rob Wallace[2], Jamie Burford[2]

[1]Imperial College London
[2]UKOG

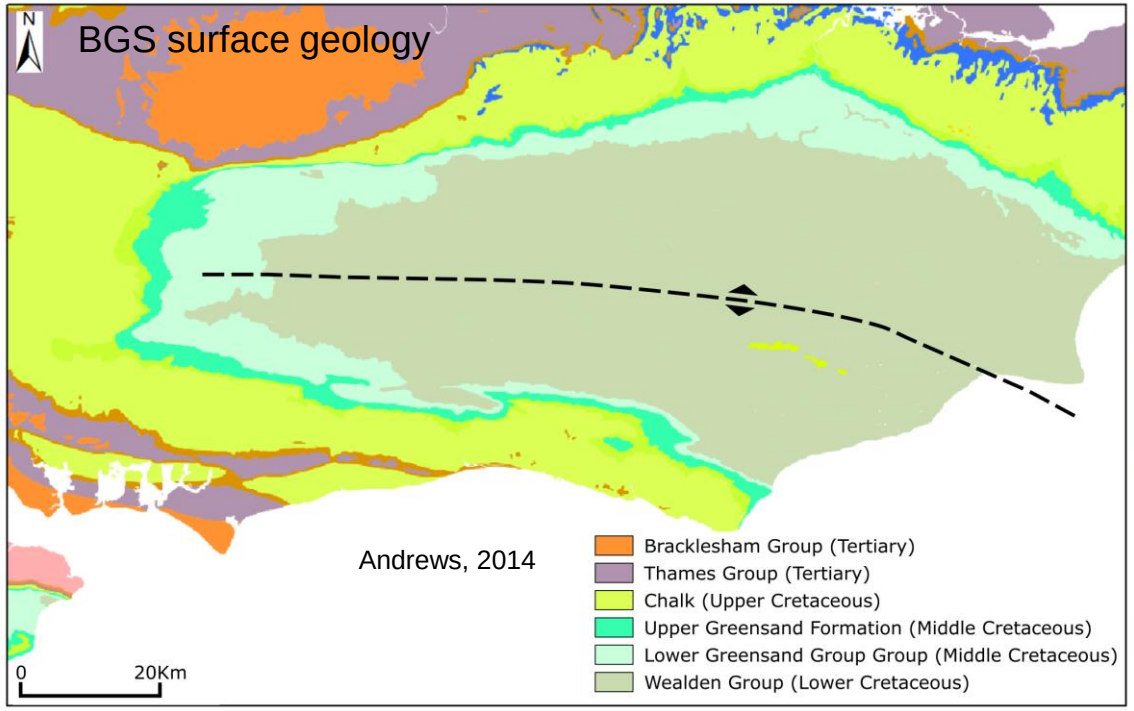
Outline

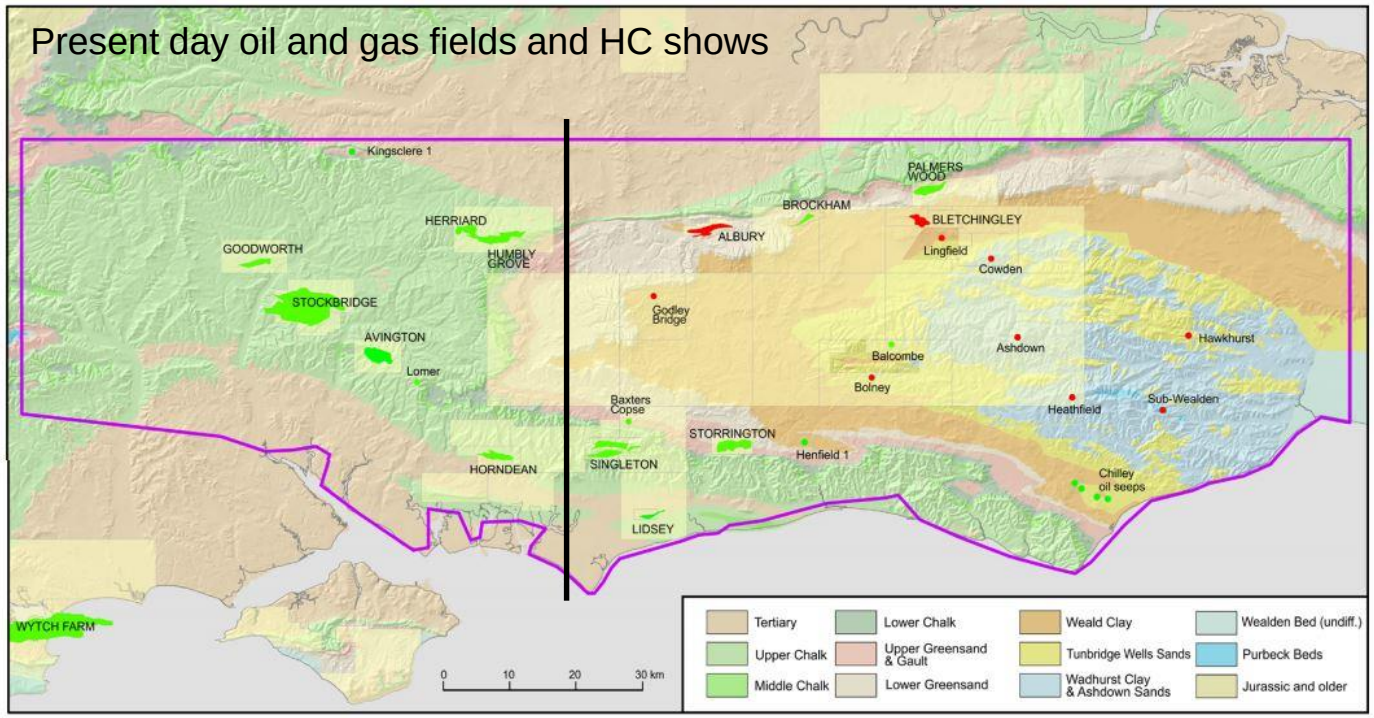
- Aims and objectives
- Geological setting and exploration history
- Interpretation and petroleum systems modelling
- Conclusions and learning

Aims and objectives

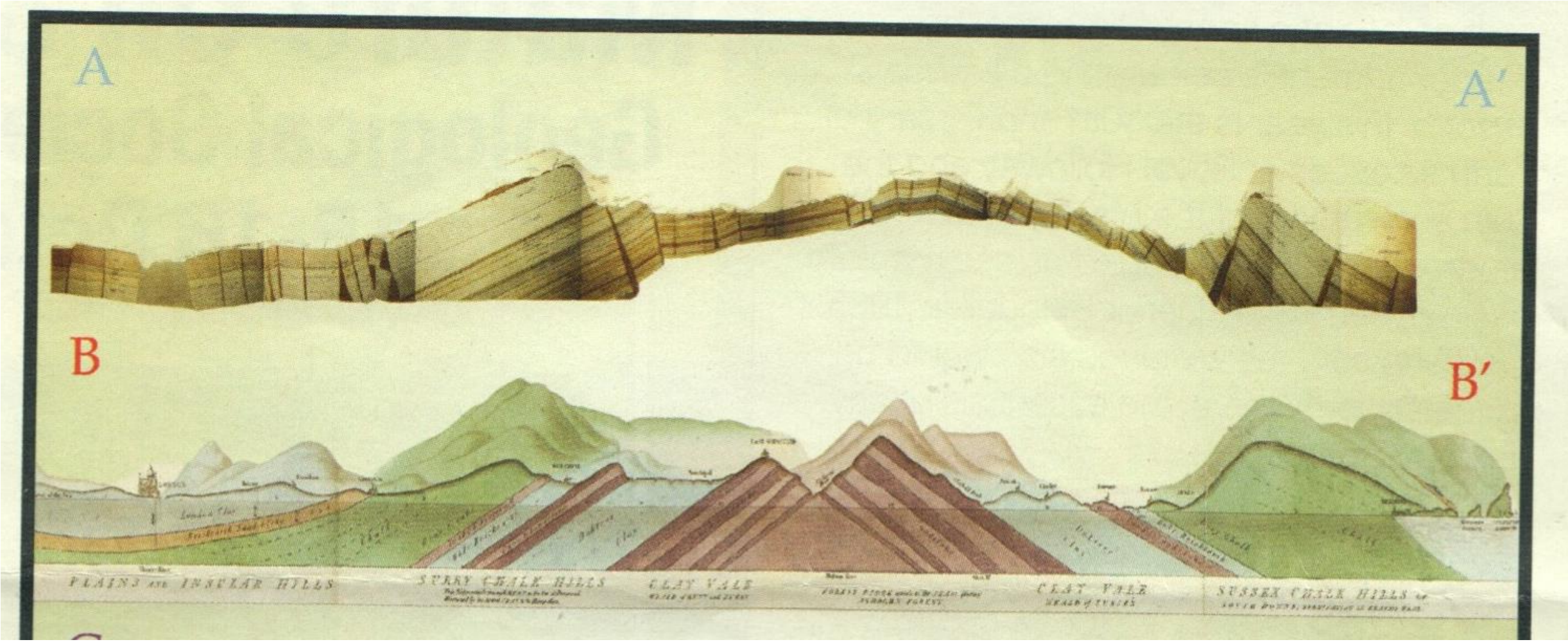
- Assess the unconventional potential of the Weald Basin
  - Reconstruct the burial history of the basin
  - Assess the thermal maturity of the Jurassic source rock intervals
  - Understand the distribution of the present day conventional oil and gas fields and shows

