

The Deep Geological Structure of Southern England

Chris Pullan and John Donato

Abstract

This presentation reproduces the series of slides presented by Chris Pullan to the Hertfordshire Geological Society on 3rd September 2026. It represents a summary of a current interpretation of the deep geological structure of Southern England. The work is ongoing and consequently the ideas presented are, at least in part, preliminary and speculative.

There is an extensive well and seismic database available through the UKOGL website for Southern England. This database gives a good understanding of the structural and stratigraphic evolution of the Mesozoic and Tertiary sediments in the Wessex and Weald Basins. Unfortunately, few wells penetrate deeply into the Paleozoic section, and seismic resolution below the Triassic is generally very poor. In order to understand the deep or pre-Permian geology of the area, gravity and magnetic techniques must be relied upon. It is necessary to consider, and attempt to remove, the effects of the Permian and later sediments in order to reveal the deeper Paleozoic structural picture. For this reason, a residual gravity map has been created, revealing three major features: the Southwest England Anomaly, the South Coast Anomaly and the Central England Anomaly. The Southwest England Anomaly is believed to reflect the right lateral translation of the Southwest England Terrain along a major NW-SE trending wrench fault running from the Isle of Wight to the Bristol Channel, being active mainly during the Late Carboniferous-Early Permian Variscan Orogeny. The east-west trending South Coast Anomaly is interpreted to be a thickened zone of Paleozoic section that may have been emplaced as a northerly-directed major thrust complex during the Variscan. The Central England Anomaly lies to the north of a zone of thickened Paleozoic section and appears associated with a Lower Paleozoic structural high, bordered by thicker Lower Paleozoic intervals. The east-west trending Mendips-Hogs Back Deformation Zone that forms the northern edge of the Weald-Wessex Basins is not a major lineament in the gravity and magnetic data. Also, the well data to the north and south of this deformation zone show continuity of the older Lower Paleozoic section, with no significant stratigraphic, thickness or facies changes. This lineament is known to have been rejuvenated and deformed during the Mesozoic and Tertiary intervals, as well as during the Variscan. The influences of the Acadian and Shelveian orogenies are seen in the extreme east of the area.



The Deep Geological Structure of Southern England

Chris Pullan and John Donato

Outline of Talk

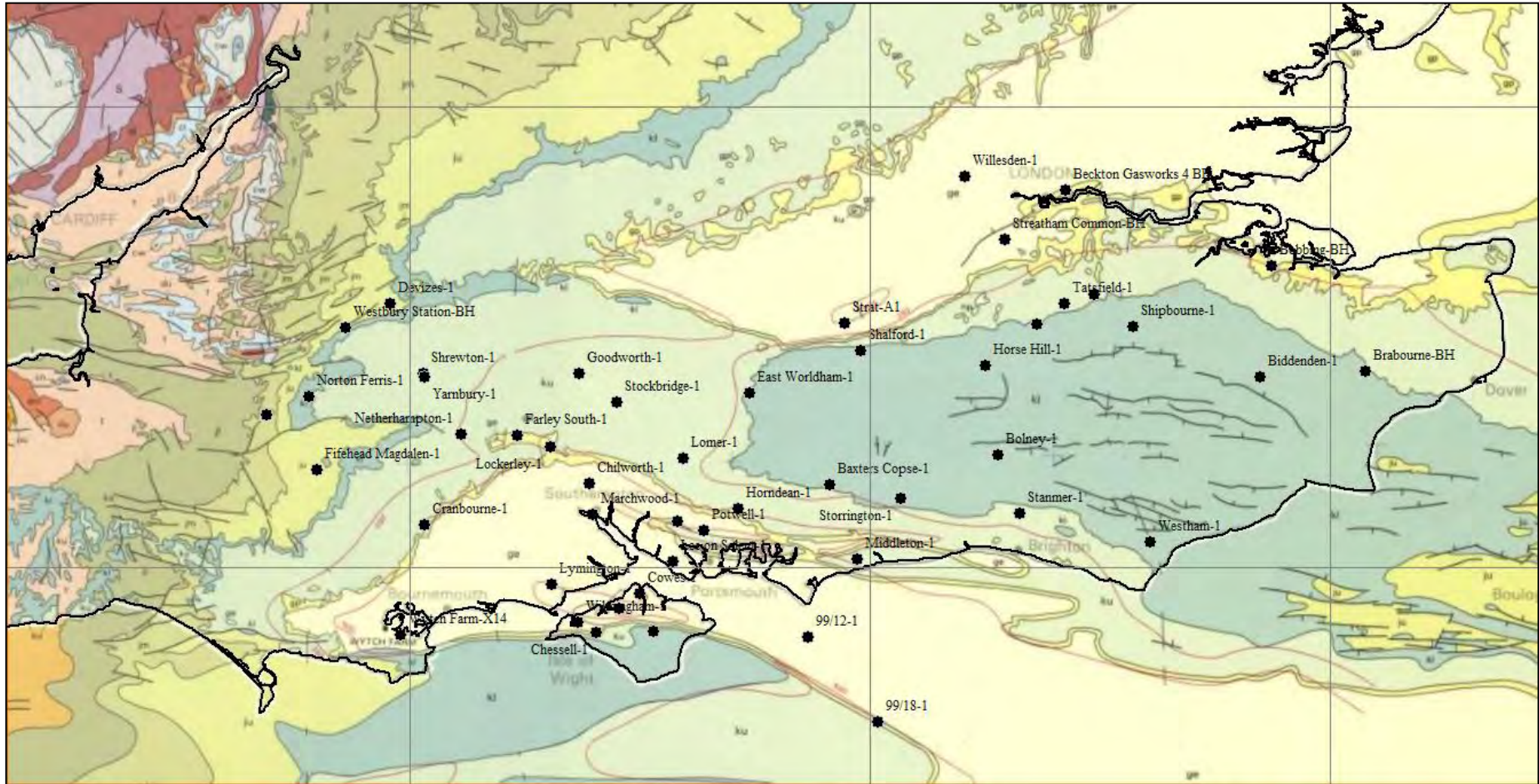
- Area of Presentation
- Database for Study
- Gravity and Magnetism Analysis
- Paleozoic Structural and Stratigraphic Evolution of the Area
- Interpretation of the Identified Geophysical Anomalies:

Southwest England Terrane

Central England Anomaly

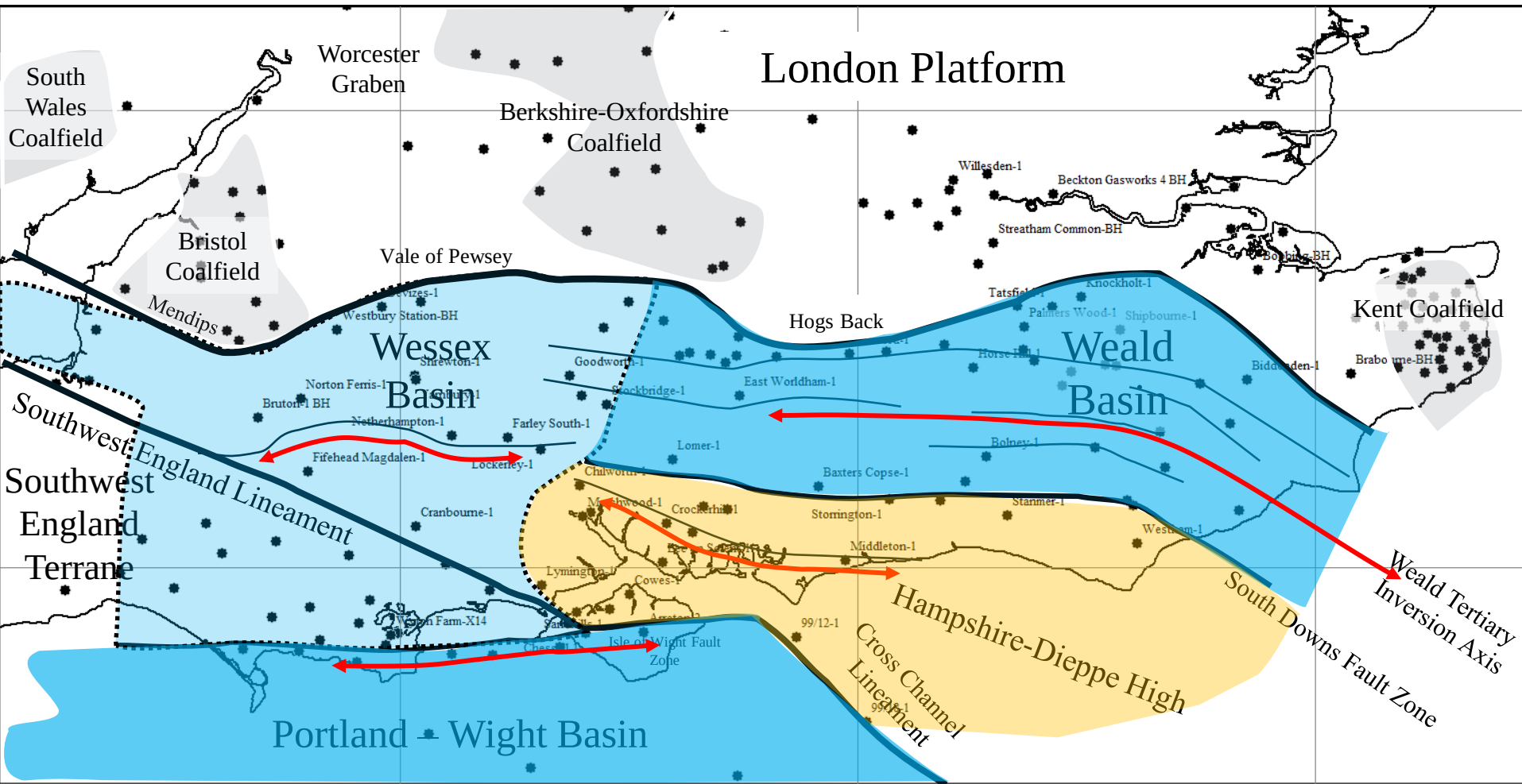
South Coast Anomaly

Southern England – Area to be Discussed



Contains British Geological Survey materials © UKRI.

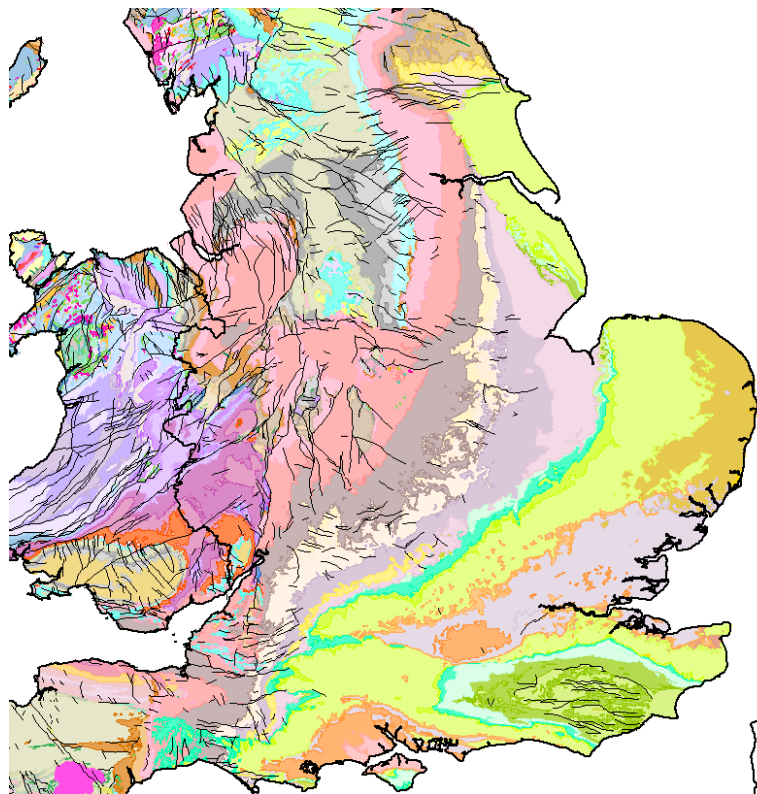
Southern England – Mesozoic Structural Elements



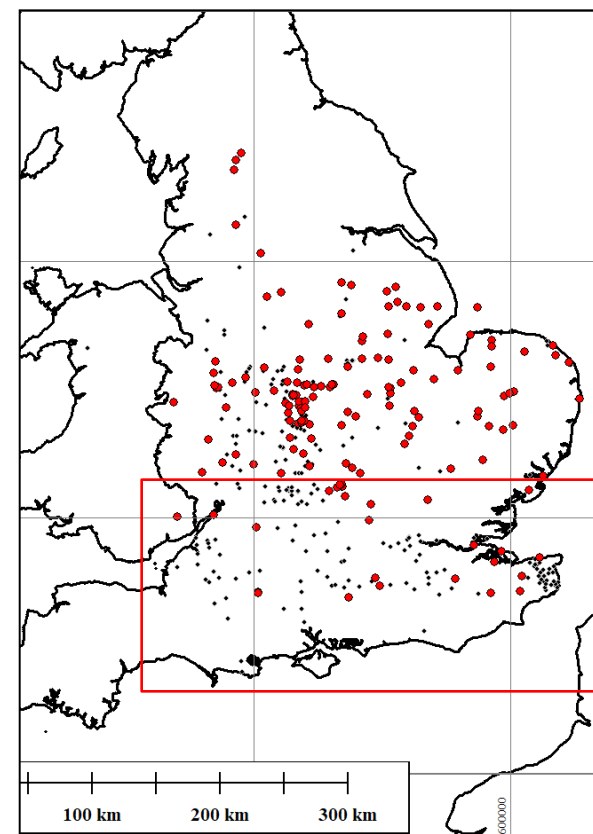
Tertiary Inversion

Geological Database

- Outcrop geology and sheet memoirs, as well as regional memoirs from the BGS
- Well data
 - Lithology
 - Stratigraphy
 - Electric Log data
 - Palaeontology
 - Maturity
 - Other borehole data
- Published data

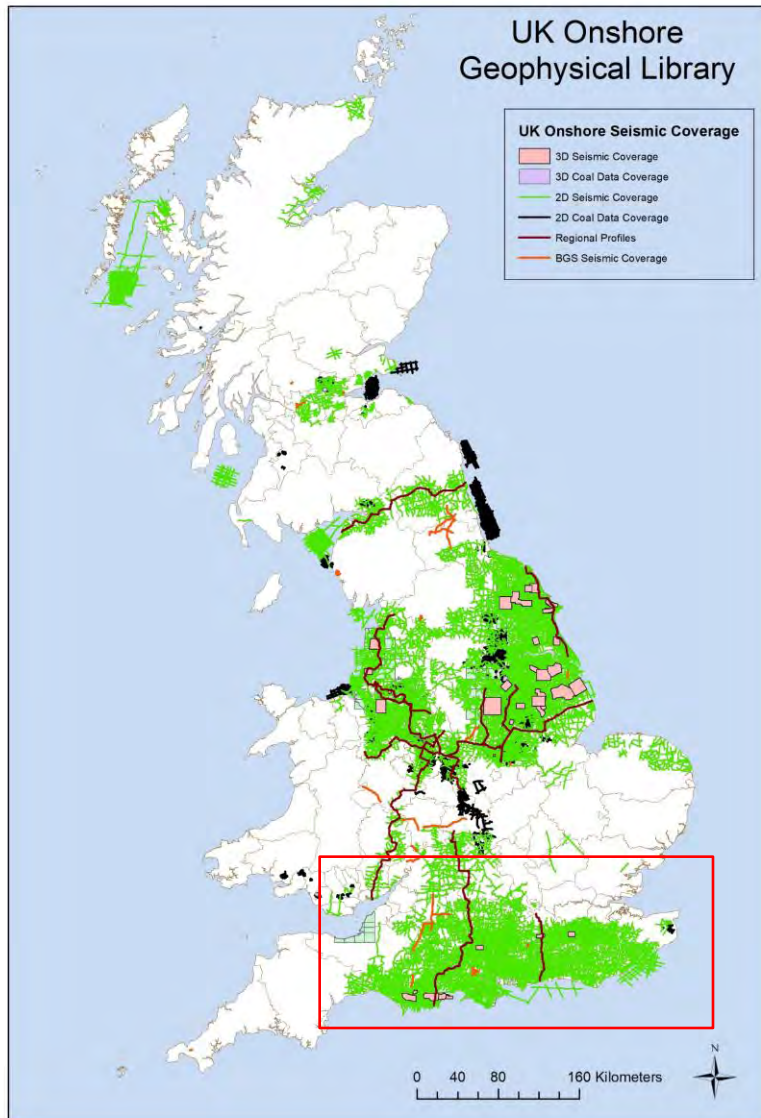


Contains British Geological Survey materials © UKRI.