Geological setting





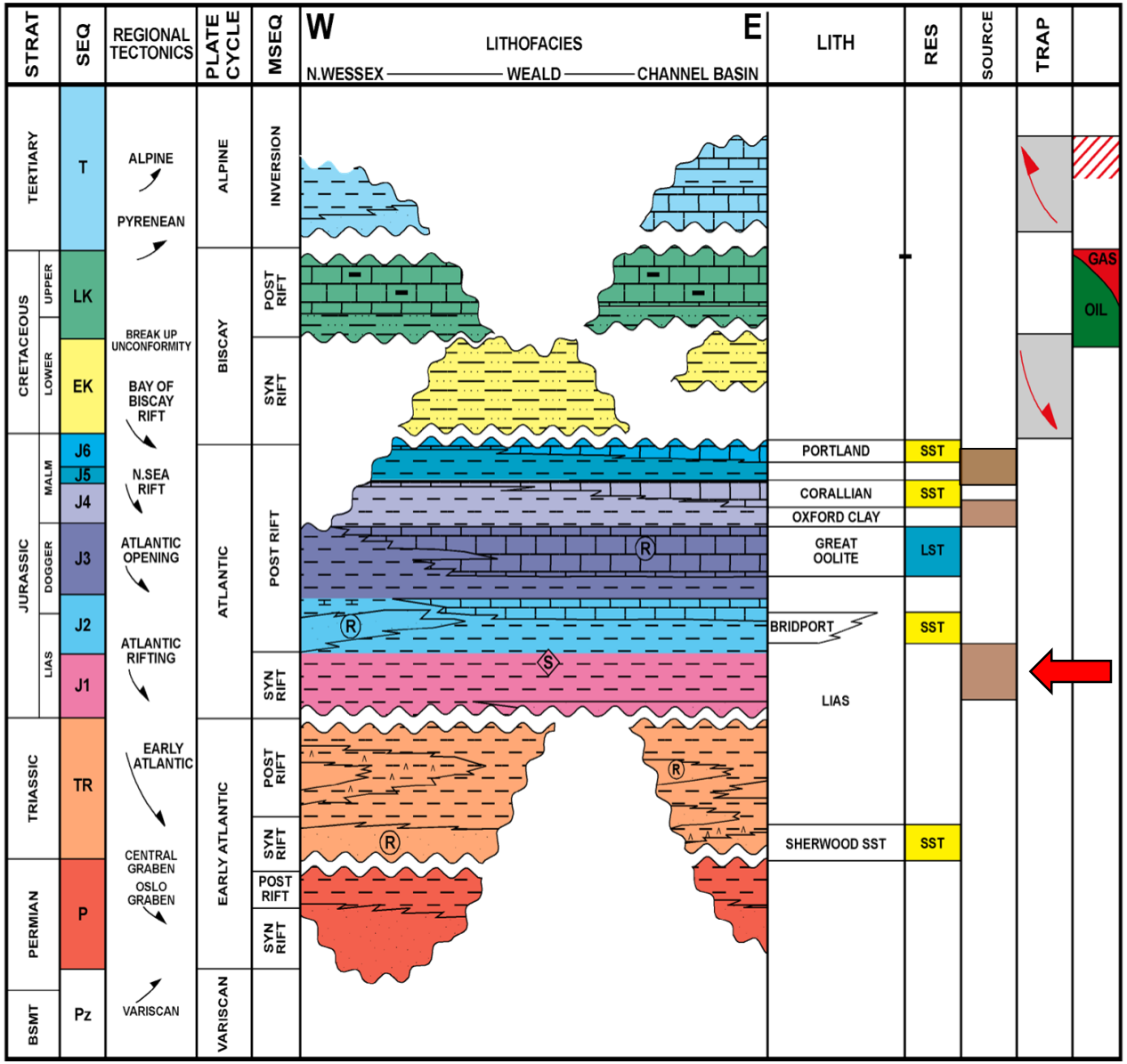
Weald Basin cross section



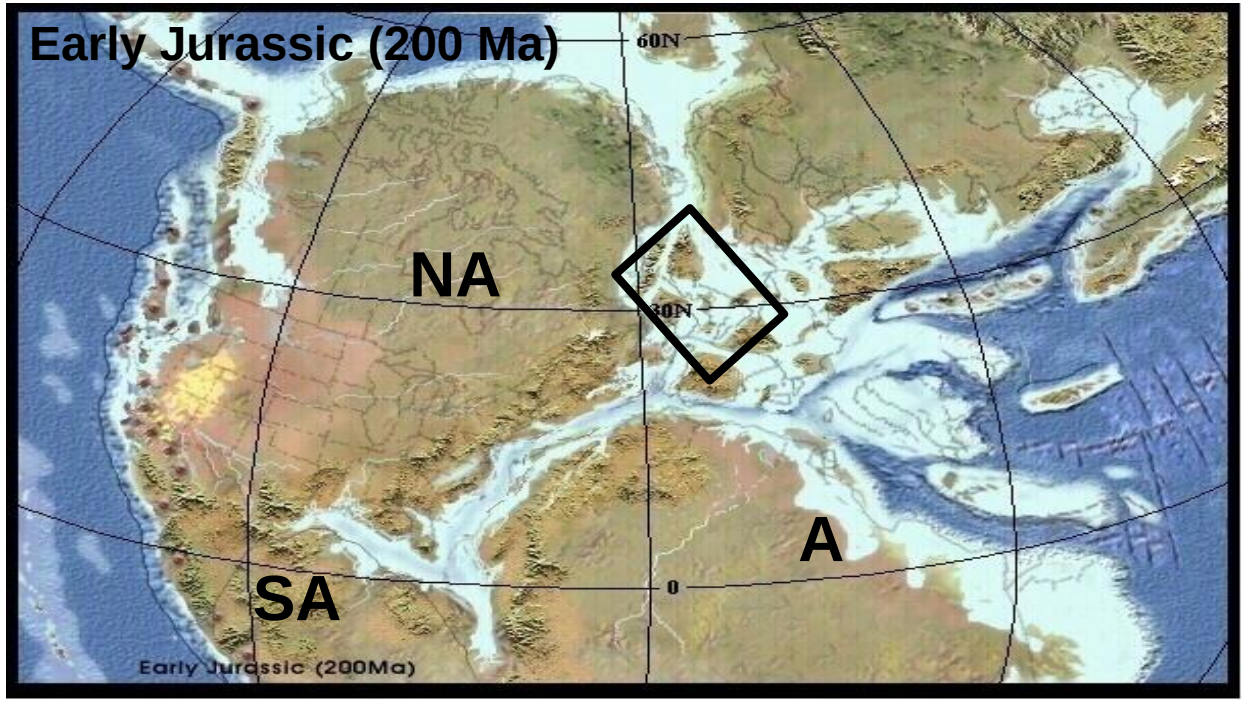
Section A: Geological cross section of the Weald by John Farey (1807)

Section B: Geological cross section of the Weald by William Smith (1819)

Tectonic evolution



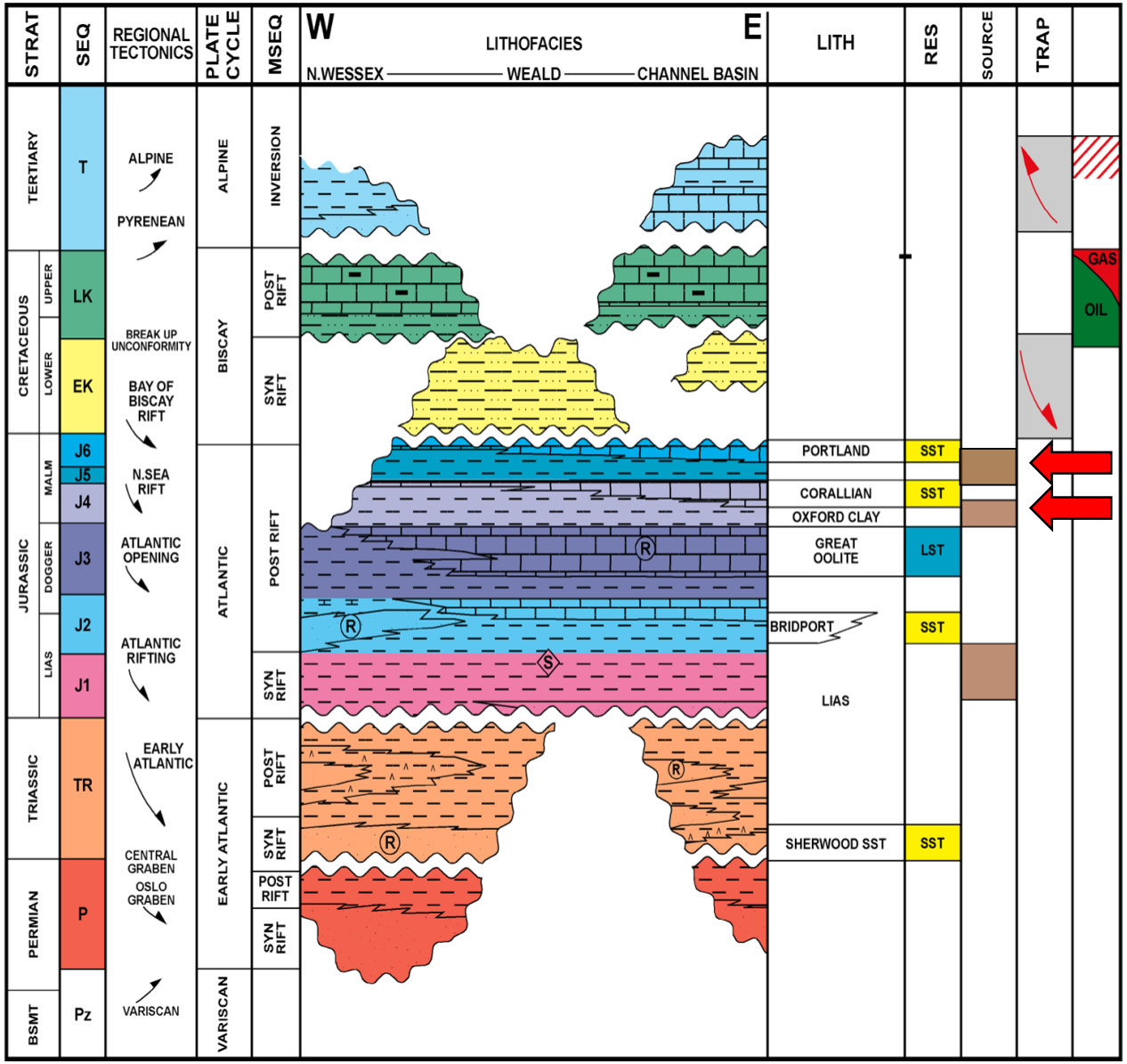
Hawkes et al, 1998



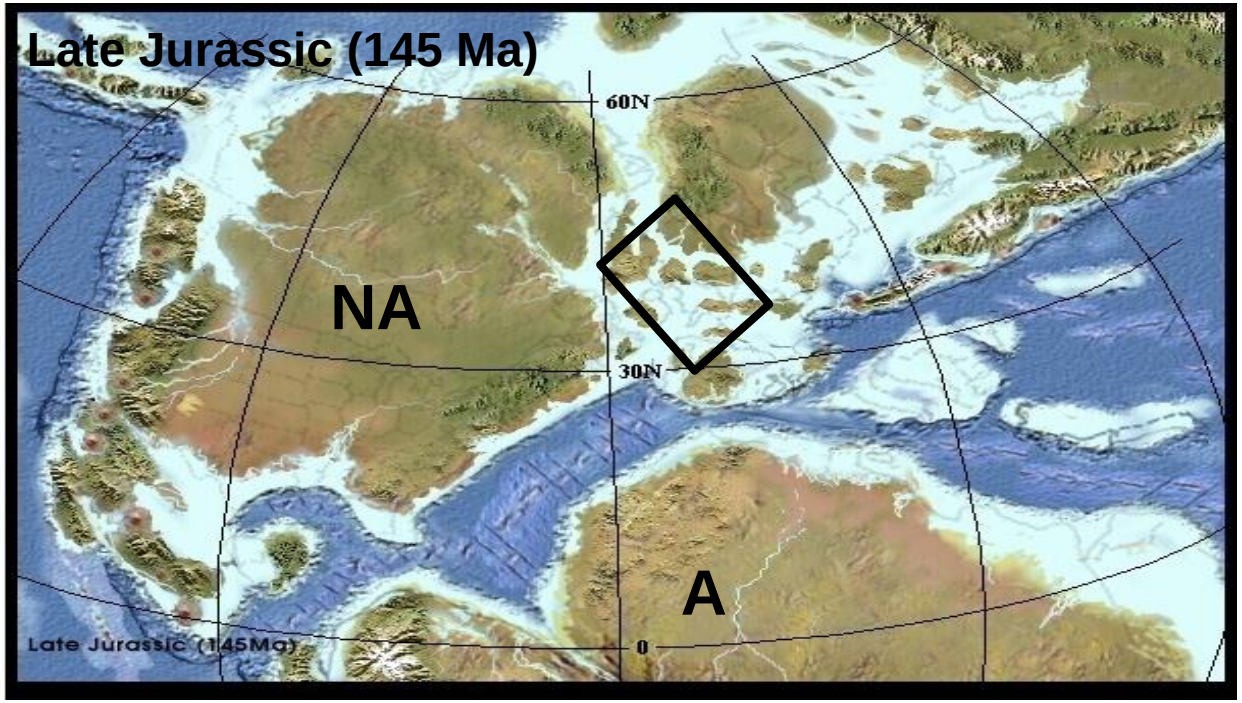
(Blakey R. 2011)

NA: North America
SA: South America
A: Africa

Tectonic evolution



Hawkes et al, 1998



(Blakey R. 2011)

NA: North America
SA: South America
A: Africa

Jurassic Shales (Wessex Basin outcrops)

Lias (Lower Jurassic)

Oxford Clay (Middle Jurassic)

Kimmeridge Clay (Upper Jurassic)

Kimmeridge Clay – fractures and joints

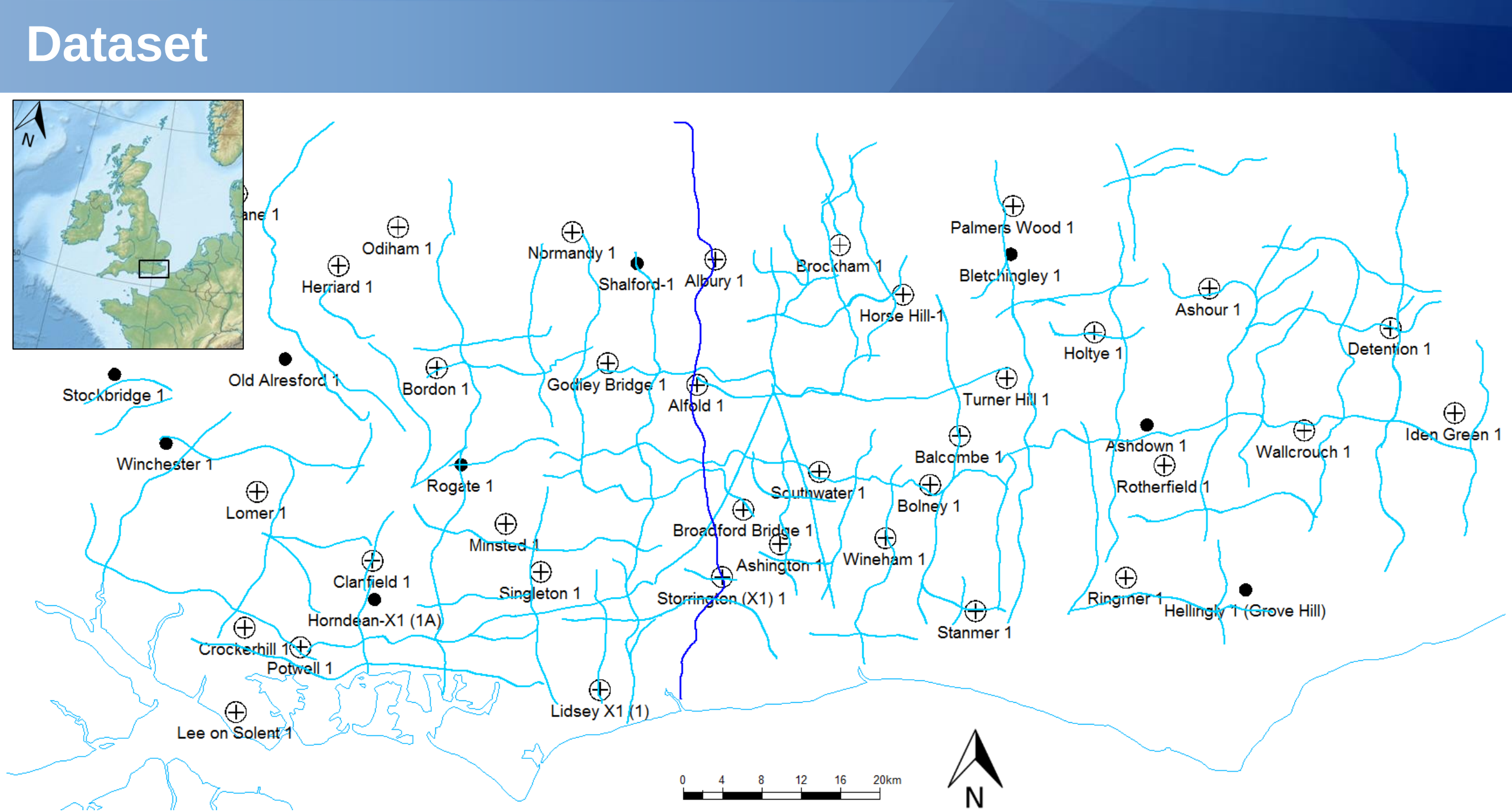
Exploration history

- Phase 1: exploration focused on big anticlines, carbonate reservoirs & big hopes
  - Portsdown, Kimmeridge Bay (1934)
- Phase 2: Seismic and the hidden fault blocks
  - Wytch Farm (1977) - Wessex Basin
  - Humbley Grove, Hornedean, Stockbridge, Storrington, Singleton - Weald Basin
- Phase 3: shale oil in tight fractured carbonate (return to the big anticline?)
  - Horse Hill-1 (2014): oil flowed from two micritic limestone intervals within the Kimmeridge Clay

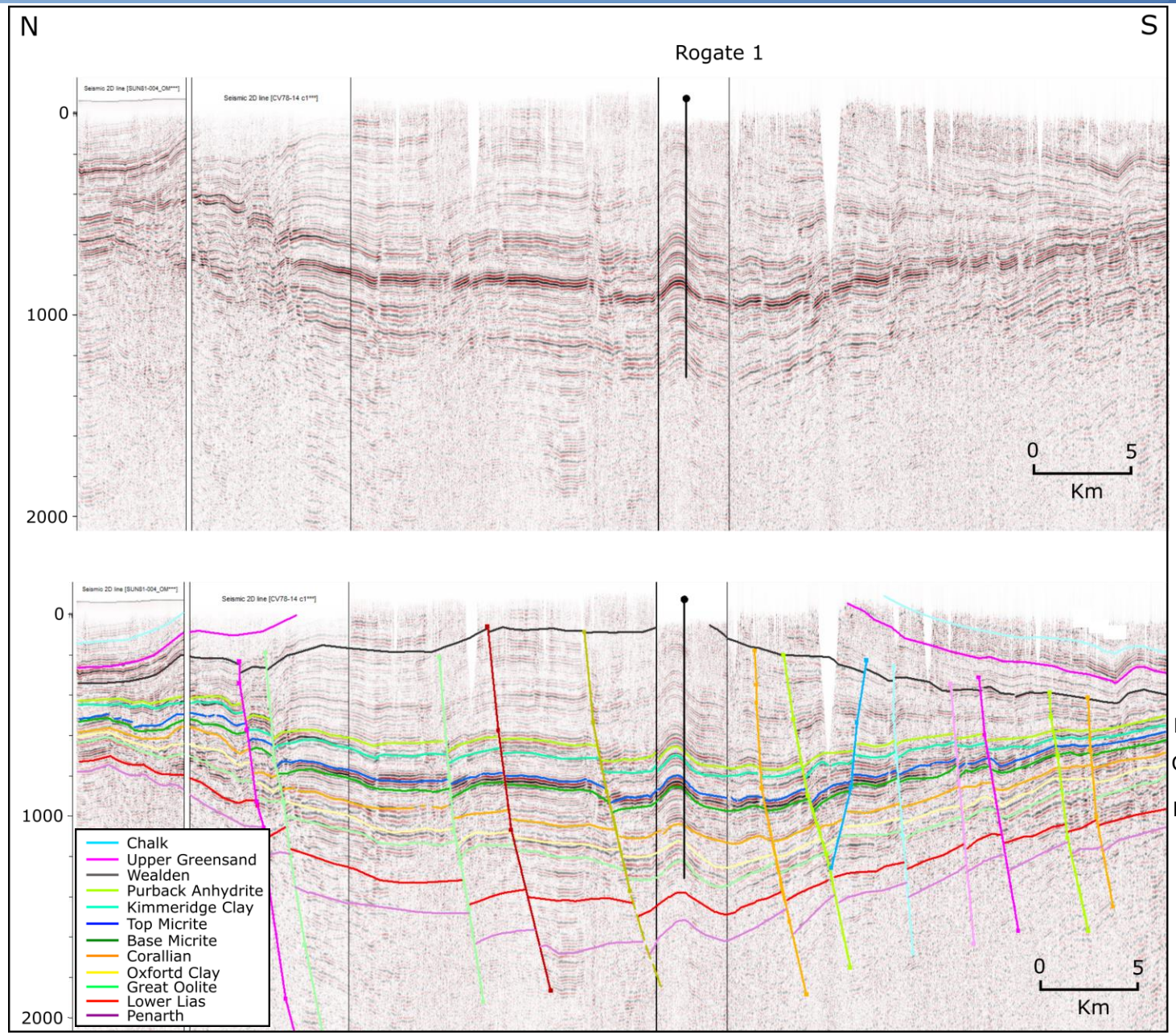
Oil discovery near Gatwick airport 'significant'
By John Moylan
Industry correspondent, BBC News
9th April 2015