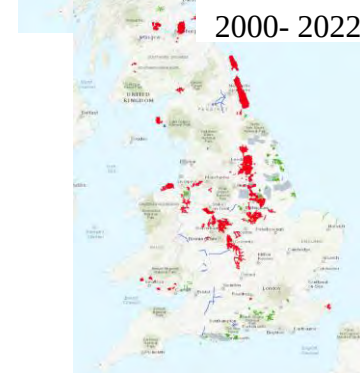
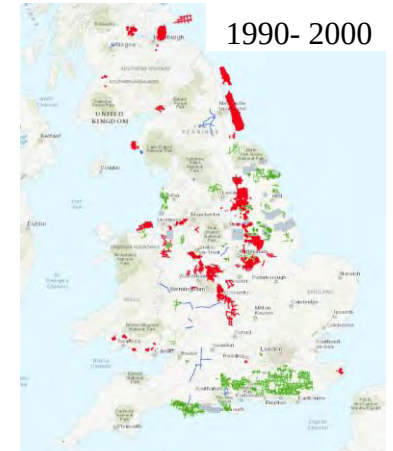


360 Selected Boreholes reaching the Palaeozoic with large dots showing wells reaching the Lower Paleozoic (140)

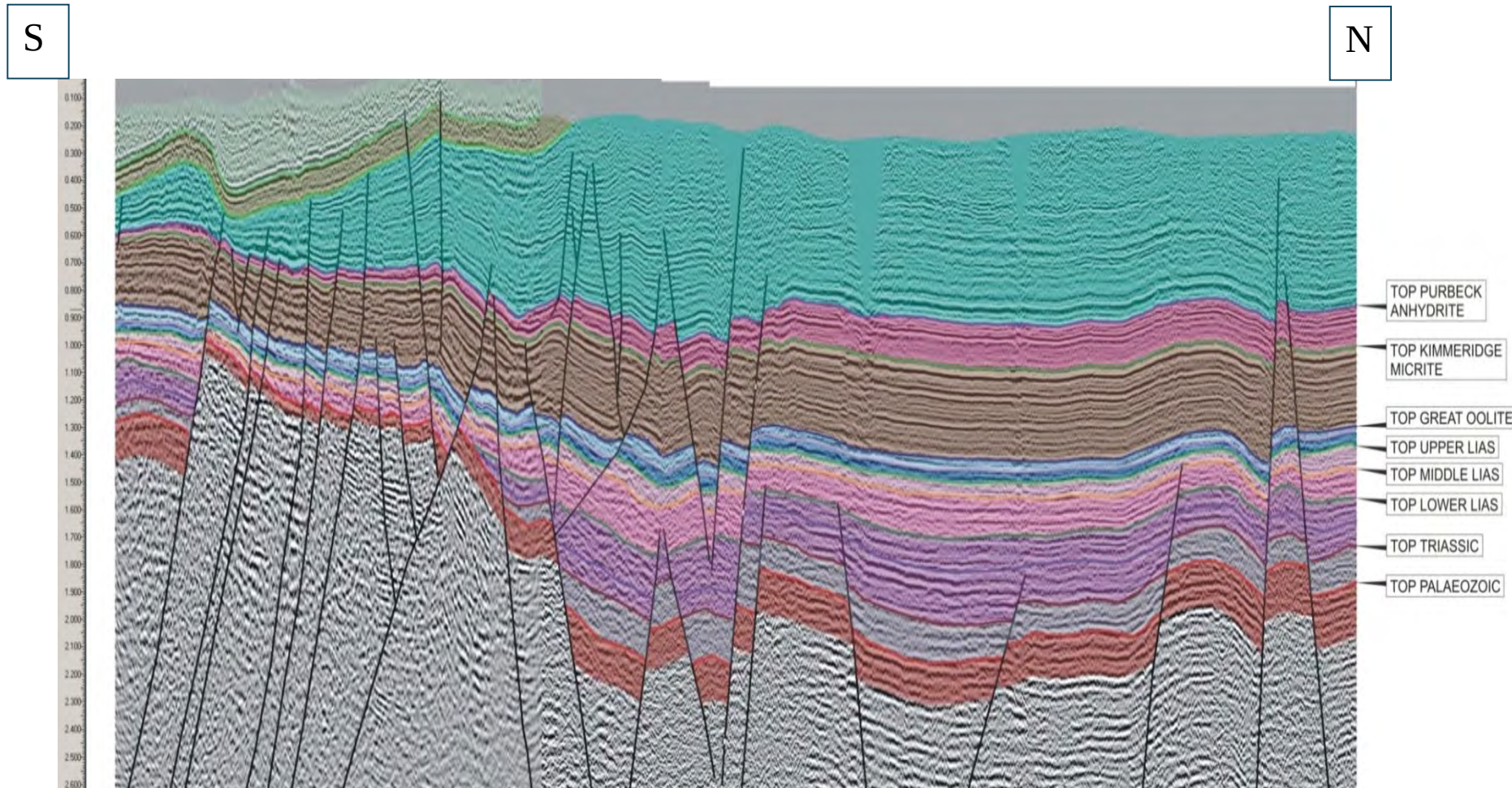
Seismic Coverage



www.ukogl.org.uk



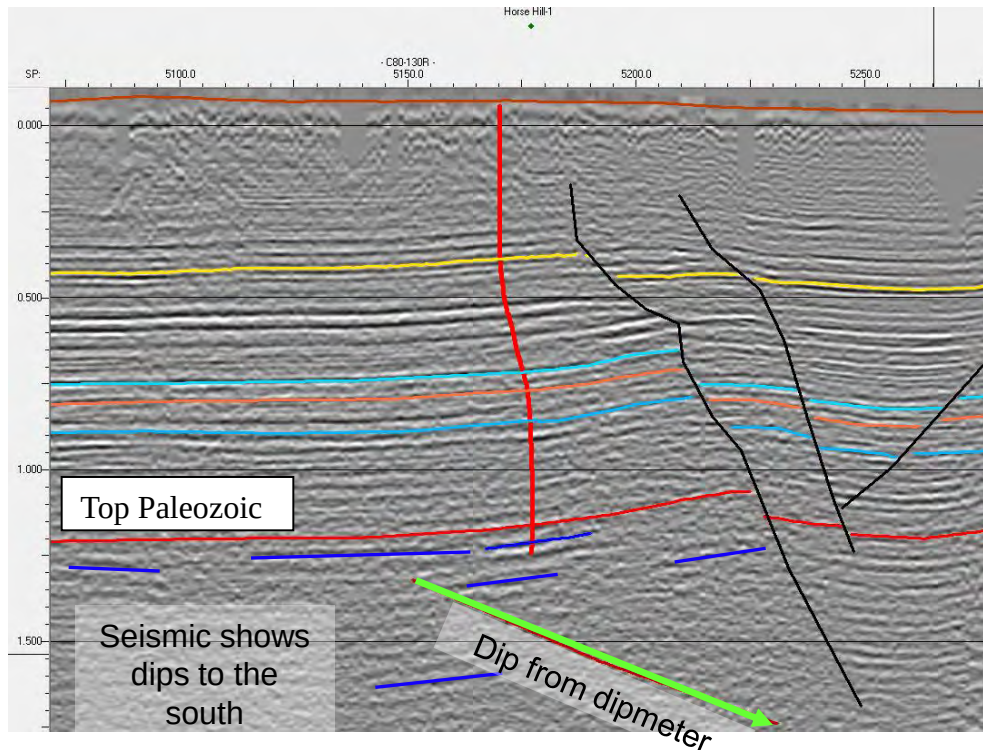
Seismic Line across Southern Weald



Horse Hill 1

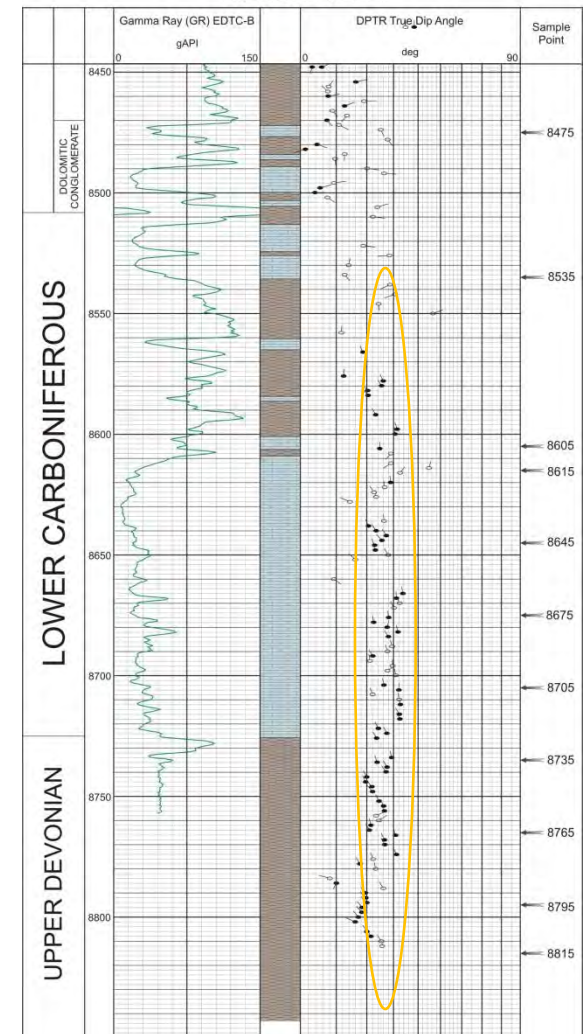
S

N



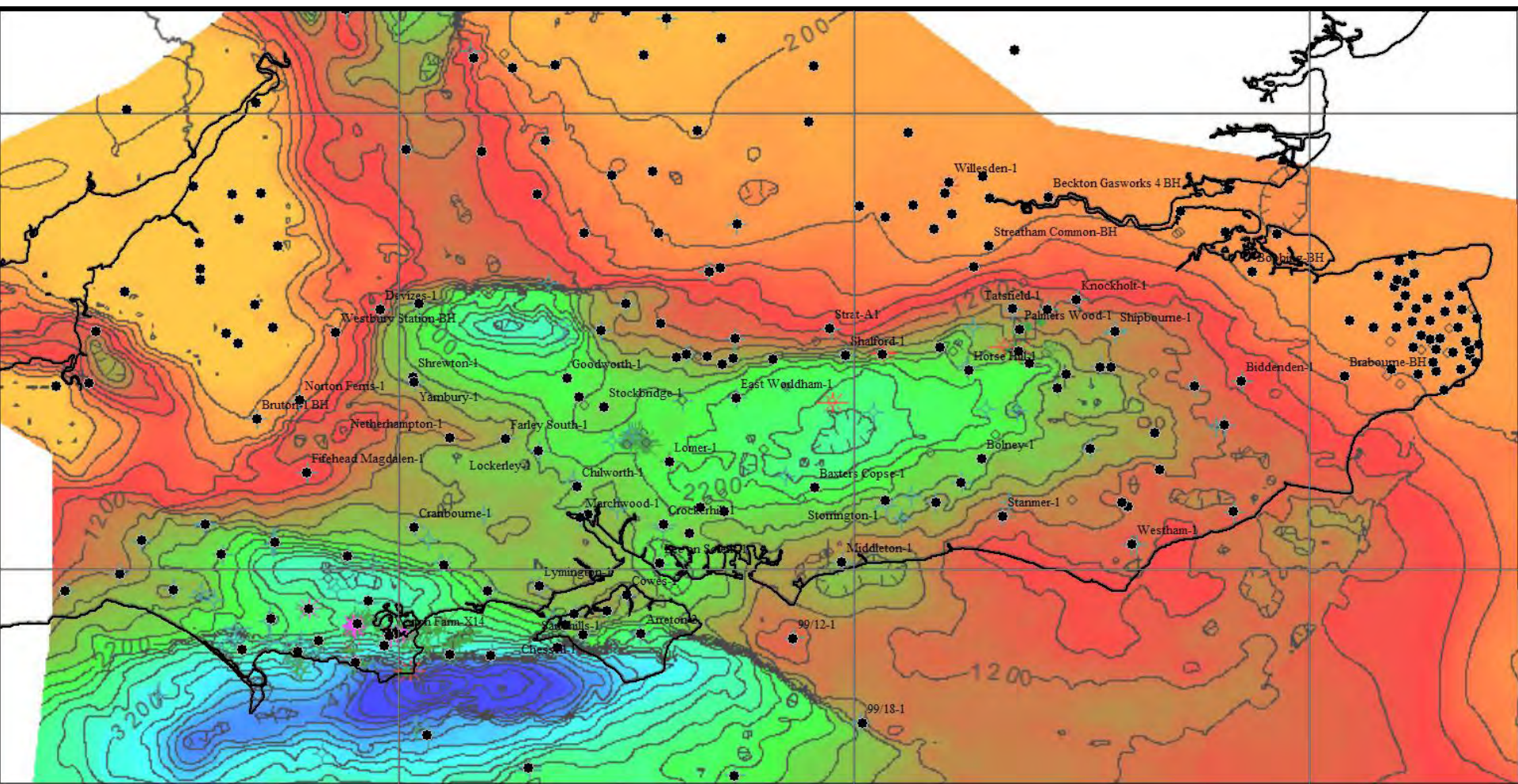
- Over much of southern England the Palaeozoic structure cannot be reliably mapped using seismic

HORSE HILL-1



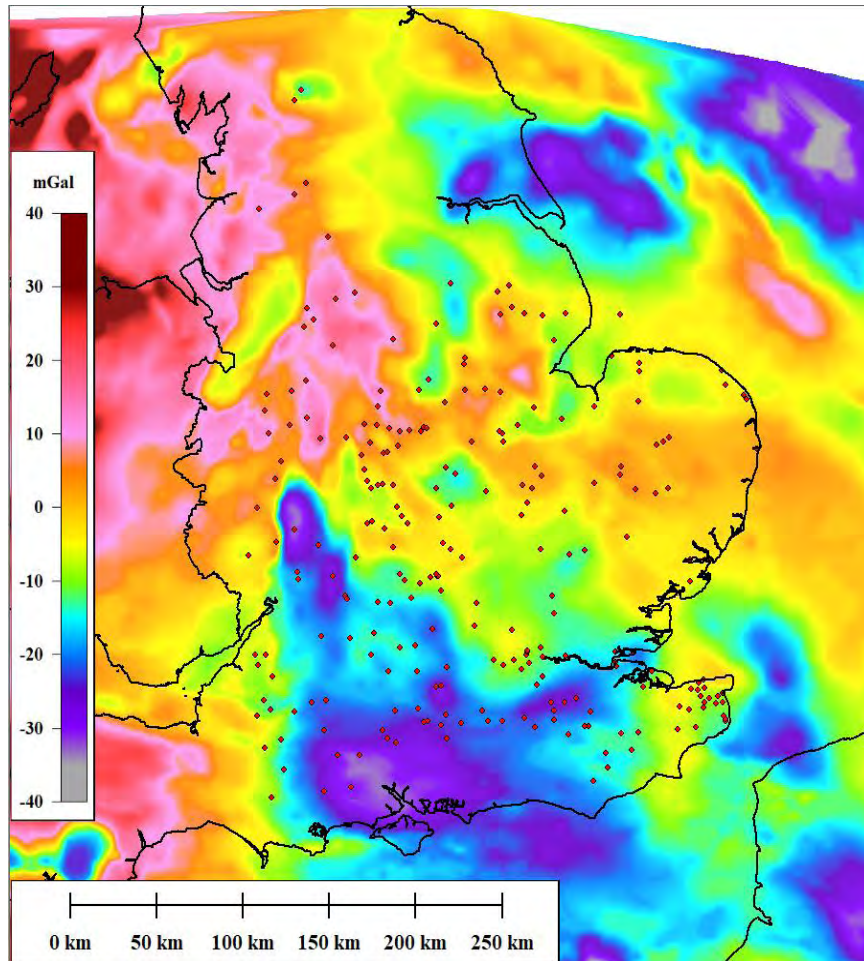
Dipmeter demonstrates a reasonably consistent dip of 20-35° dip to the north

Southern England – Top Paleozoic Structure Map



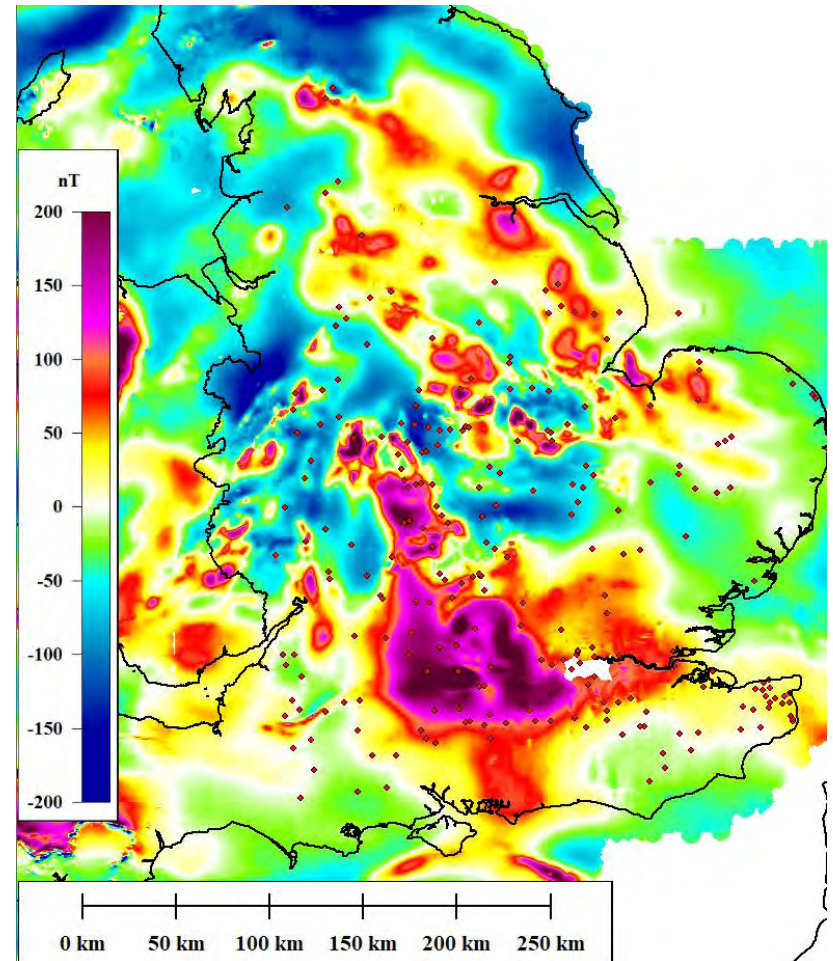
Courtesy of Malcolm Butler

Geophysical Database



Contains British Geological Survey materials © UKRI.