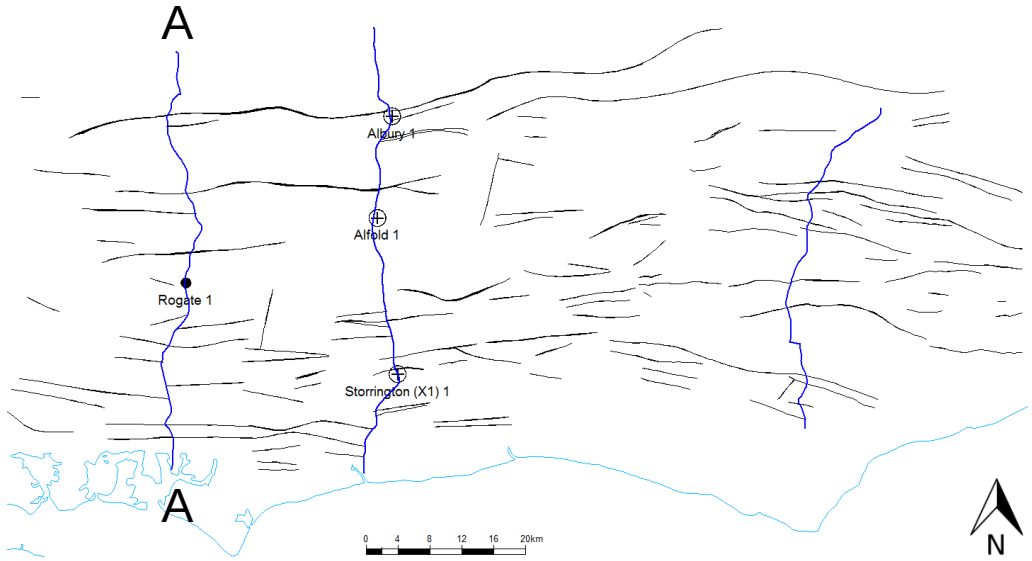
BBC NEWS

Dataset


N
Odiham 1
Herriard 1
Normandy 1
Shalford-1
Albury 1
Brockham 1
Palmers Wood 1
Bletchingley 1
Horse Hill-1
Ashour 1
Holtye 1
Detention 1
Stockbridge 1
Old Alresford 1
Bordon 1
Godley Bridge 1
Alfold 1
Turner Hill 1
Winchester 1
Rogate 1
Balcombe 1
Ashdown 1
Wallcrouch 1
Iden Green 1
Rotherfield 1
Lomer 1
Southwater 1
Bolney 1
Broadford Bridge 1
Minsted 1
Ashington 1
Wineham 1
Clanfield 1
Singleton 1
Storrington (X1) 1
Ringmer 1
Hellingly 1 (Grove Hill)
Horndean-X1 (1A)
Stanmer 1
Crockerhill 1
Potwell 1
Lidsey X1 (1)
Lee on Solent 1
0 4 8 12 16 20km
N