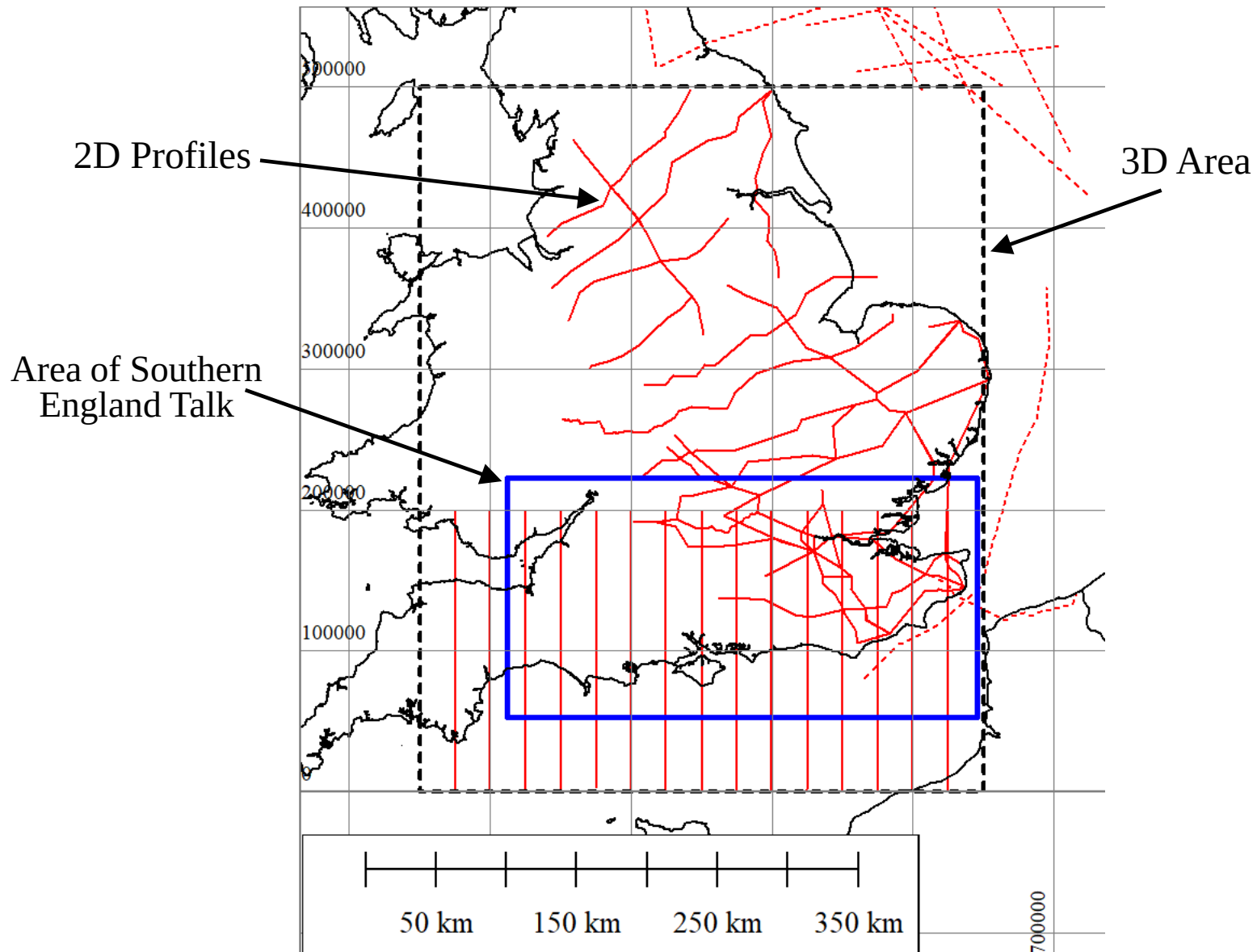
Gravity – BGS Bouguer Map



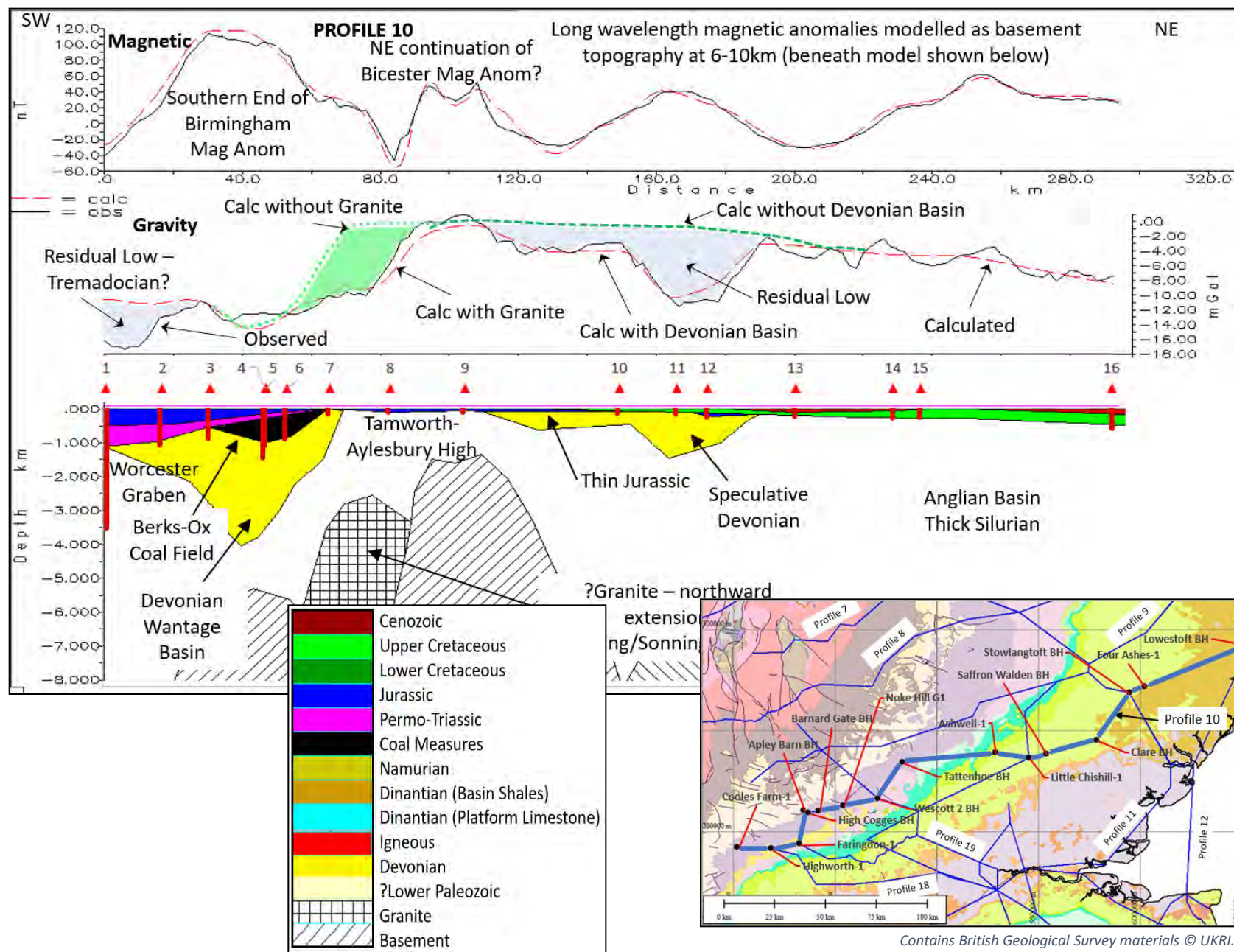
Contains British Geological Survey materials © UKRI.

Magnetic – BGS Magnetic Map

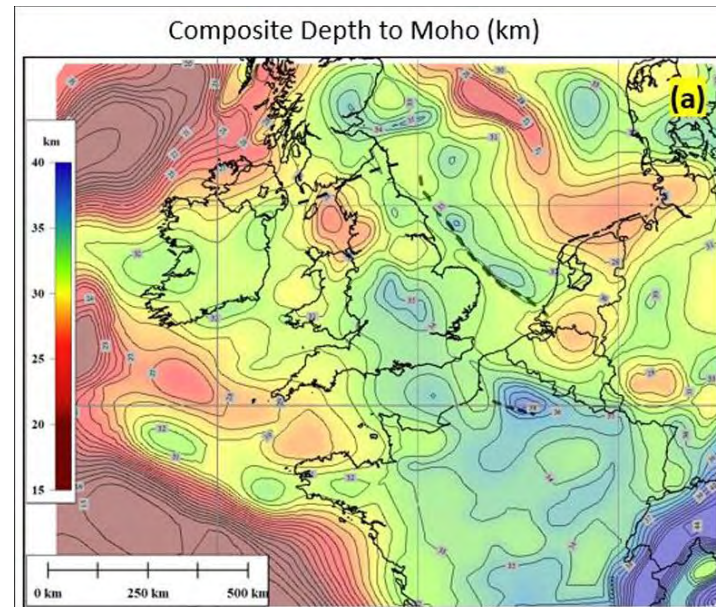
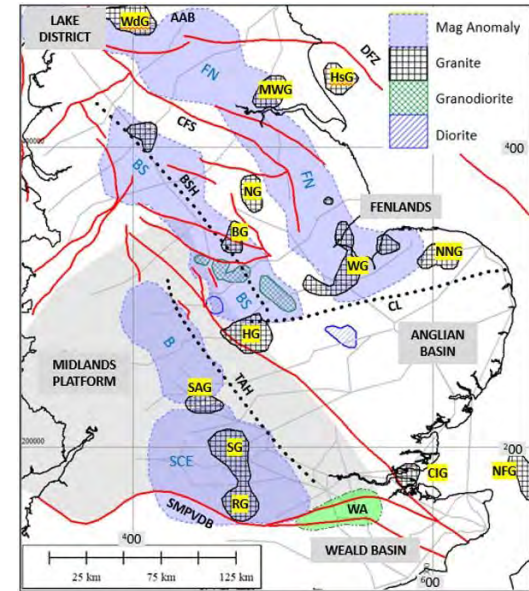
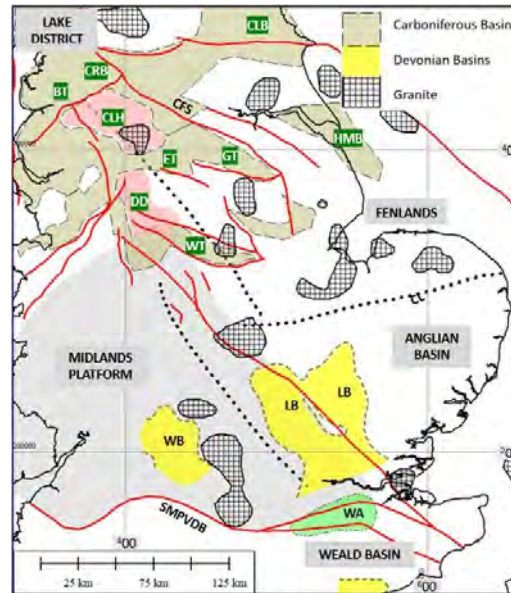
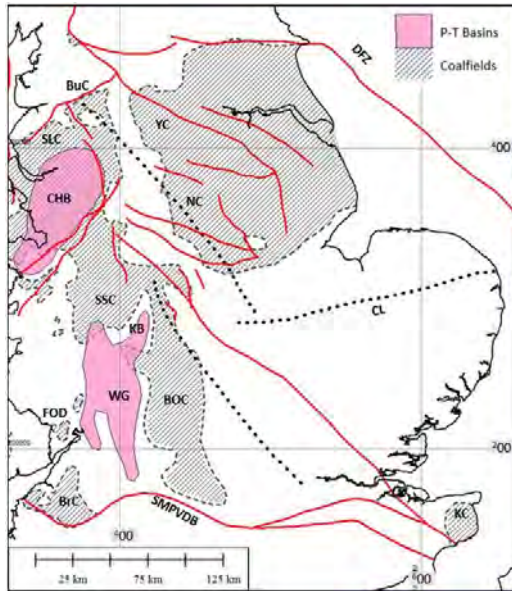
Locations of Modelled 2D Profiles and 3D Area



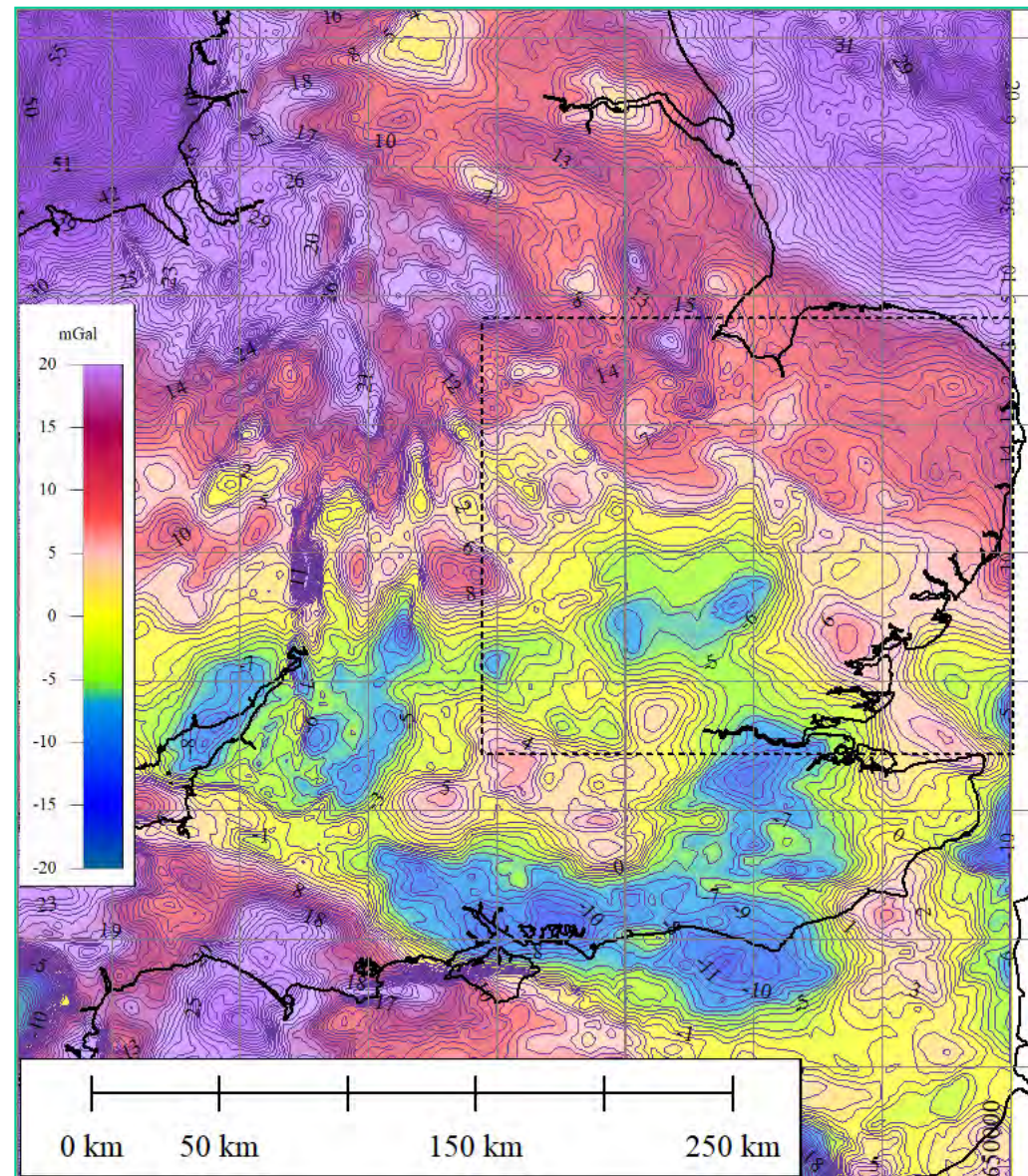
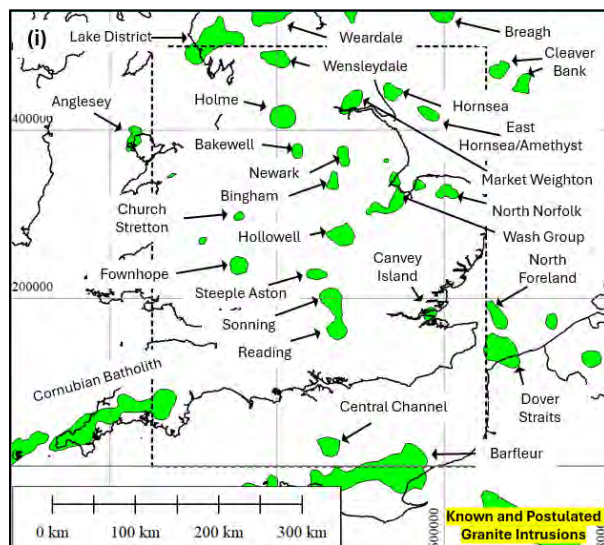
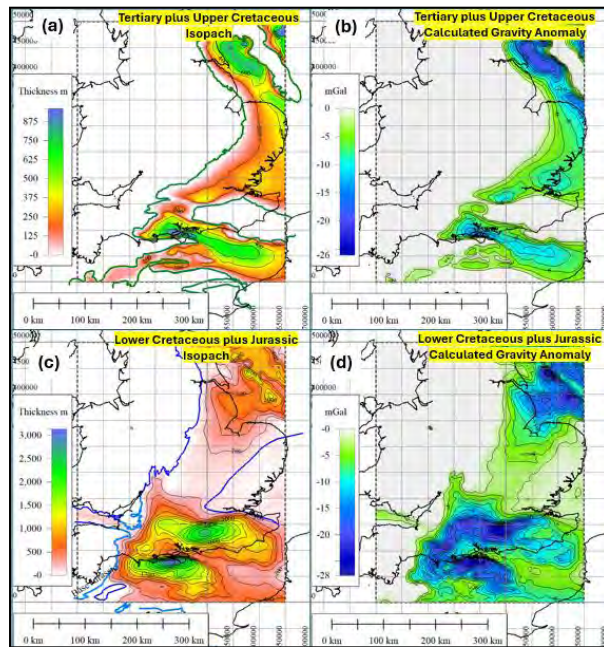
Gravity and Magnetics 2D Profile Work