Seismic interpretation



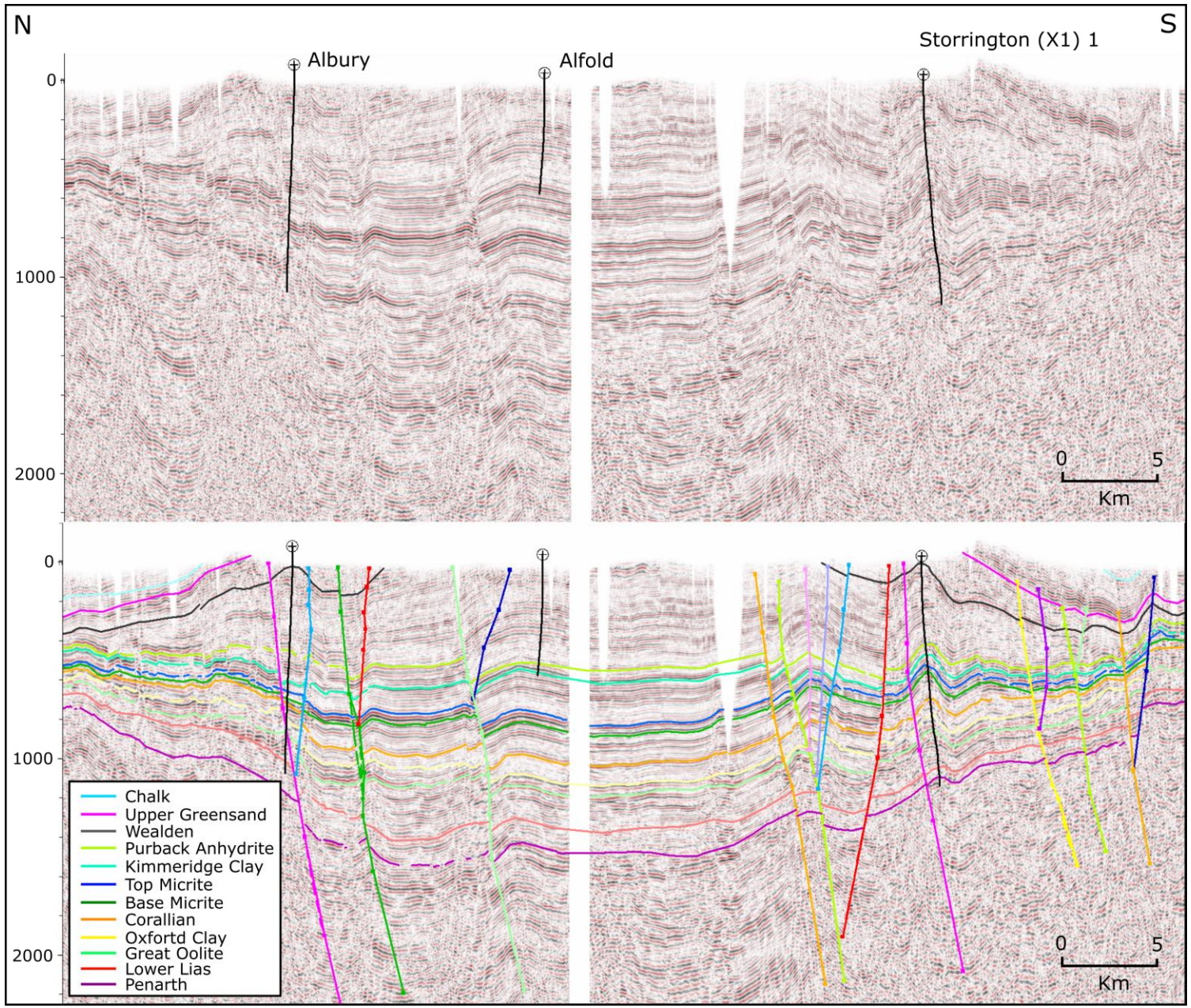


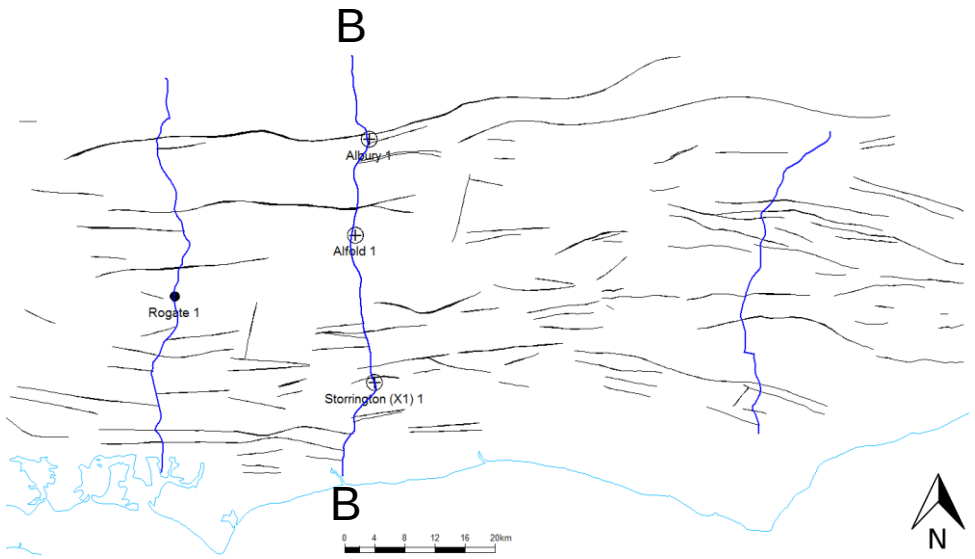
Kimmeridge Clay

Oxford Clay

Lias

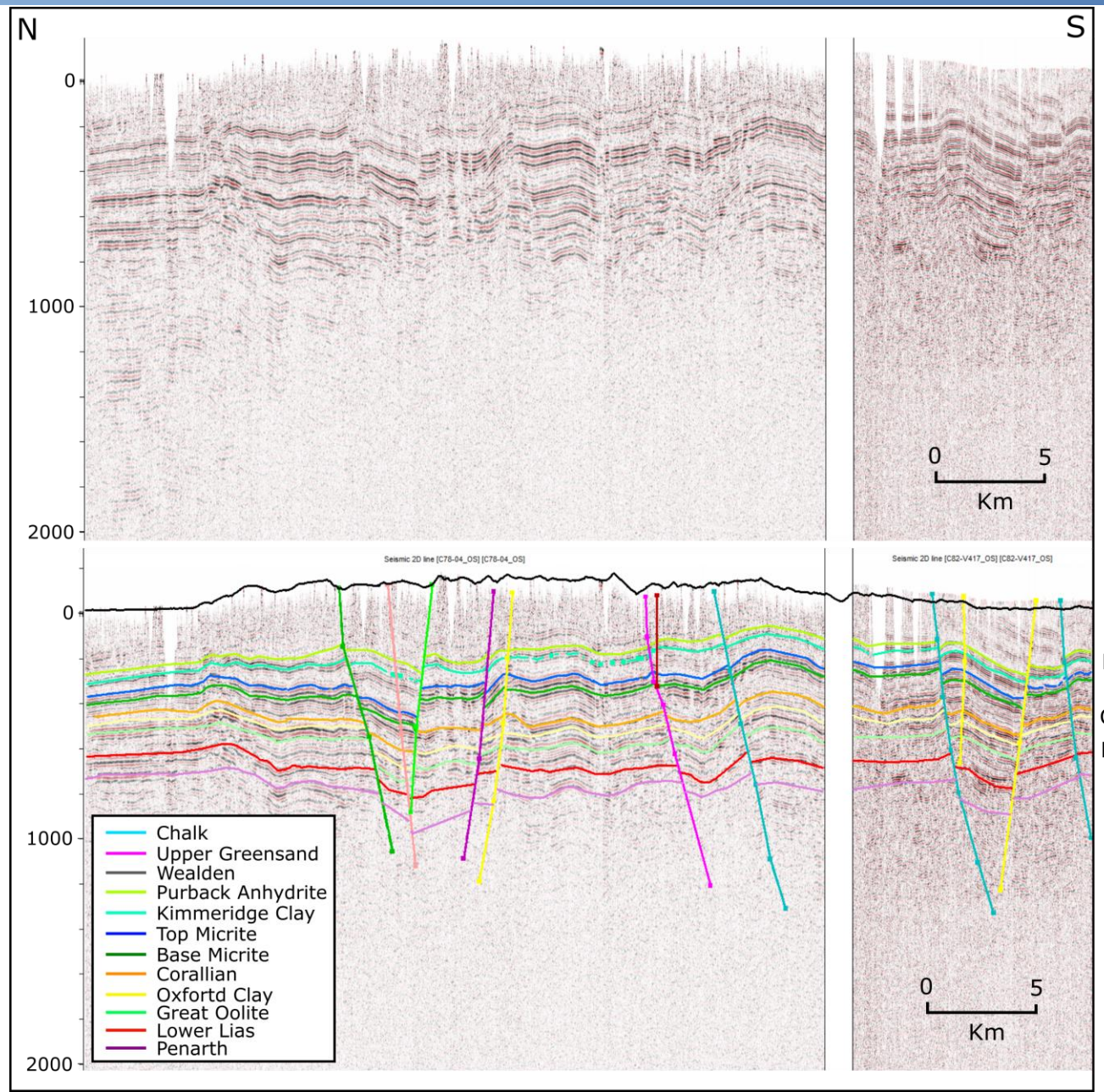
Seismic interpretation

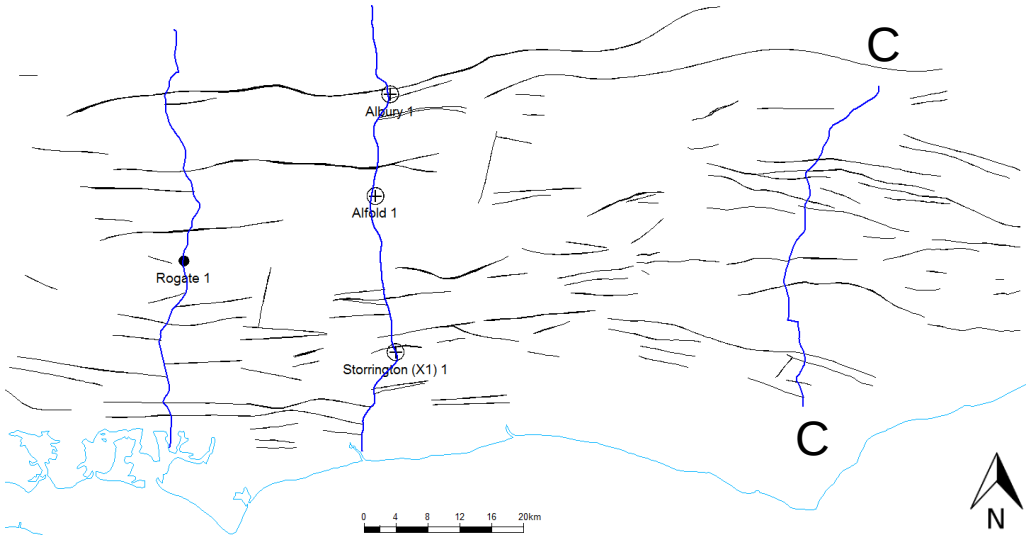




Kimmeridge Clay
Oxford Clay
Lias

Seismic interpretation



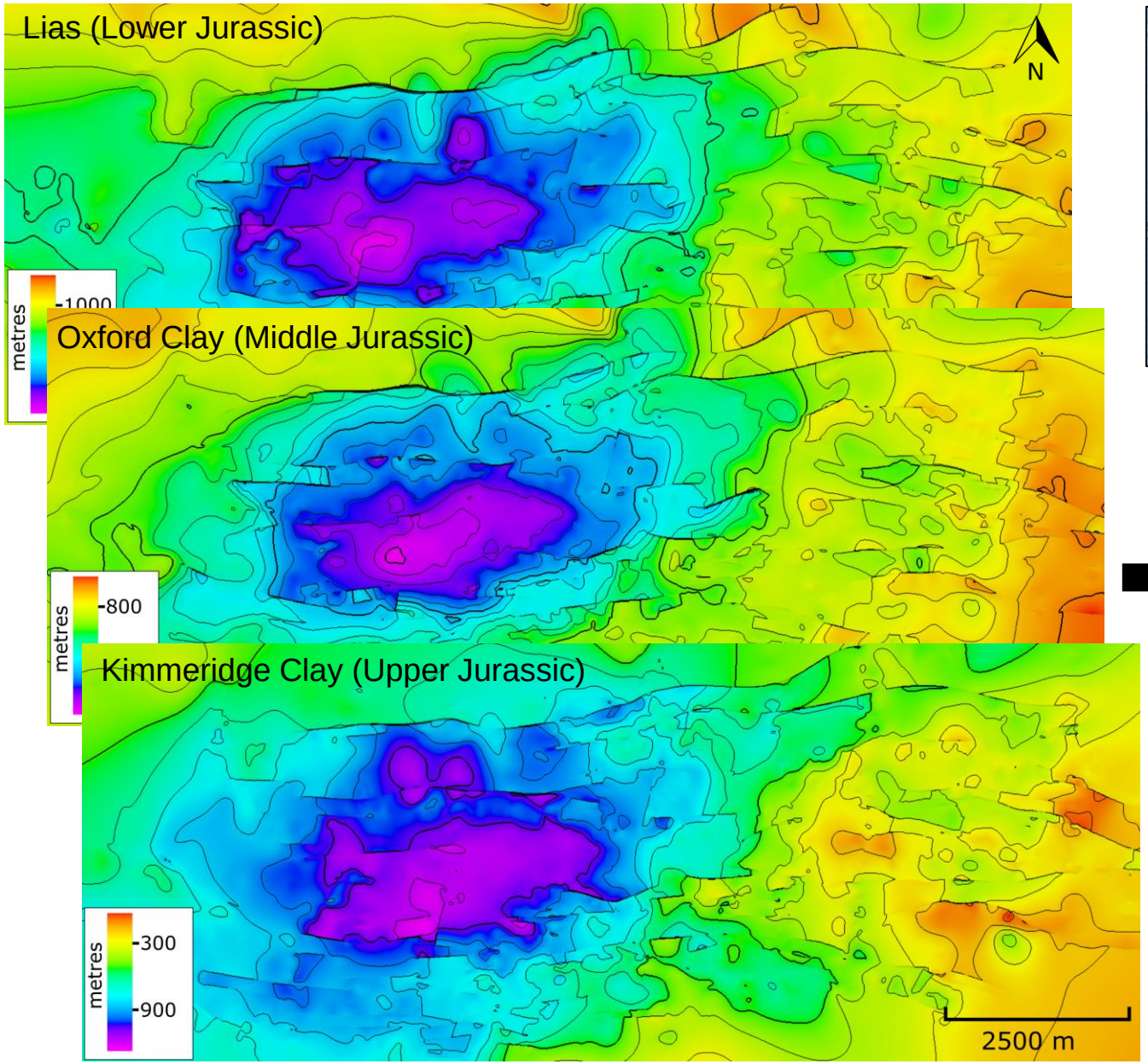


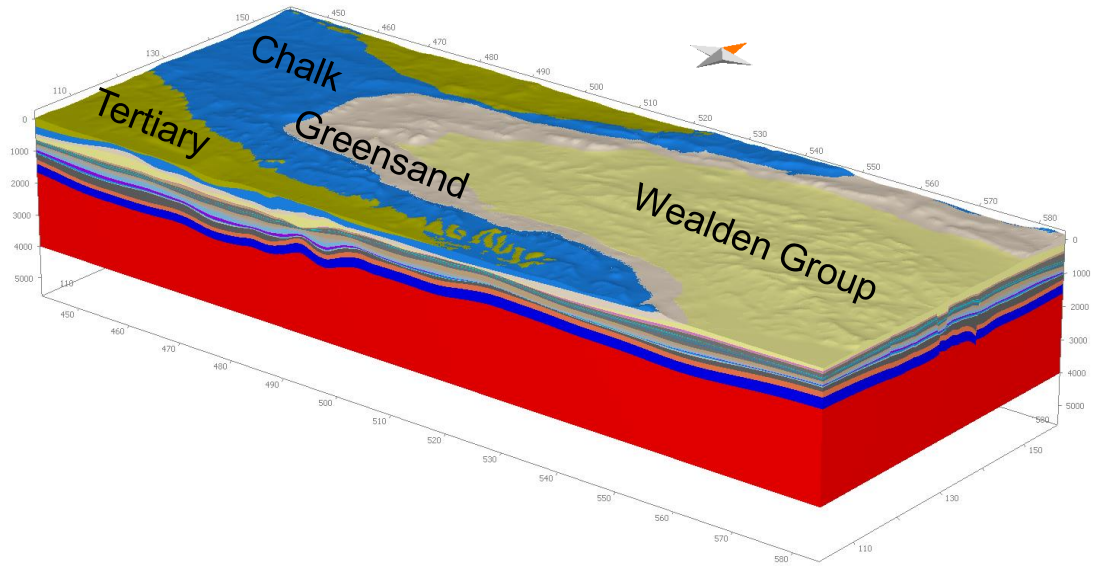
Kimmeridge Clay

Oxford Clay

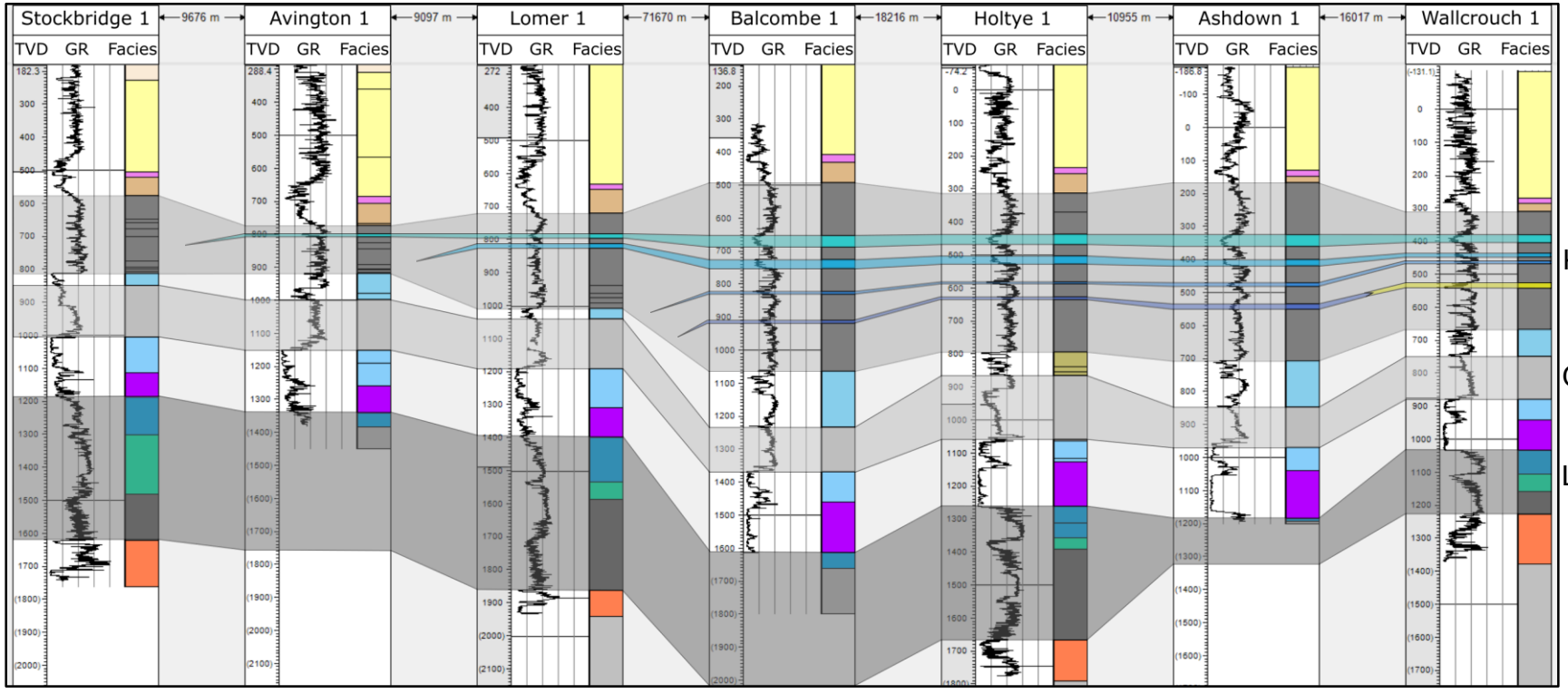
Lias

Basin and Petroleum systems modelling