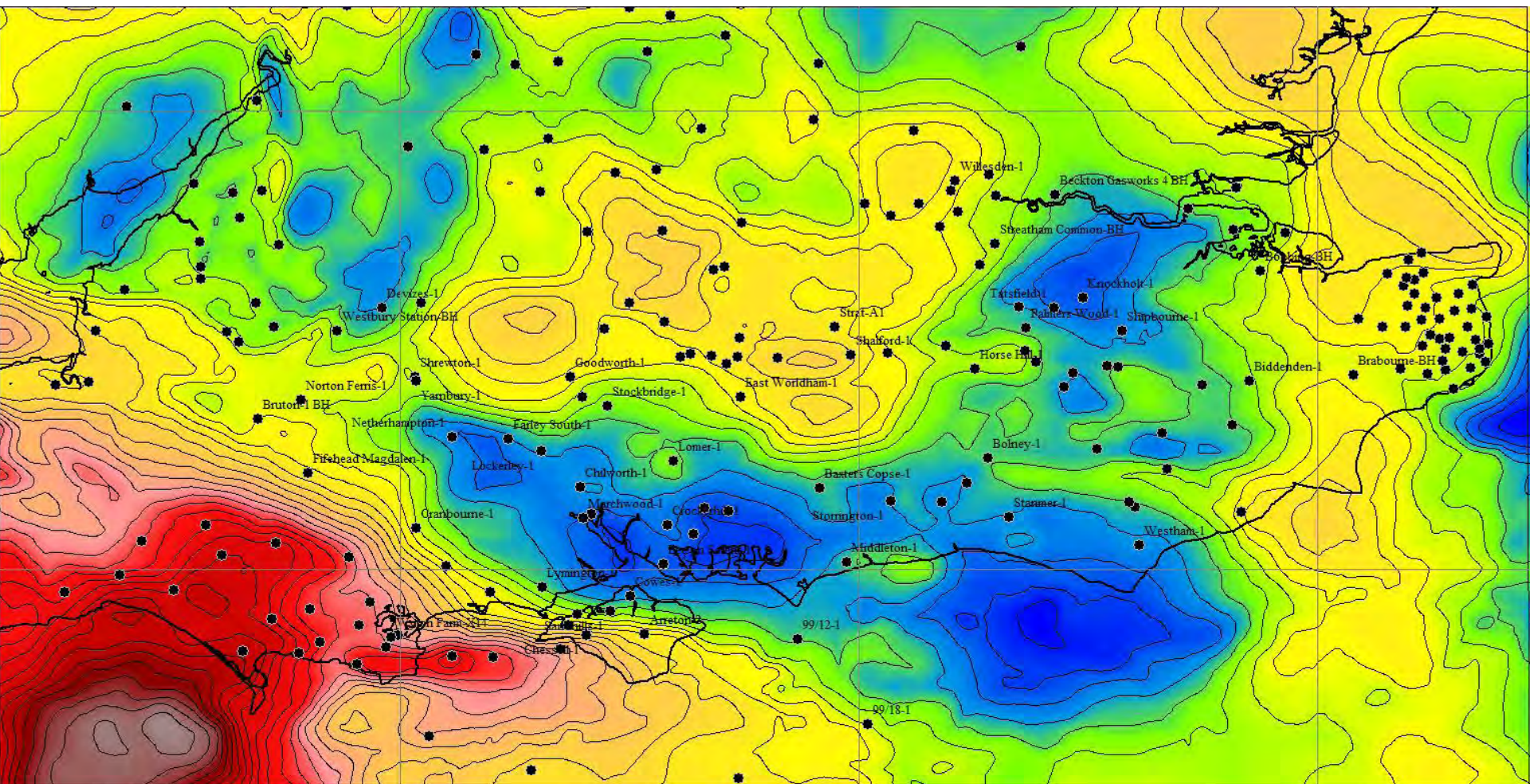
Gravity and Magnetics 2D Profile Work Results



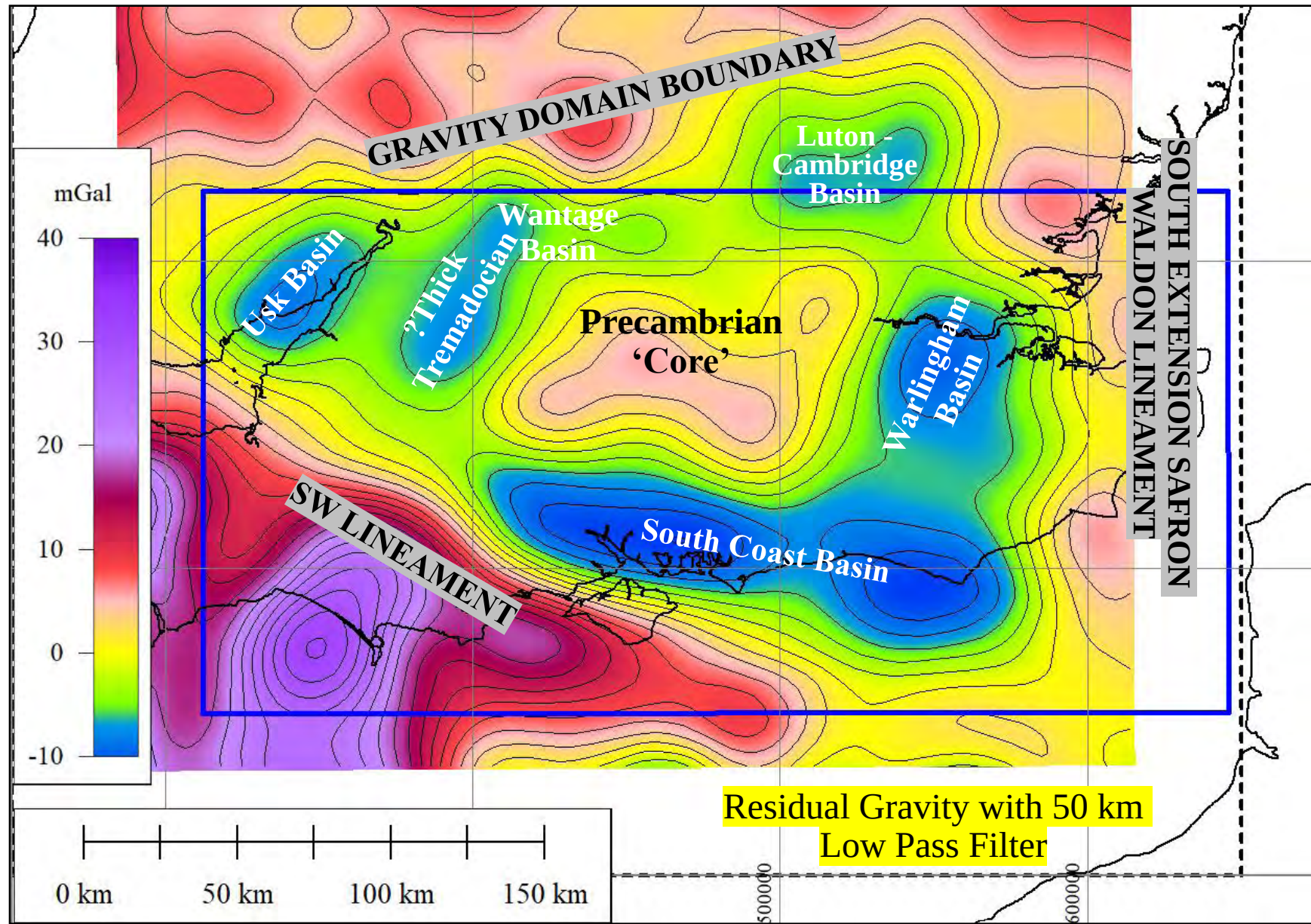
Gravity 3D Work



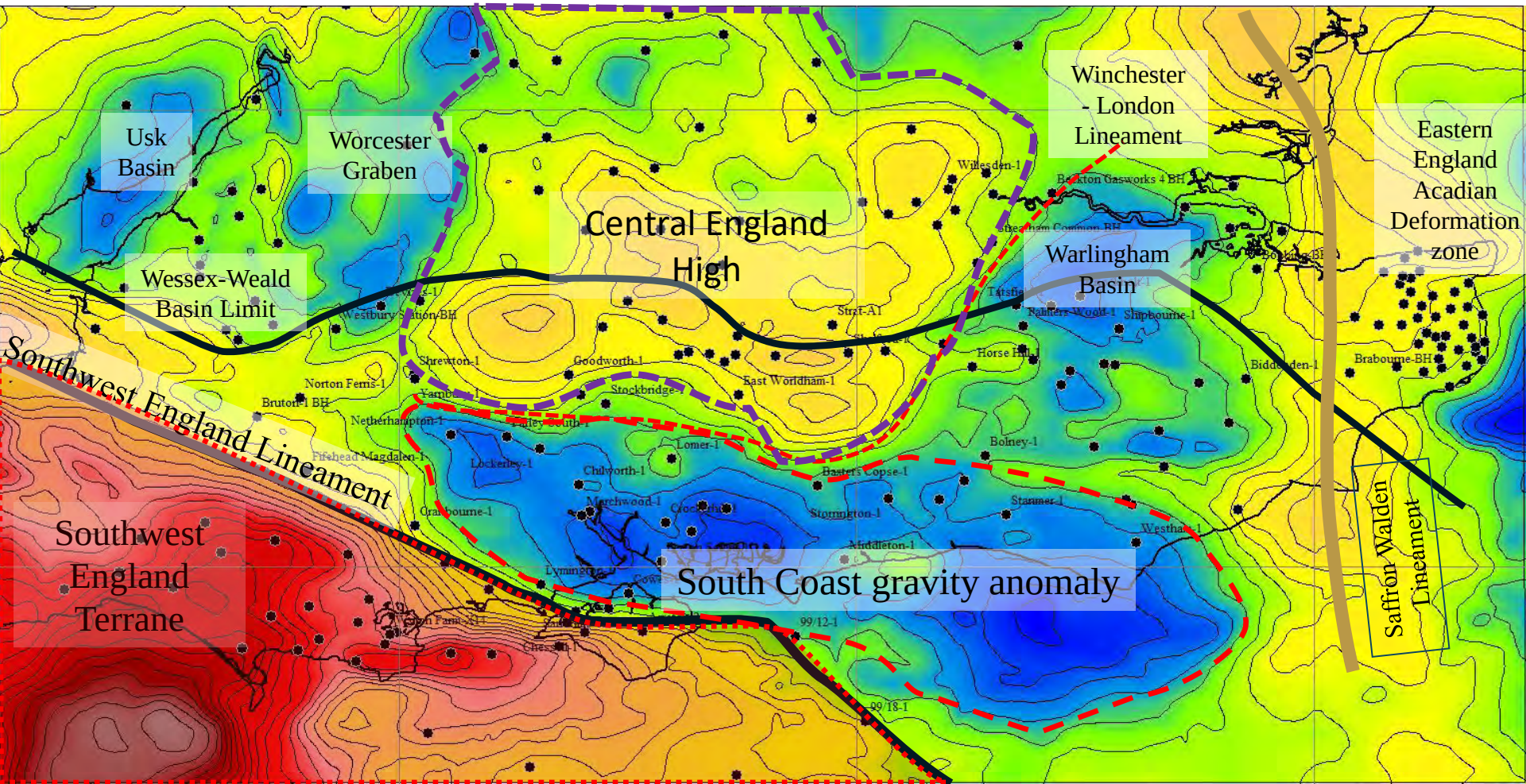
Southern England – Residual Gravity



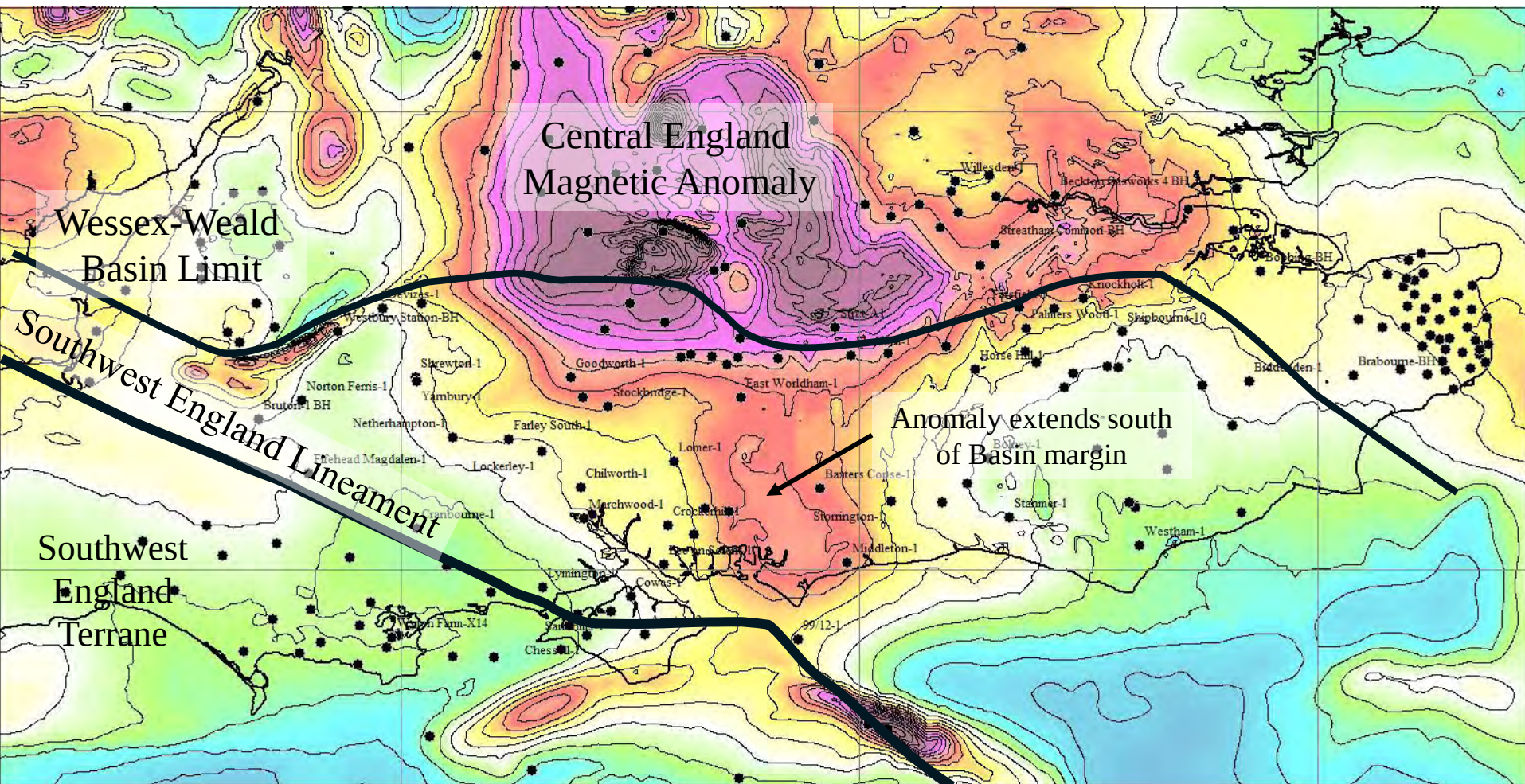
Deep Structure – Precambrian ‘Core’ Flanked by Basins



Southern England – Residual Gravity Main Features



Southern England – Observed Magnetic



Contains British Geological Survey materials © UKRI.