Facies distribution



Kimmeridge Clay (TOC ≈ 6%)

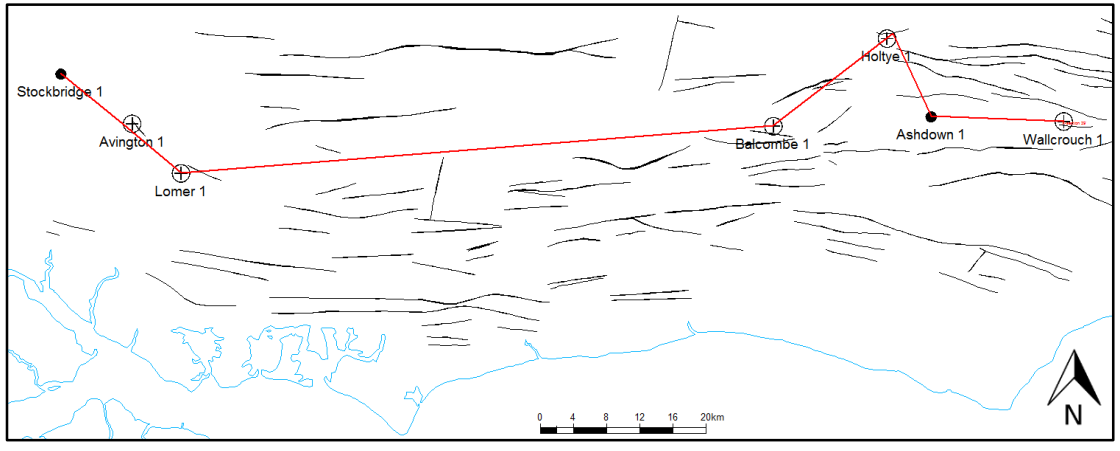
Oxford Clay (TOC ≈ 4%)

Lias (TOC < 2%)

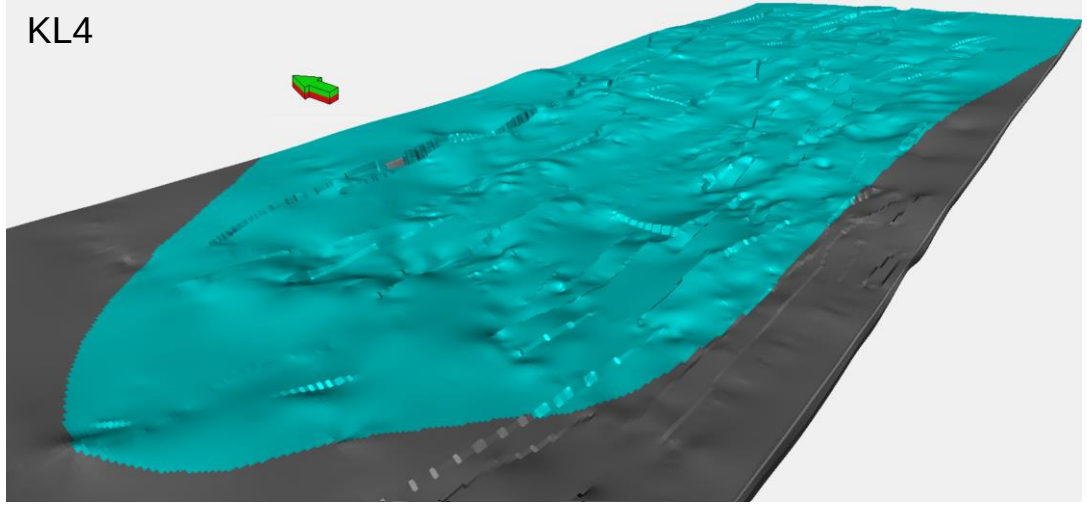
- Wealden
- Purbeck Anhydrite
- Portland Sst
- Kimmeridge Clay
- KL4
- KL3
- KL2
- KL1
- Litoral Sst
- Corallian
- Oxford Clay
- Great Oolite
- Inferior Oolite
- Upper Lias
- Middle Lias
- Lower Lias

} Lias

- Penarth

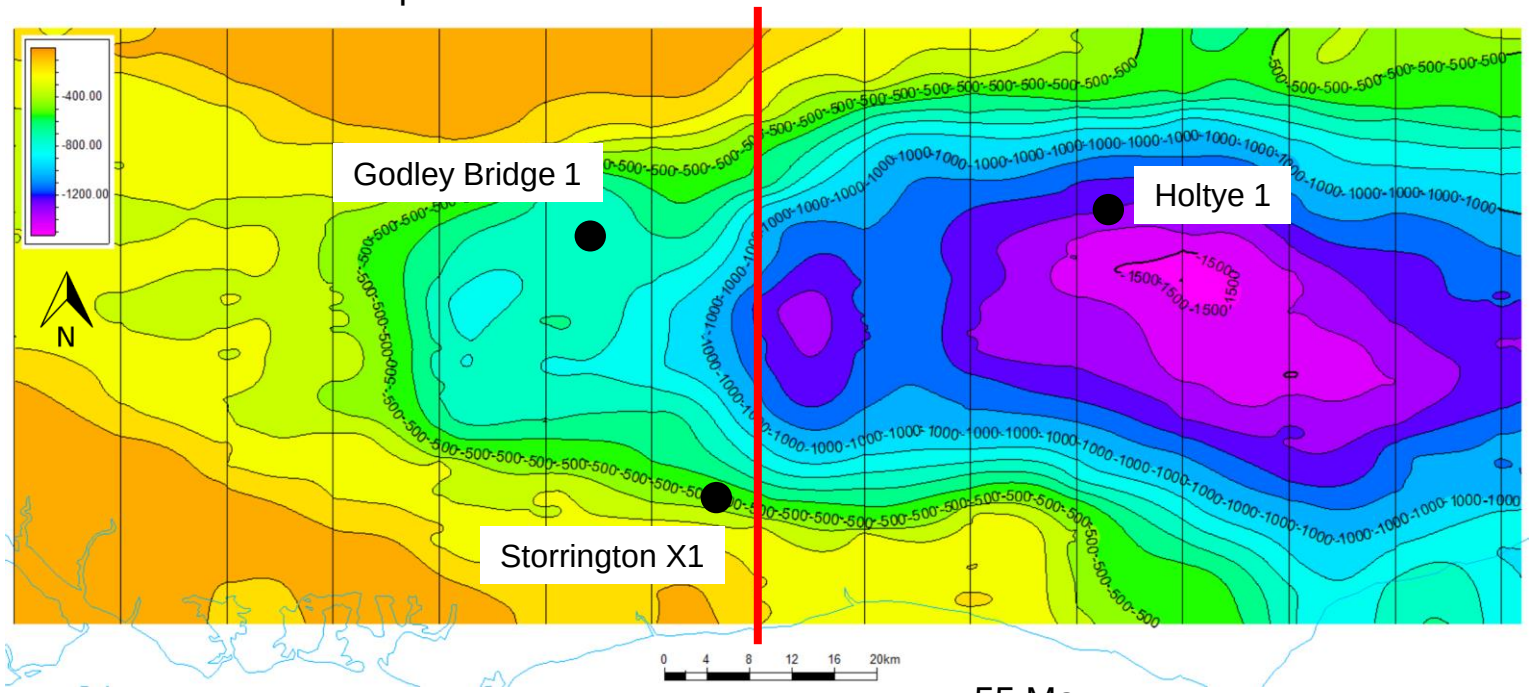


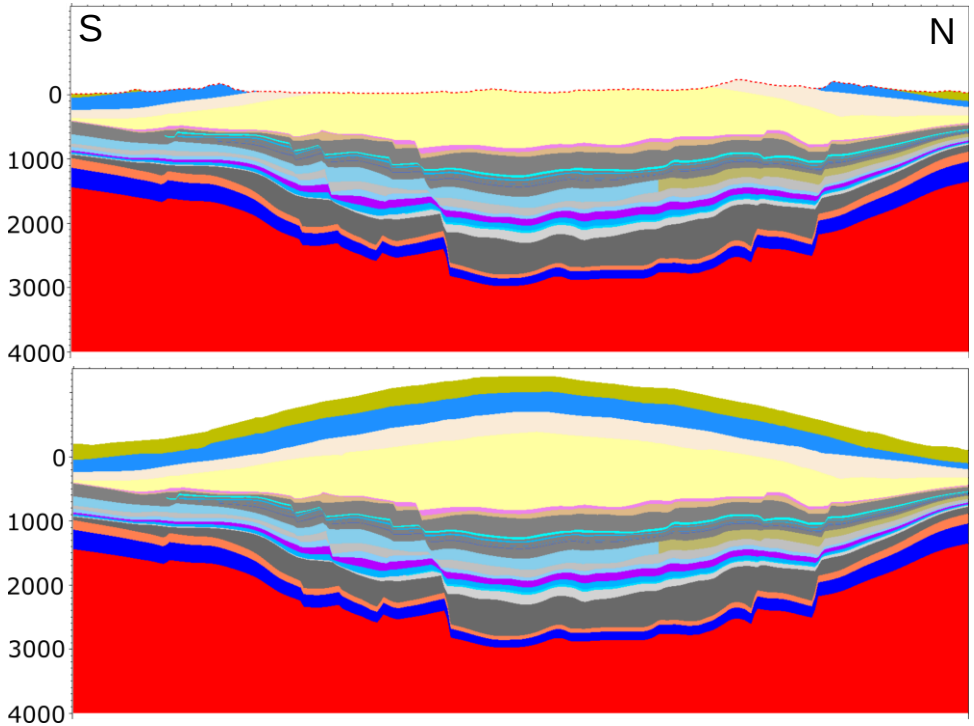
3D model



Burial restoration (metres)