Central England Magnetic Anomaly

West

E. WORCESTER

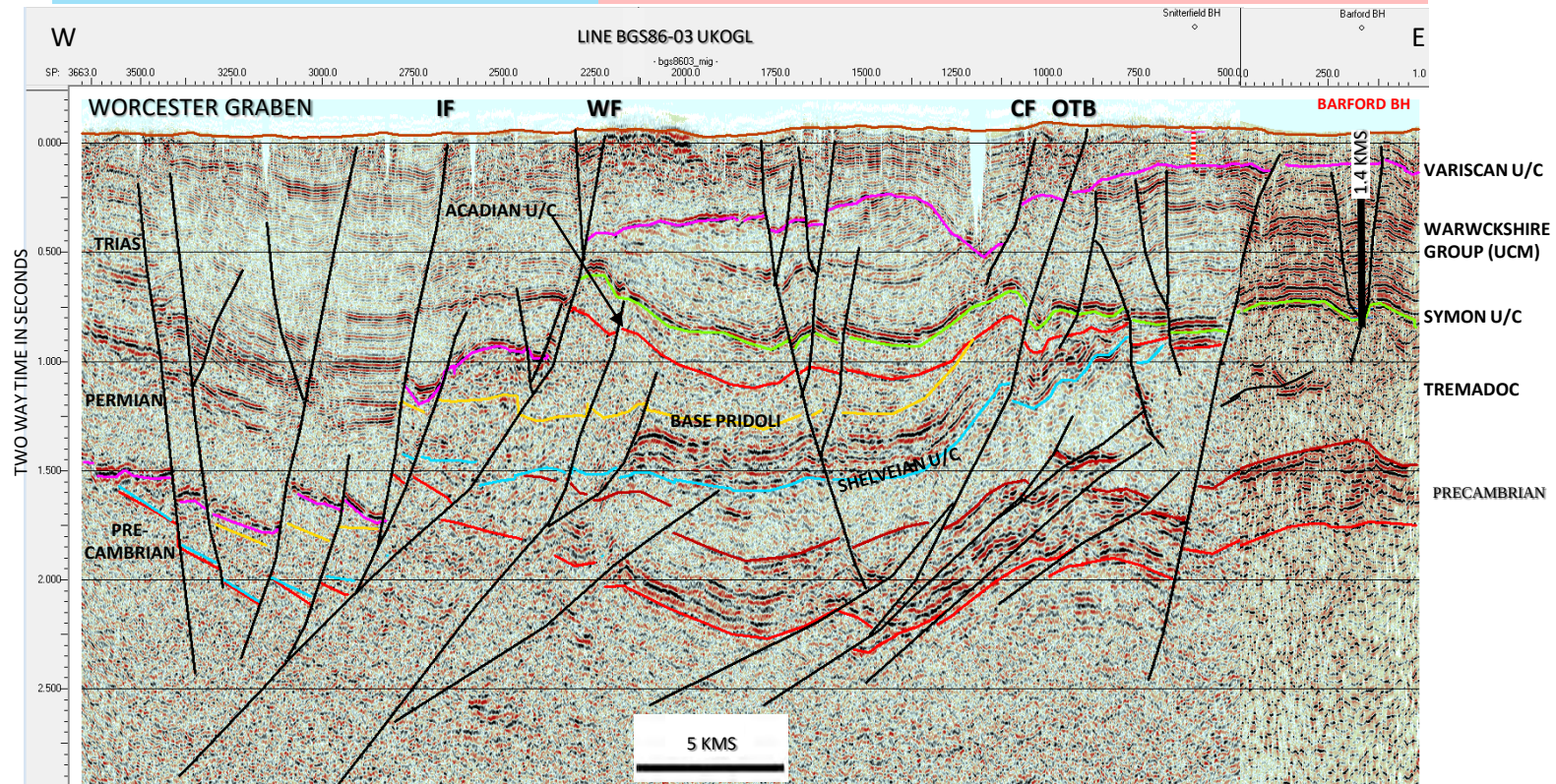
S.OF ALCESTER

N.OF STRATFORD-ON-AVON

East

WORCESTER GRABEN

MIDLANDS PLATFORM



Courtesy of Malcolm Butler

Central England Magnetic Anomaly

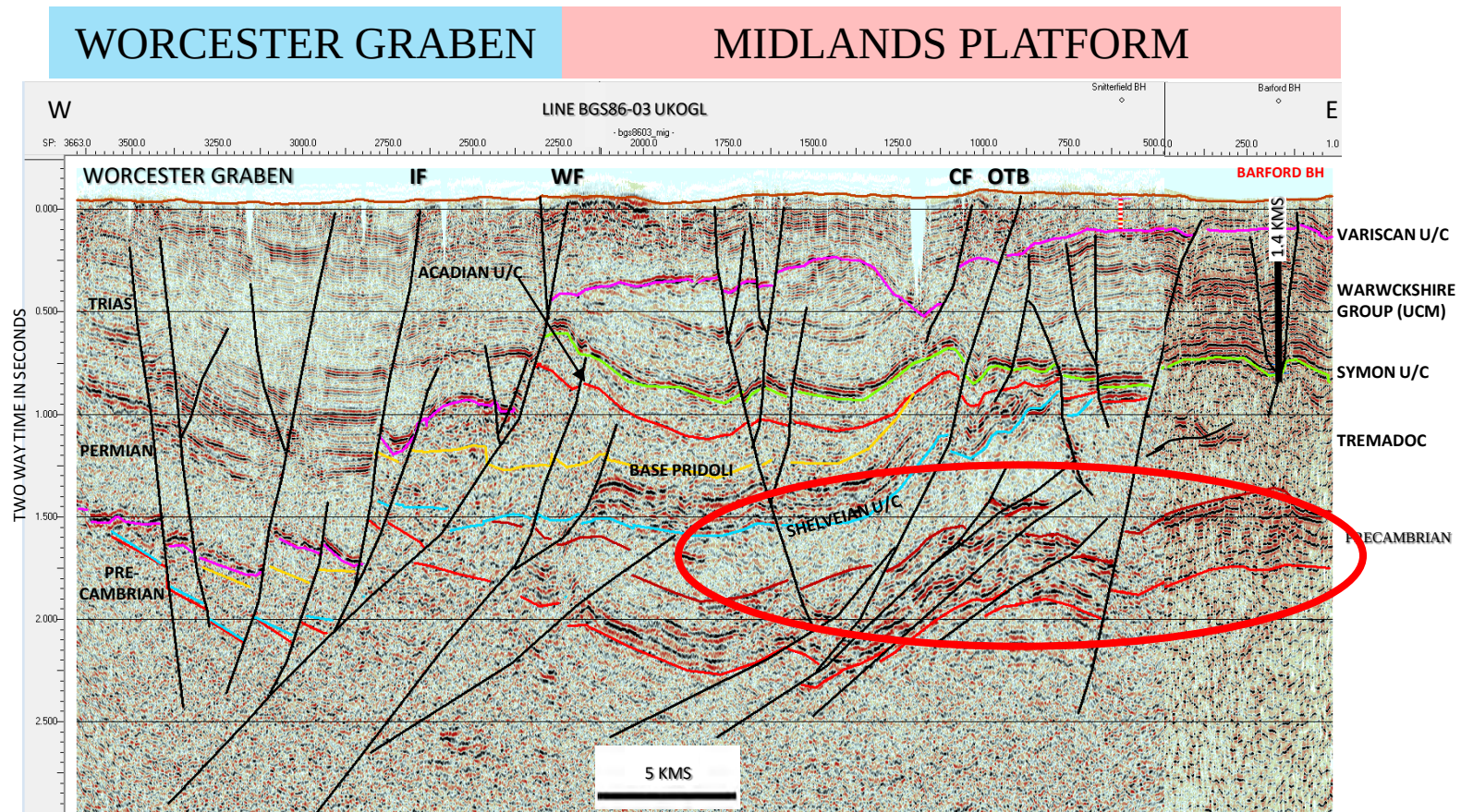
West

E. WORCESTER

S.OF ALCESTER

N.OF STRATFORD-ON-AVON

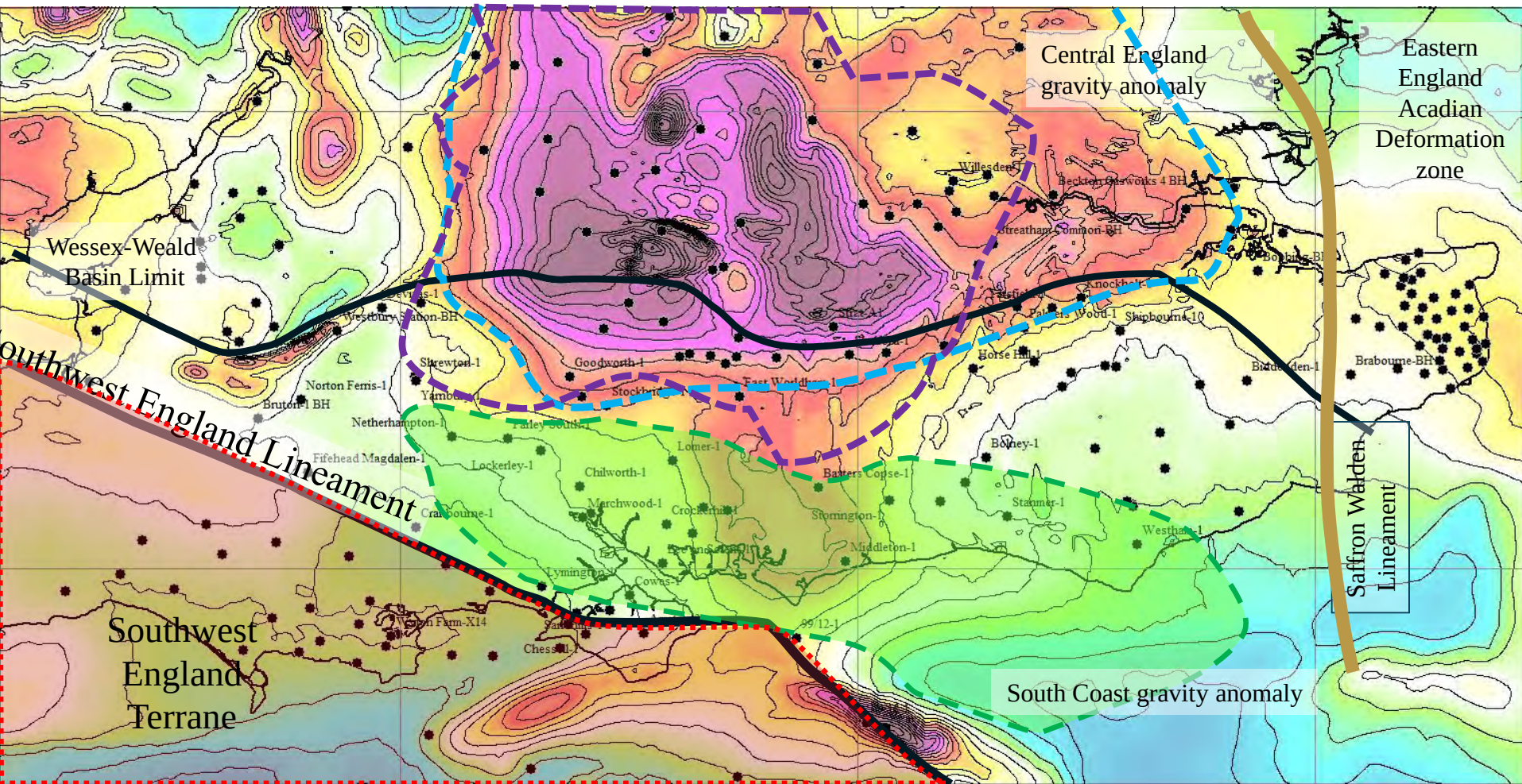
East



Zone of Central England
Magnetic Anomaly

Courtesy of Malcolm Butler

Southern England – Gravity and Magnetic Anomalies



Contains British Geological Survey materials © UKRI.



Approximate extent of Central
England Gravity anomaly



Approximate extent of Central
England Magnetic anomaly



Approximate extent of South
Coast Gravity anomaly

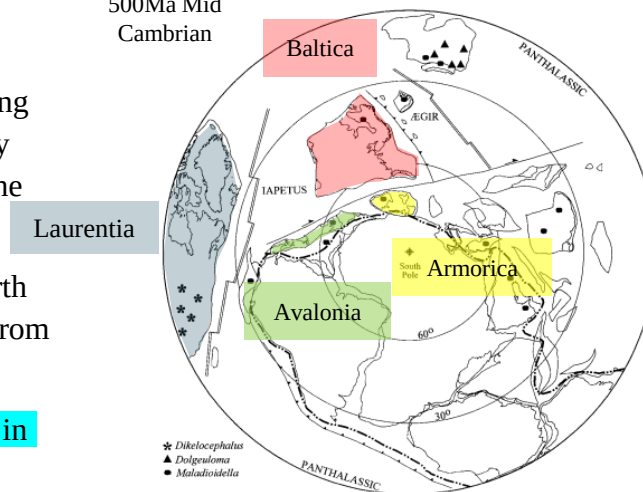
Plate Setting - Palaeomagnetism

- The principal evidence for the plate positions comes from Palaeomagnetism. It gives latitude control but no longitude control. This data is supplemented by faunal studies
- Palaeomagnetic data control for England and Wales comes mainly from the Midlands Microcraton (the Silurian volcanics of Southern England and the igneous rocks in the Midlands), the Lake District and North Wales
- Palaeomagnetism shows that in the Caradoc to Mid Devonian period the Lake District was rotated 50° anticlockwise with respect to North Wales. Palaeomagnetic data from Nuneaton shows that since the Upper Ordovician the Lake District has rotated 160° clockwise

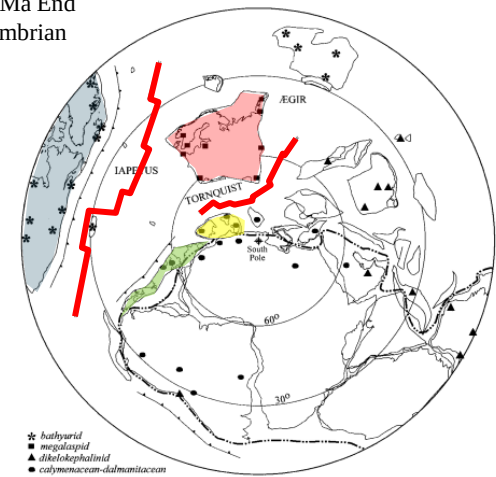
Lower Paleozoic Plate Movements

- A series of plates – Laurentia, Avalonia, Baltica and Armorica separated from Supercontinent Gondwanaland at different times
- Laurentia separated from South America during Vendian to Lower Cambrian times and rapidly drifted north to Equatorial Regions creating the Iapetus Ocean
- Avalonia separated from Pannotia, drifted north rapidly in the Ordovician and was separated from the Baltica plate by the Tornquist Ocean
- Avalonia plate collided with the Baltica plate in Late Ordovician (Ashgill) times – 450my– Shelvian Orogeny
- Avalonia/Baltica collided with the Laurentian plate in Mid-Late Silurian times with the closure of the Iapetus Ocean to form Laurasia – Caledonian Orogeny
- The Armorican plate was separated from the other plates by the Rheic Ocean. The closure of this Ocean was the first part of the Variscan Orogenic episode
- Gondwanaland moved north with time and in the Late Paleozoic the Laurentia, Avalonia, Baltica and Armorica plates joined with it to form Pangea – the main Variscan event