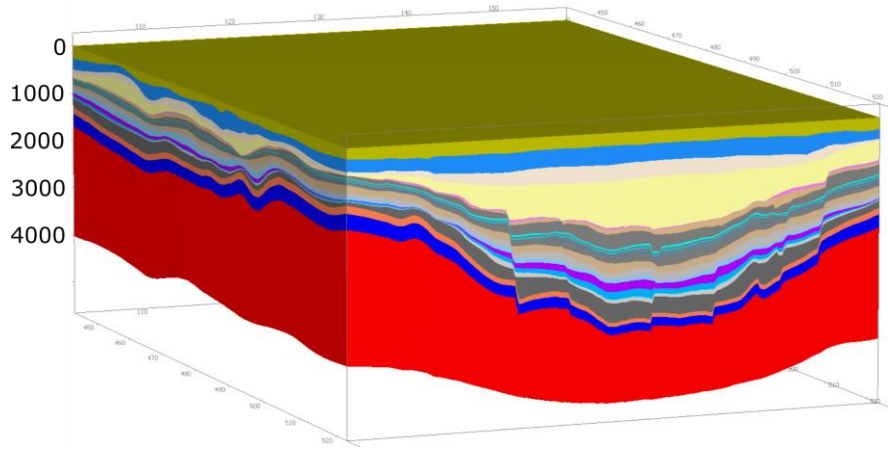
Cumulative erosion map



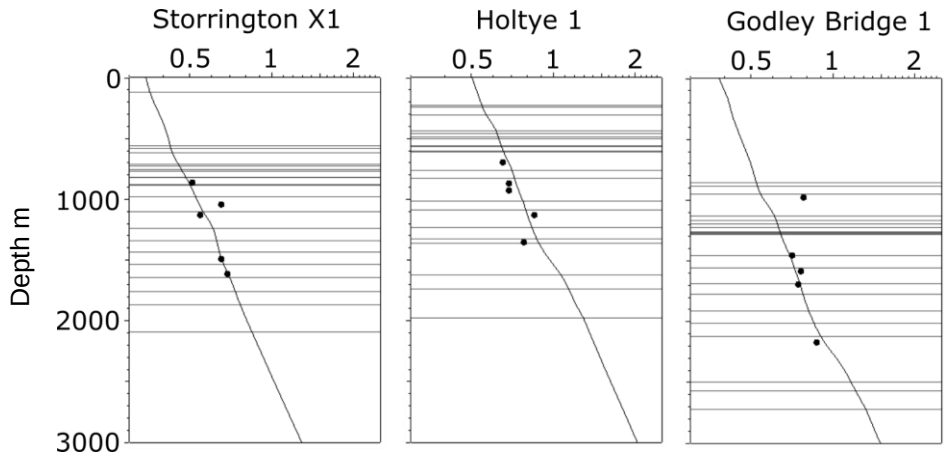


Mixed_Corallian
Oxford Clay
Great Oolite
Inferior Oolite
Upper Lias
Middle Lias Limestone
Middle Lias
Lower Lias
Penarth
Carboniferous
Devonian
Tertiary
Chalk
Greensand
Wealden
Purbeck Anydrite
Portland Sandstone
Kimmeridge Clay
Mixed_KL4_Facies
Mixed_KL3_Facies
Mixed_KL2_Facies
Mixed_KL1_Facies

55 Ma
(maximum burial)

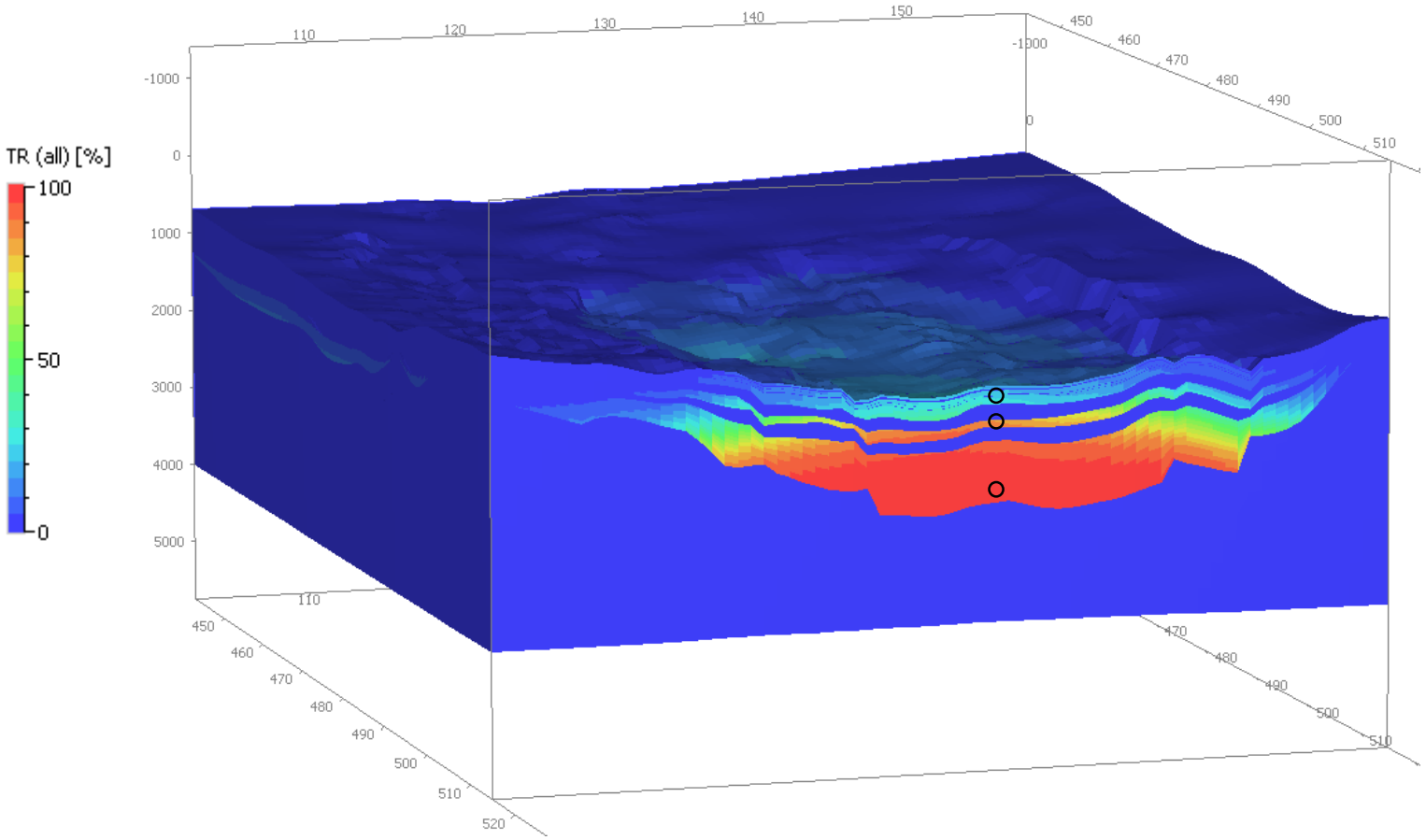


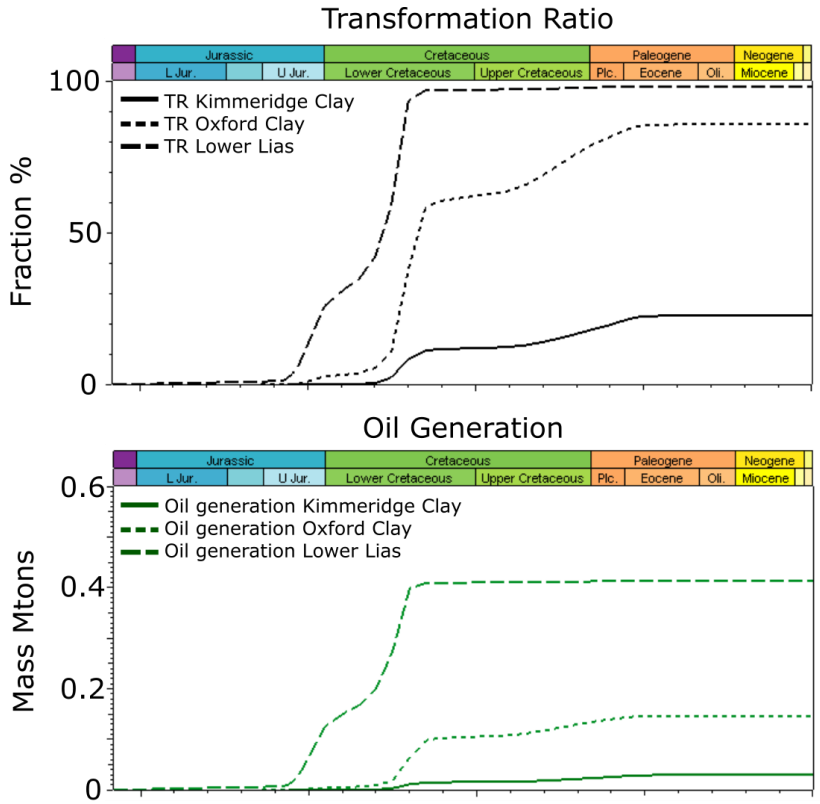
VR Calibration



Thermal maturity

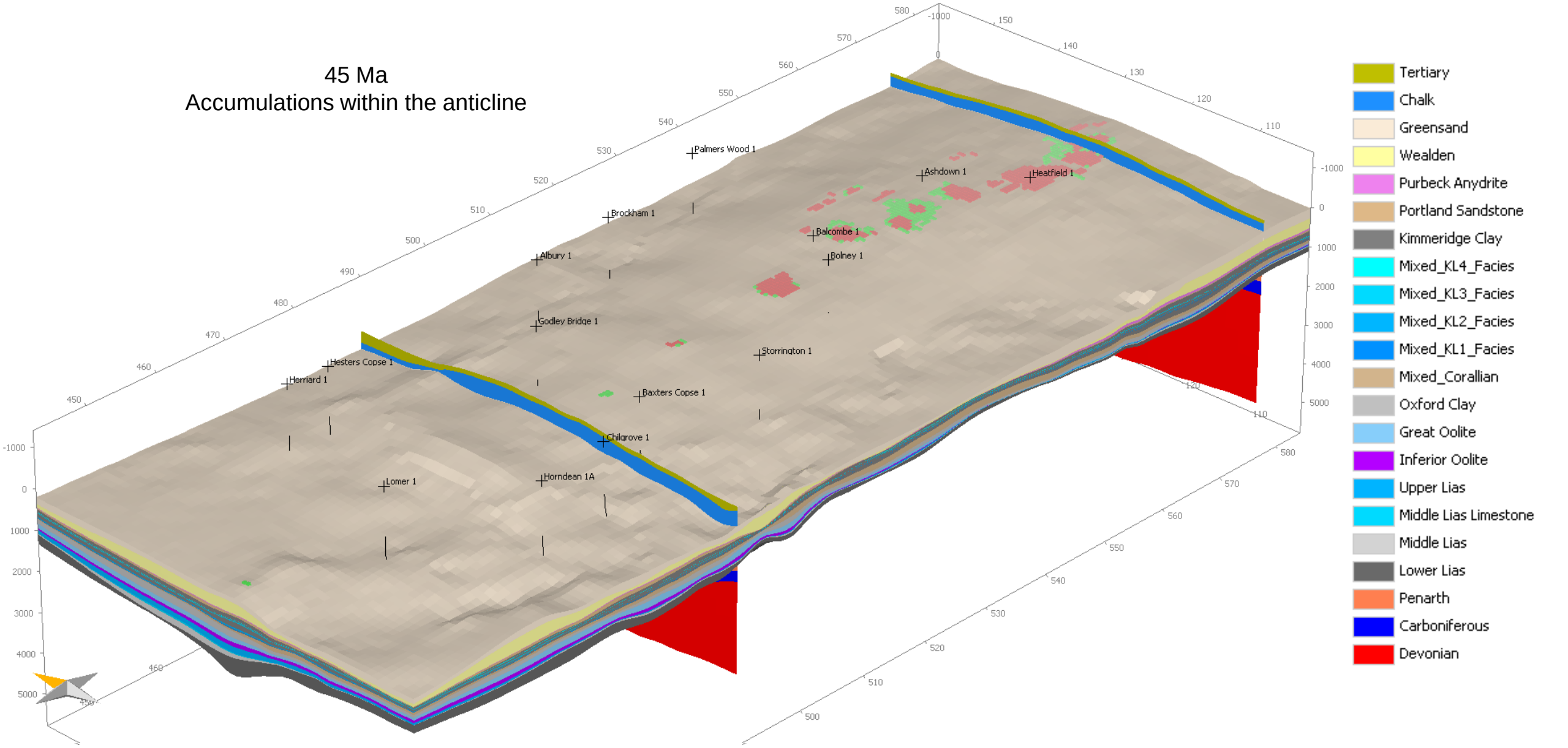
Transformation Ratio 3D model present day





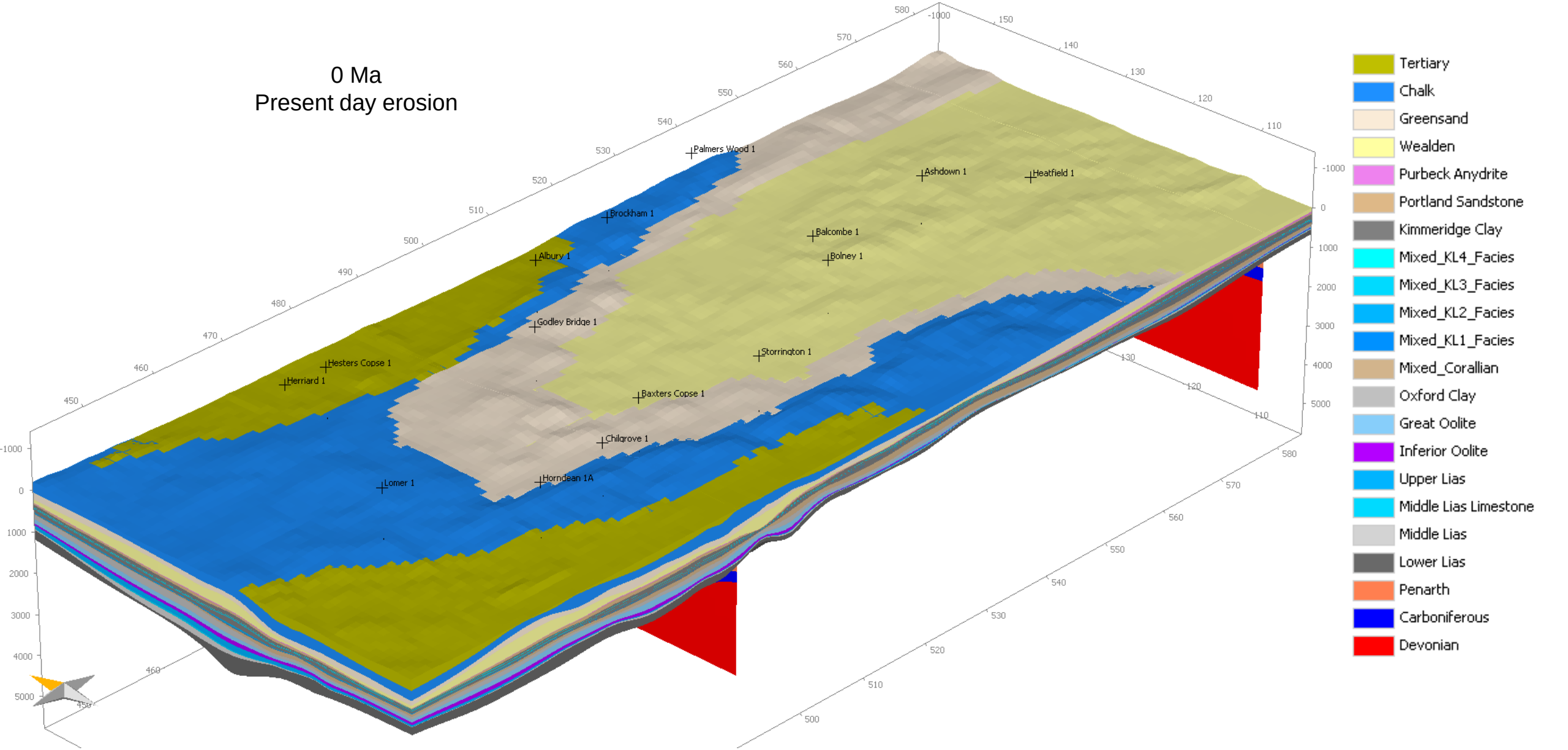
HC migration and accumulations

45 Ma
Accumulations within the anticline



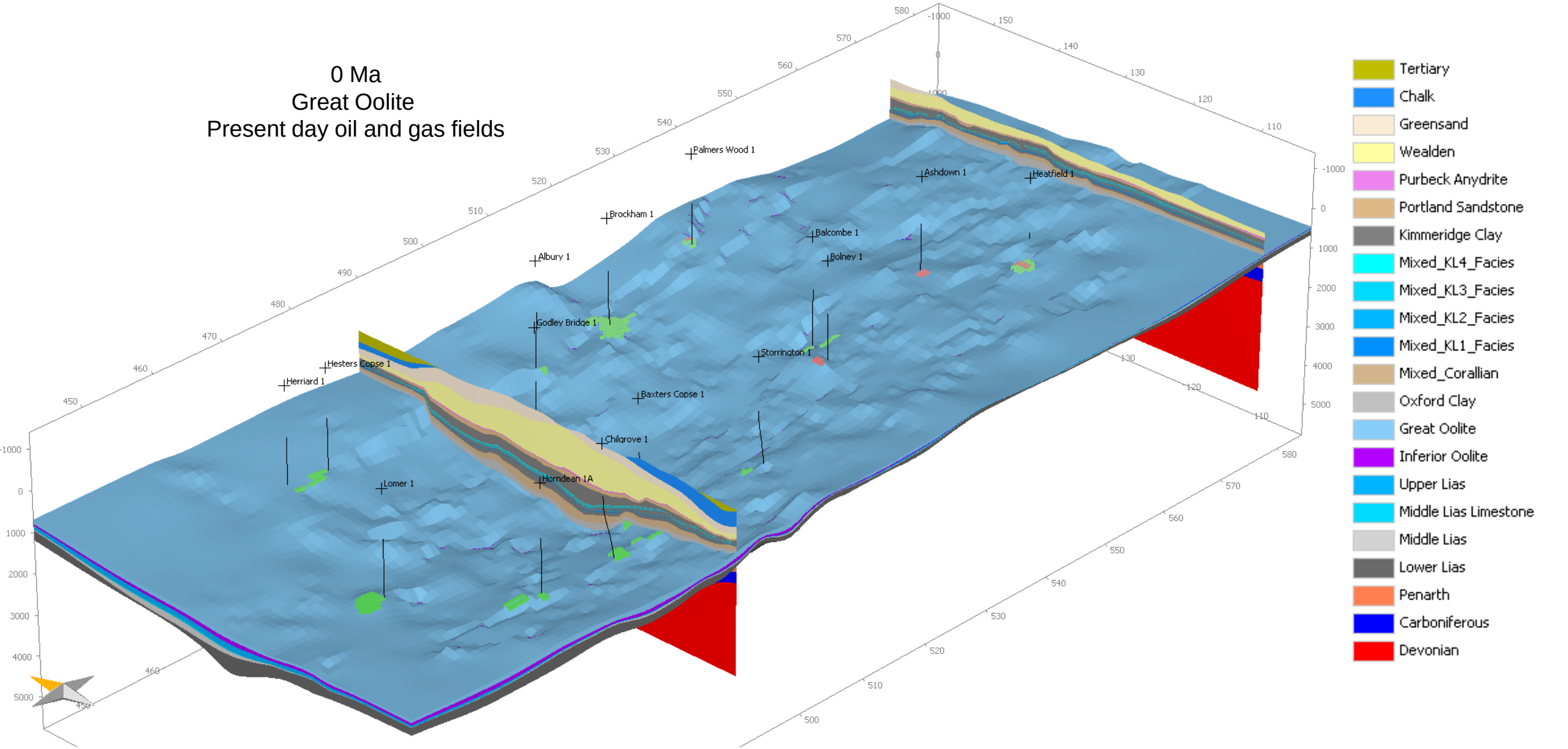
HC migration and accumulations

0 Ma
Present day erosion



HC migration and accumulations

0 Ma
Great Oolite
Present day oil and gas fields



Conclusions and learning

- Restoration against the VR suggests circa 1500 m erosion towards the eastern part of the Weald Basin
- Only the Lias and the Oxford Clay have generated gas, the Kimmeridge Clay entered the oil window during the maximum burial in certain parts of the basin
- Main accumulations in the Weald anticline have been breached during the uplift, however oil generated within the Kimmeridge Clay may be still preserved within tight fractured limestone layers
- The model can explain the current distribution of the oil and gas fields and shows in the basin