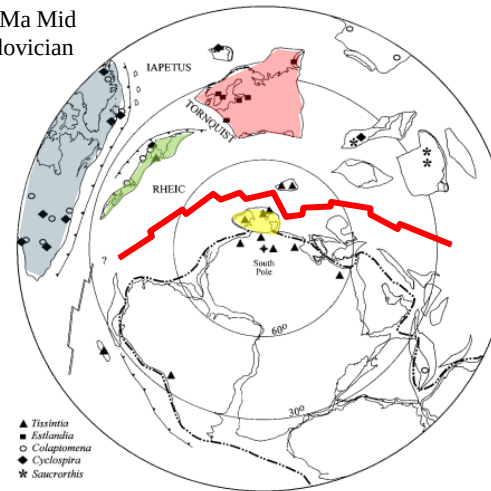
500Ma Mid Cambrian



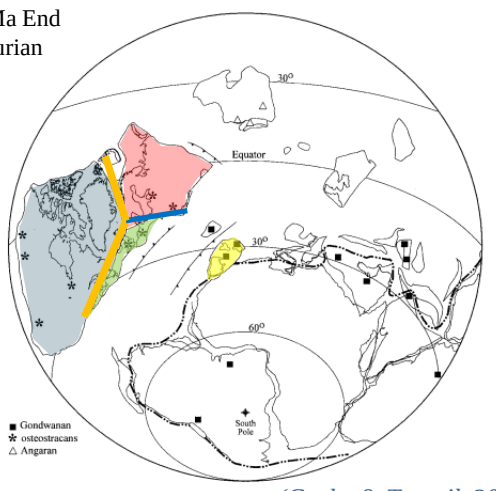
480Ma End Cambrian



460Ma Mid Ordovician



420Ma End Silurian



(Cocks & Torsvik 2002)

Spreading Axes

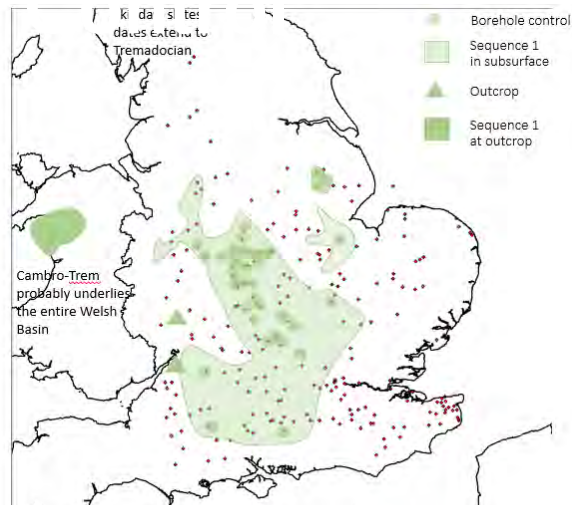
Collision Belts

Paleozoic Stratigraphy

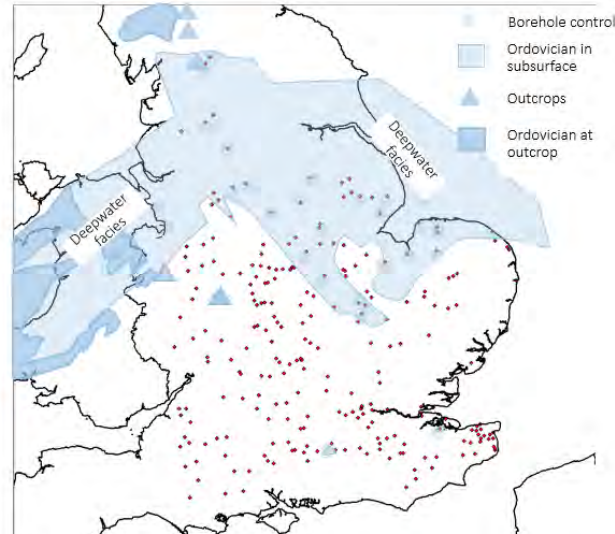
- Unconformity bounded sequences – recognised using outcrop, borehole and seismic data lying above the Precambrian Basement
- Sequence 5 – Upper Coal Measures – Variscan unconformity at top
- Sequence 4 – Upper Devonian – Upper Carboniferous – Symon unconformity at the top. Non deposition in the Namurian in Southern and Central England
- Sequence 3 – Latest Ordovician – Early Devonian – Acadian unconformity at top
- Sequence 2 – Lower – Upper Ordovician – Shelvian unconformity at top
- Sequence 1 – Cambrian – Lower Ordovician (Tremadocian) – Monian unconformity at top
- Problem of reworking of unconformities

Period	Epoch	Groups/Formations	Lithology
Permian			Mudstone with basal sandstone
~~~~~ Variscan Unconformity ~~~~~			
Carboniferous	Stephanian	Warwickshire Group	Mudstone, sandstone, siltstone
	Westphalian	~~~~~ Symon Unconformity ~~~~~	
		Pennine Coal Measures Group	Mudstone, sandstone, siltstone, coal
	Namurian	~~~~~ Unconformity ~~~~~	
	Lower		Limestone
Devonian	Upper		Mudstone, sandstone
	~~~~~ Acadian Unconformity ~~~~~		
	Lower		Sandstone
~~~~~ Brabantian Unconformity ~~~~~			
Silurian	Upper - Lower		Mudstone, sandstone
~~~~~ Shelvian Unconformity ~~~~~			
Ordovician	Upper - Lower (Arenig)		Largely absent but basal sandstone
~~~~~ Monian Unconformity ~~~~~			
Cambrian - Lower Ordovician (Tremadocian)			Siltstone, mudstone
~~~~~ Pan African Unconformity ~~~~~			
Precambrian			

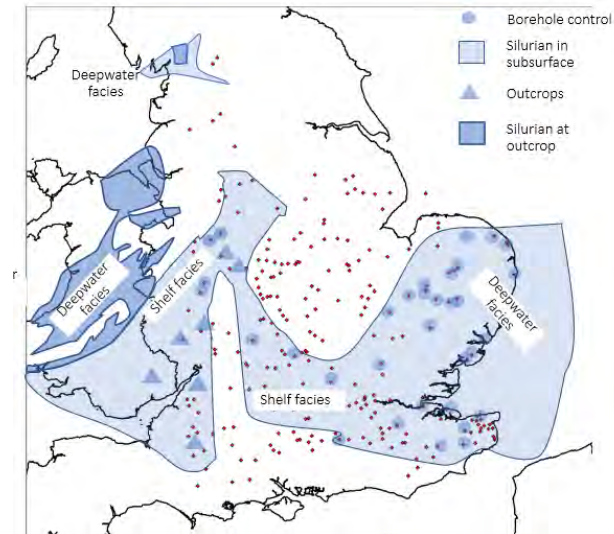
Lower Paleozoic – Outcrop and Well



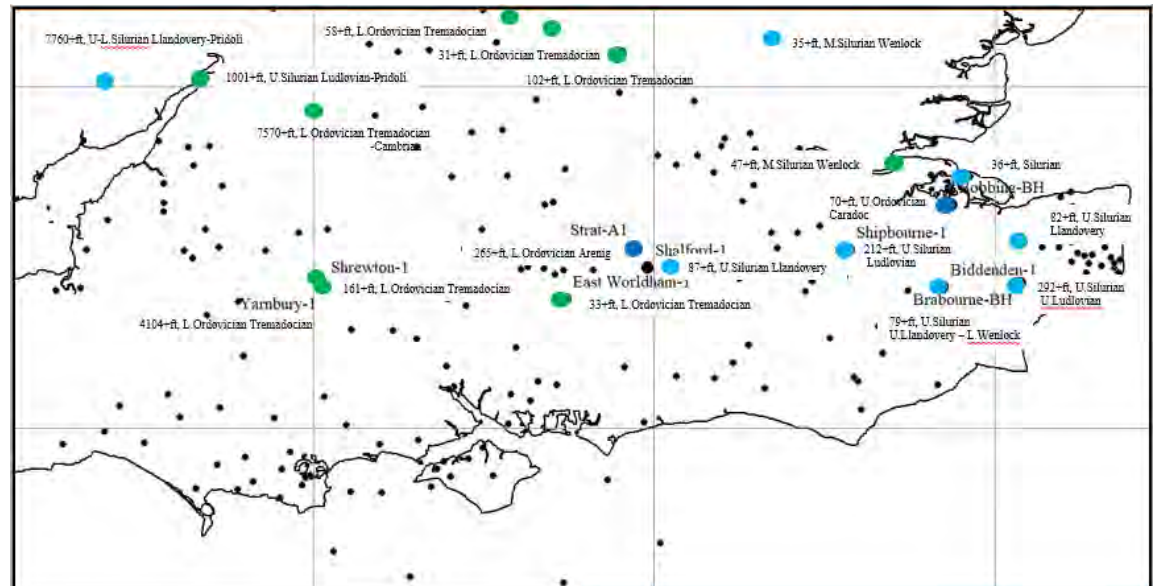
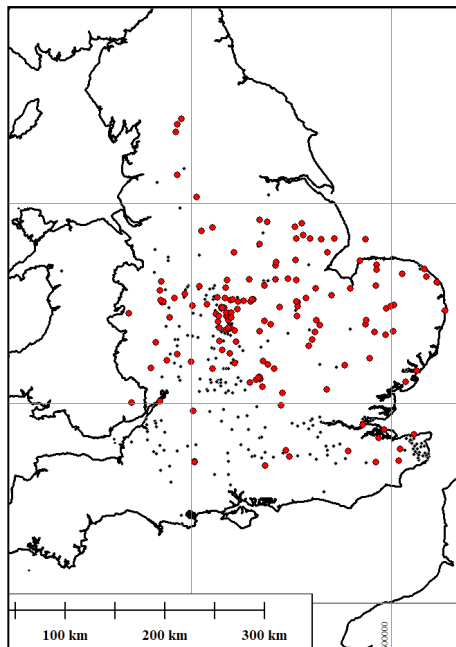
Sequence 1 – Cambrian-Tremadocian



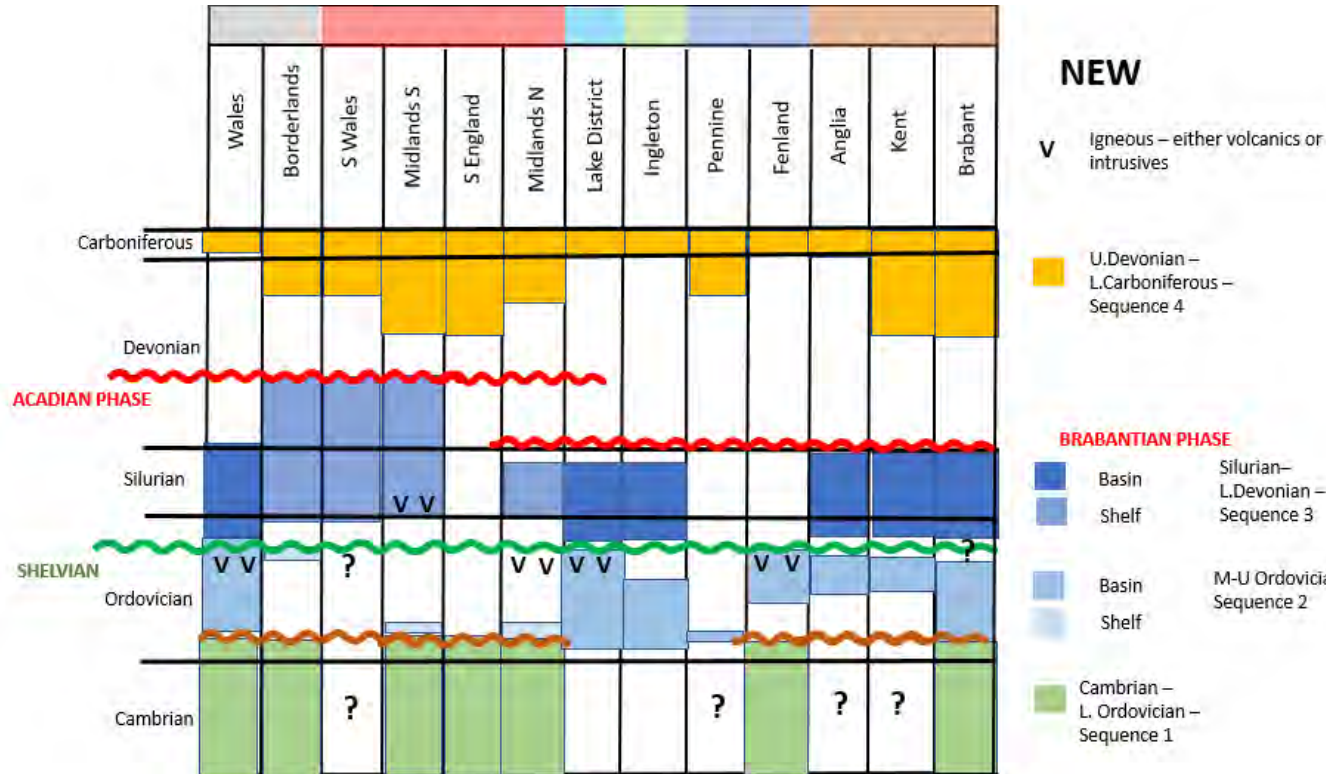
Sequence 2 – M-U Ordovician



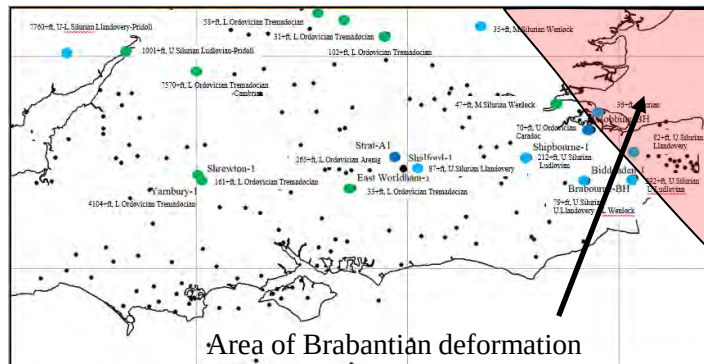
Sequence 3 – Silurian



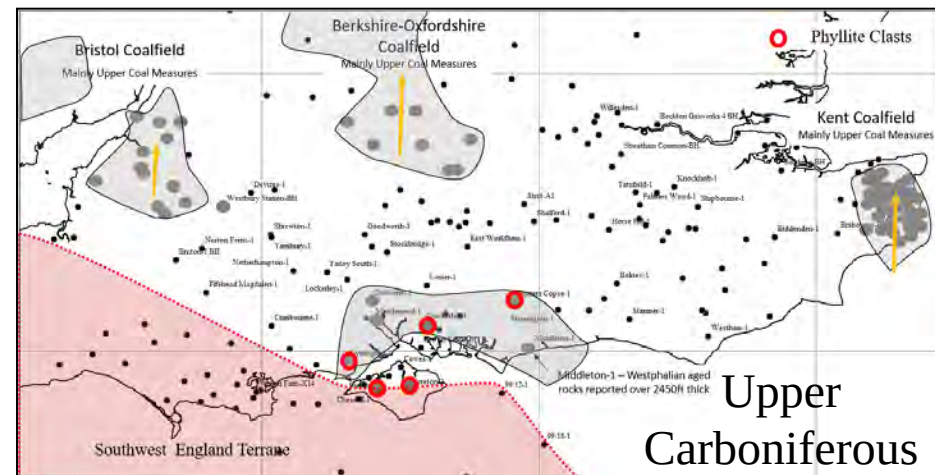
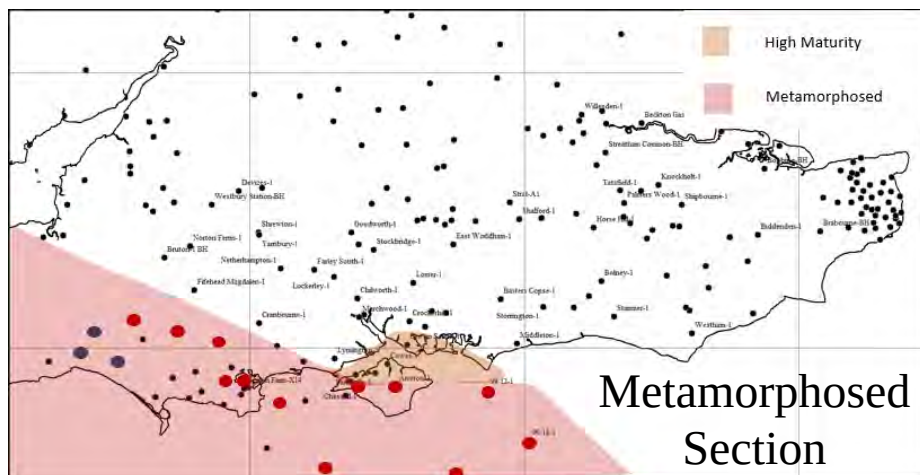
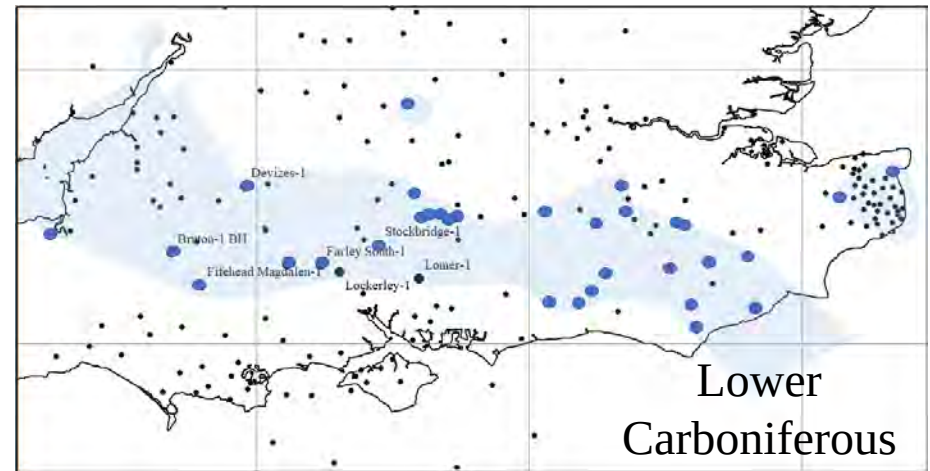
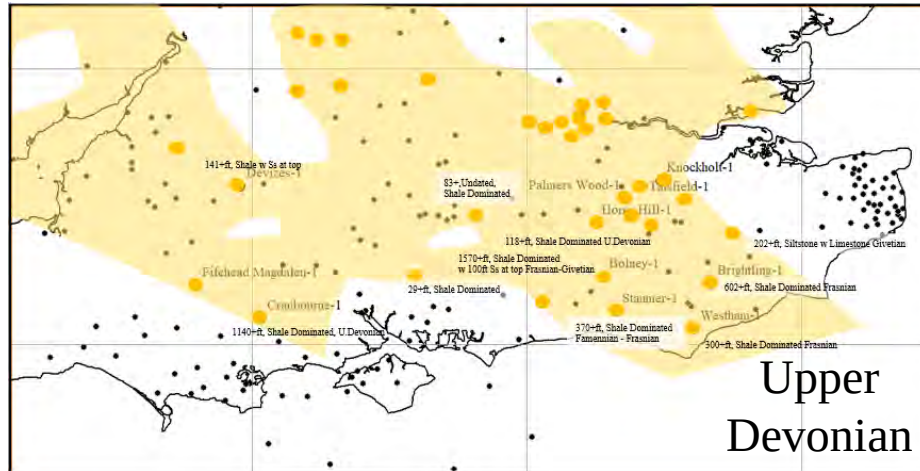
Lower Paleozoic – Shelvian and Caledonian Events



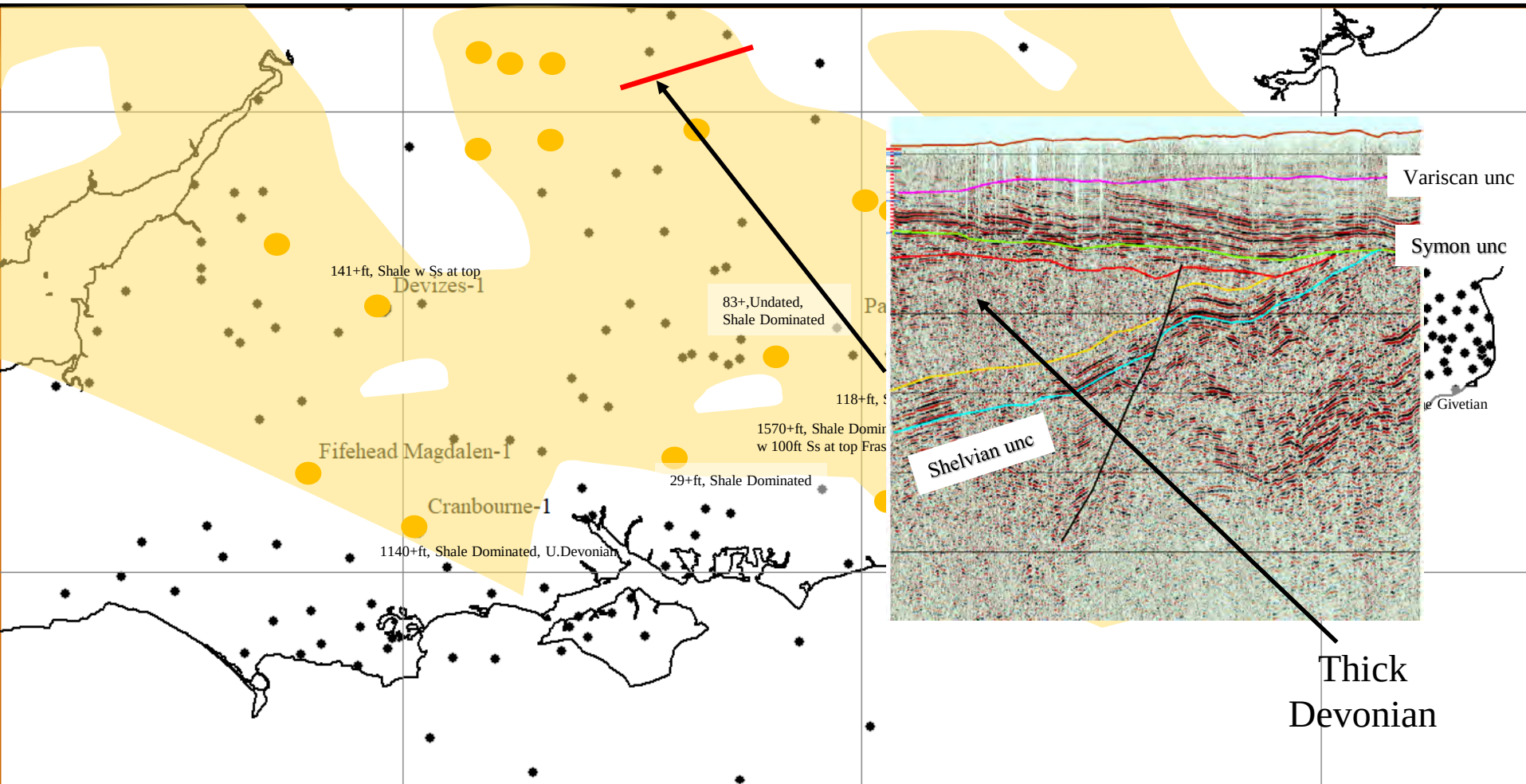
- Poor well control of the Lower Paleozoic
- Shelvian event (Late Ordovician) present but difficult to define in Kent
- Caledonian event has multiple names - Acadian in UK, Erian in Ireland and Brabantian in Belgium
- The event is recognised in folding and cleavage development. Cleavage is seen in well samples in Eastern England but there is no orientation data
- Brabantian event well recognised in Belgium
- In Charnwood the cleavage is orientated NW-SE and is dated 432-416my (Middle Silurian to Lower Devonian), with a peak at 423my (Late Silurian - Ludlovian/Pridoli)
(*Carney et al, 2008*)
- Anglia basin and Kent show enhanced maturity as compared to the London Platform and Southern England
(*Merriman et al, 1993*)
- This enhanced maturity is explained by lower Paleozoic burial with uplift (basinal inversion) during the Late Silurian deformation



Upper Paleozoic

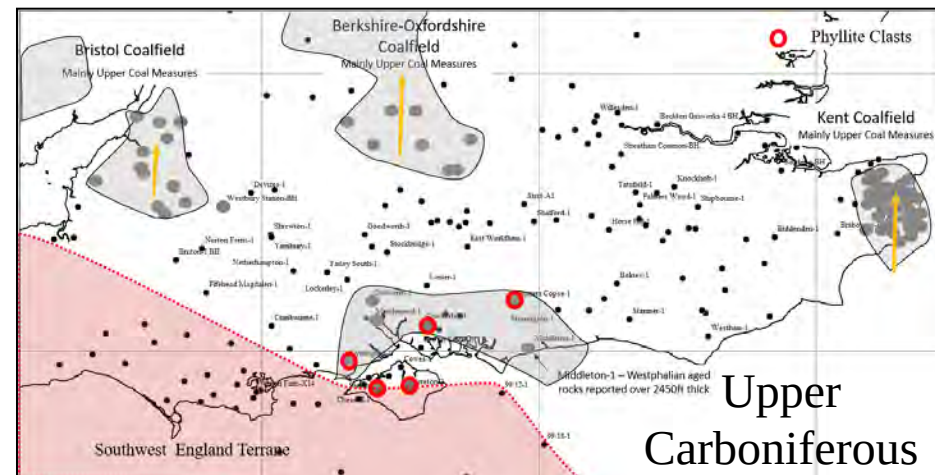
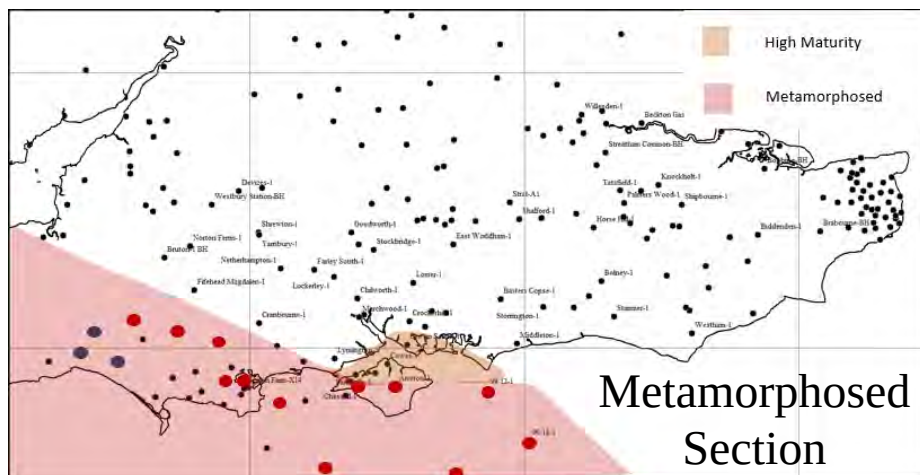
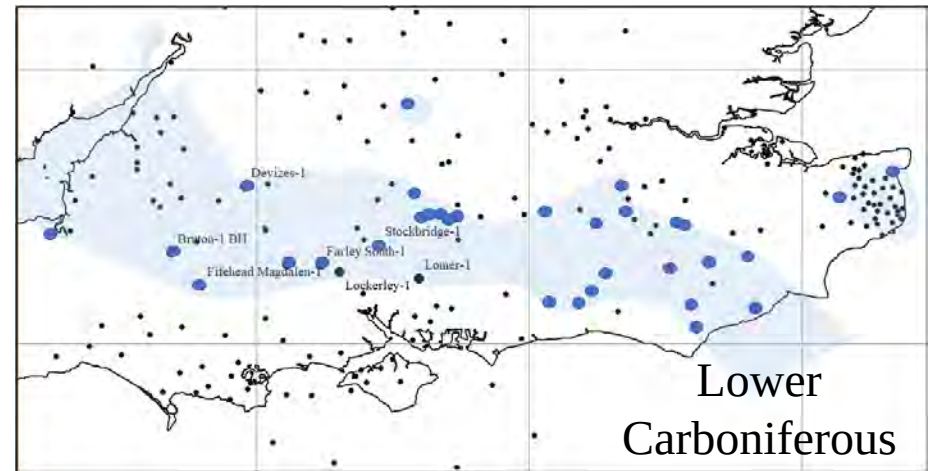
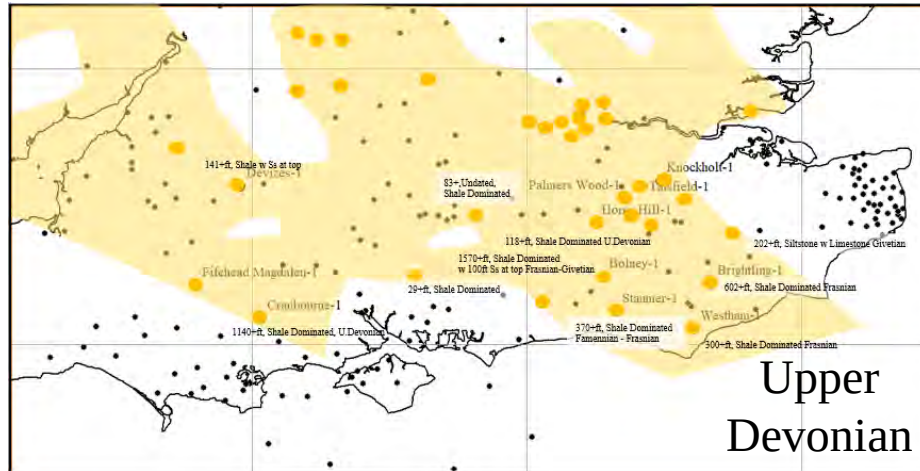


Upper Devonian Map

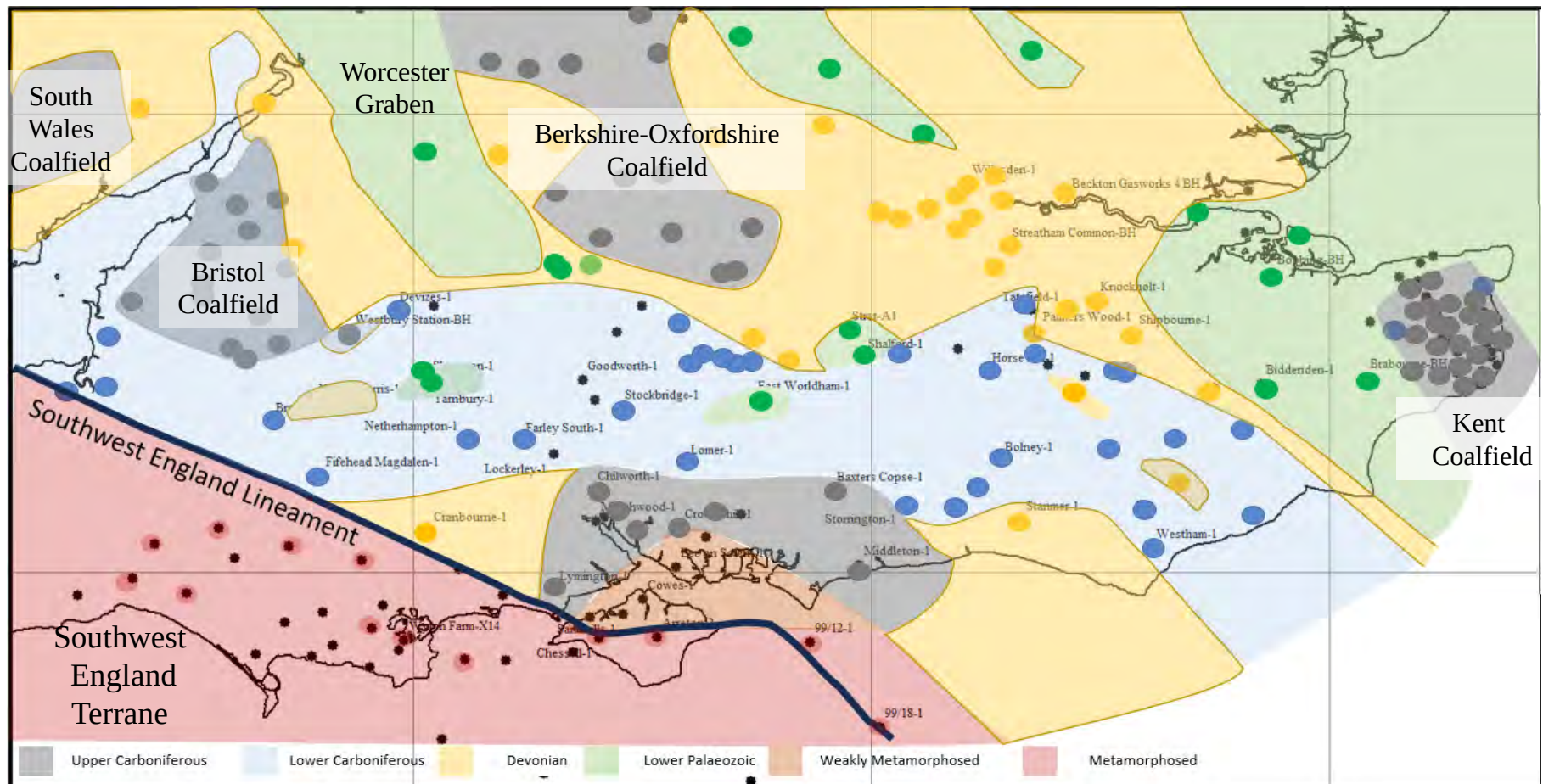


Courtesy of Malcolm Butler

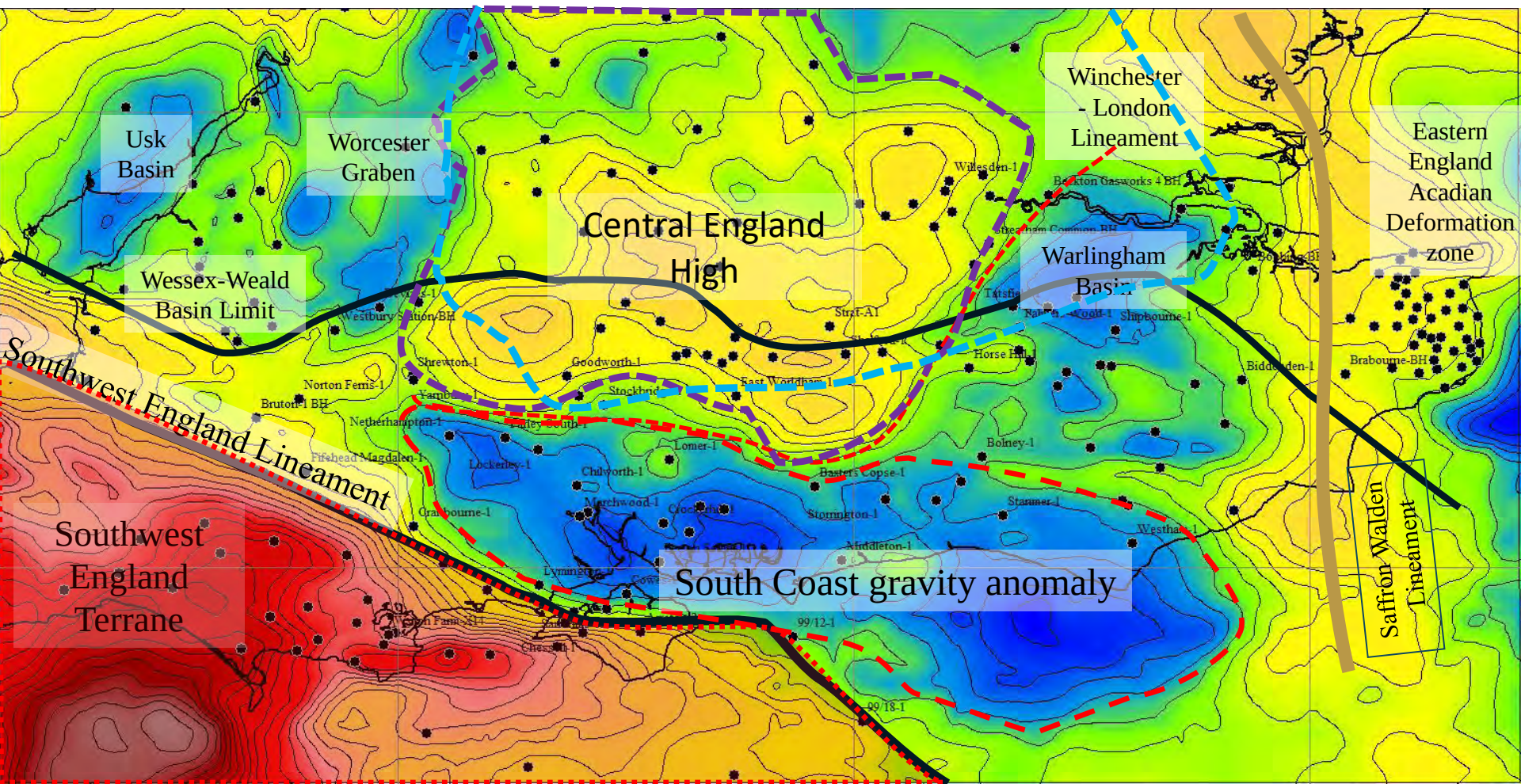
Upper Paleozoic



Variscan Subcrop Map



Southern England – Residual Gravity Main Features



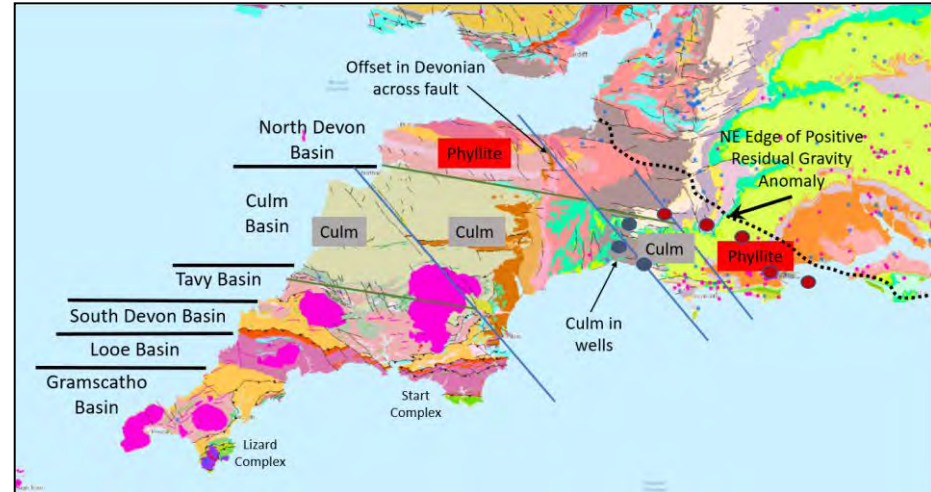
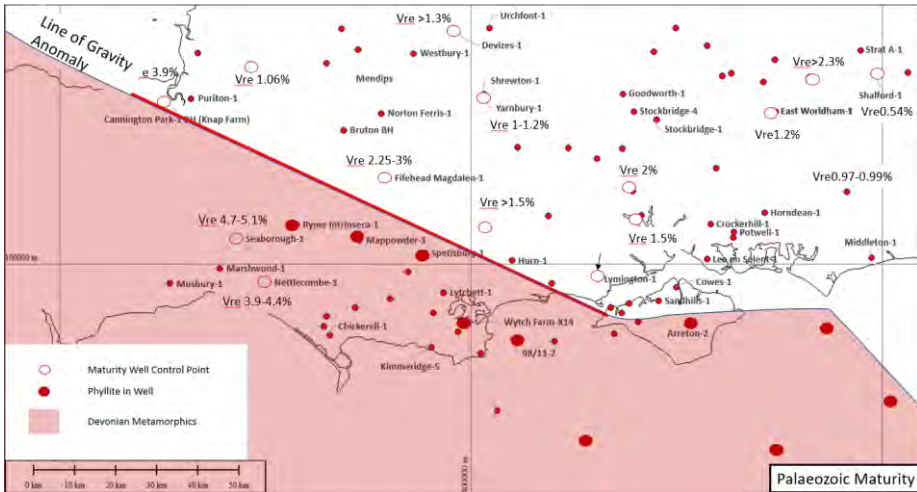
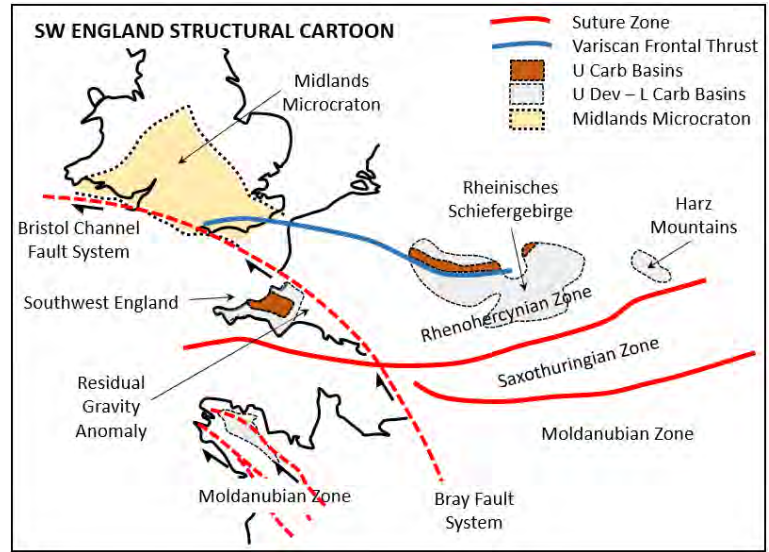
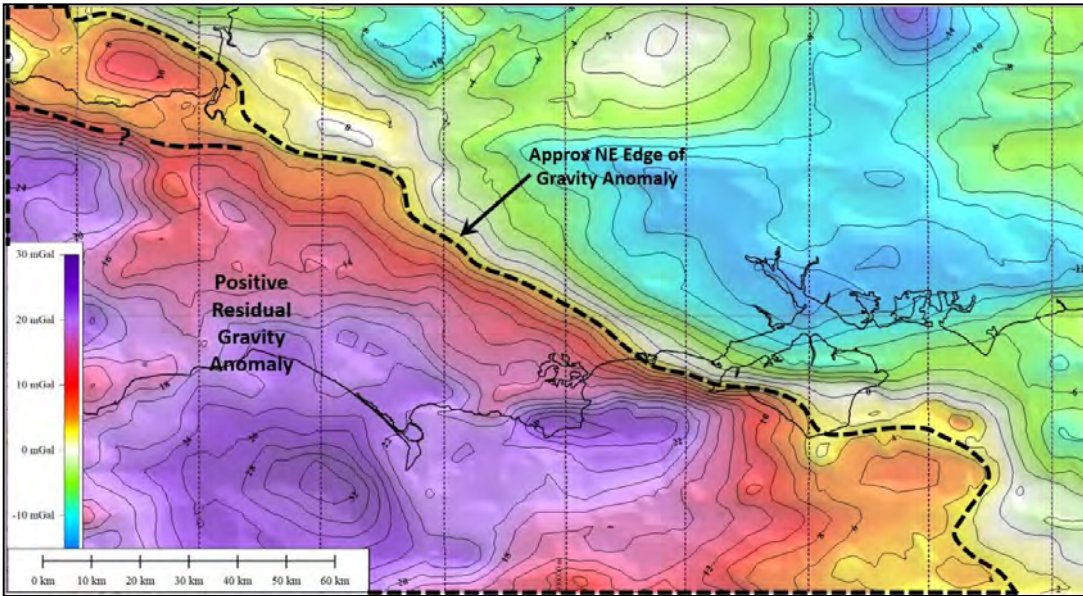
Approximate extent of Central England Gravity anomaly



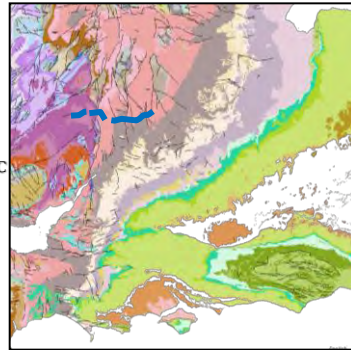
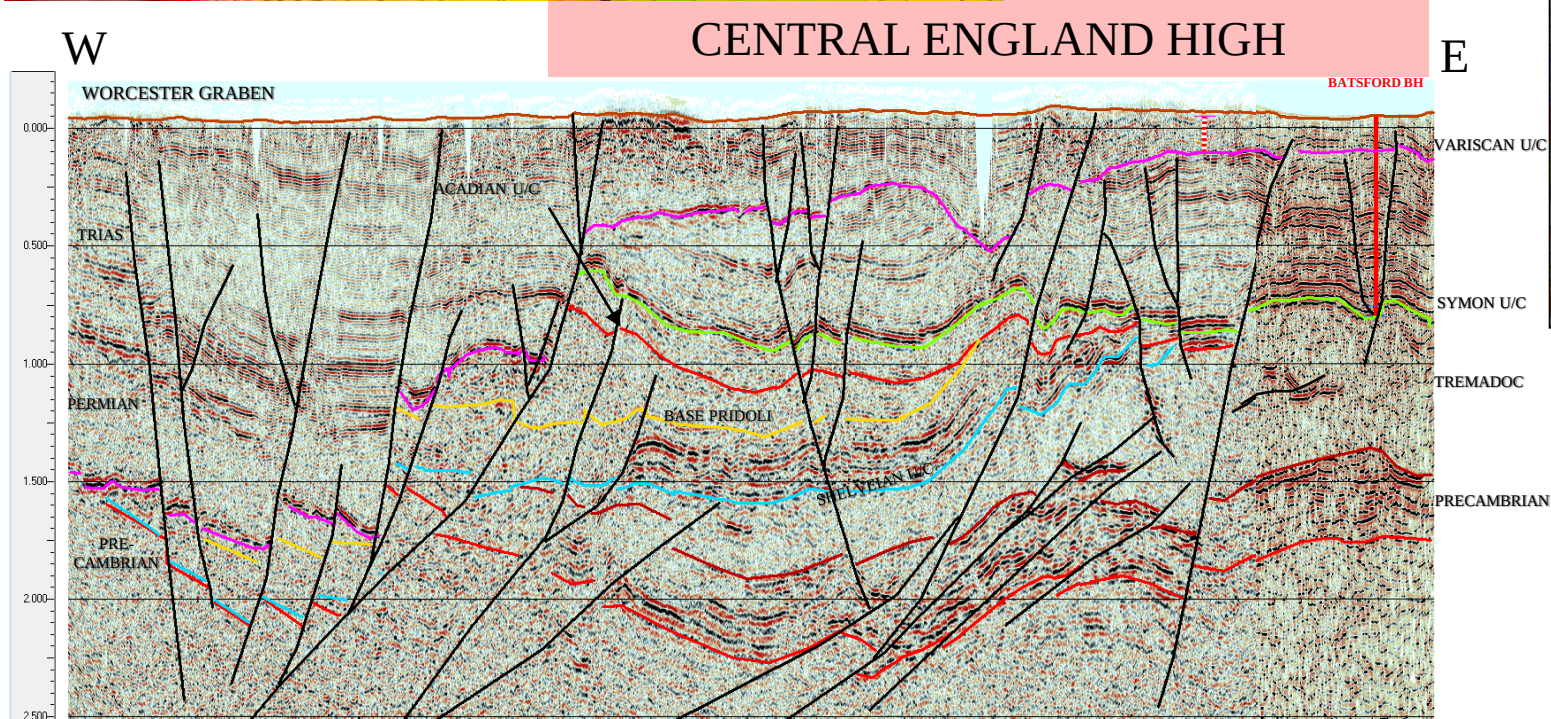
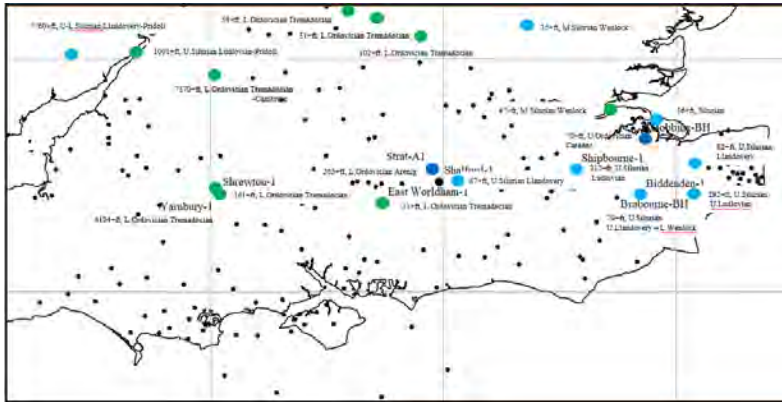
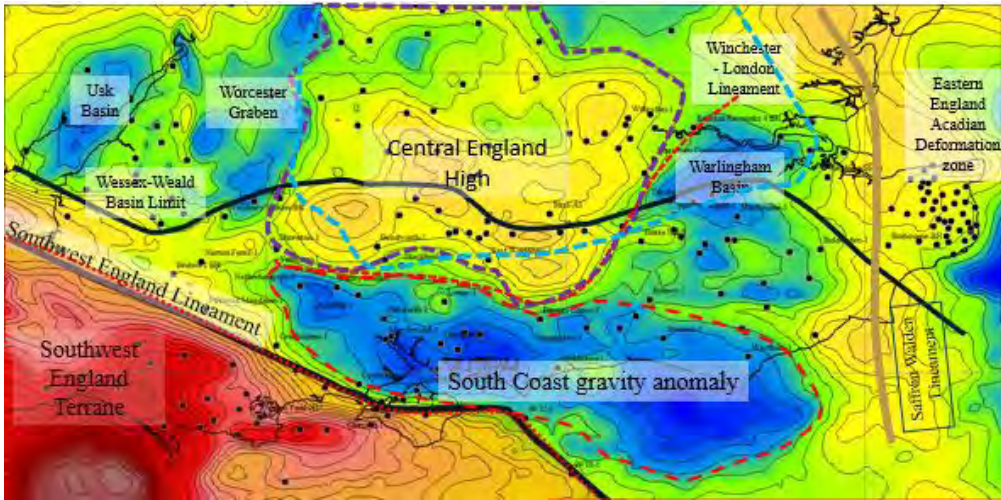
Approximate extent of South Coast Gravity anomaly

Southwest England – Namurian Event

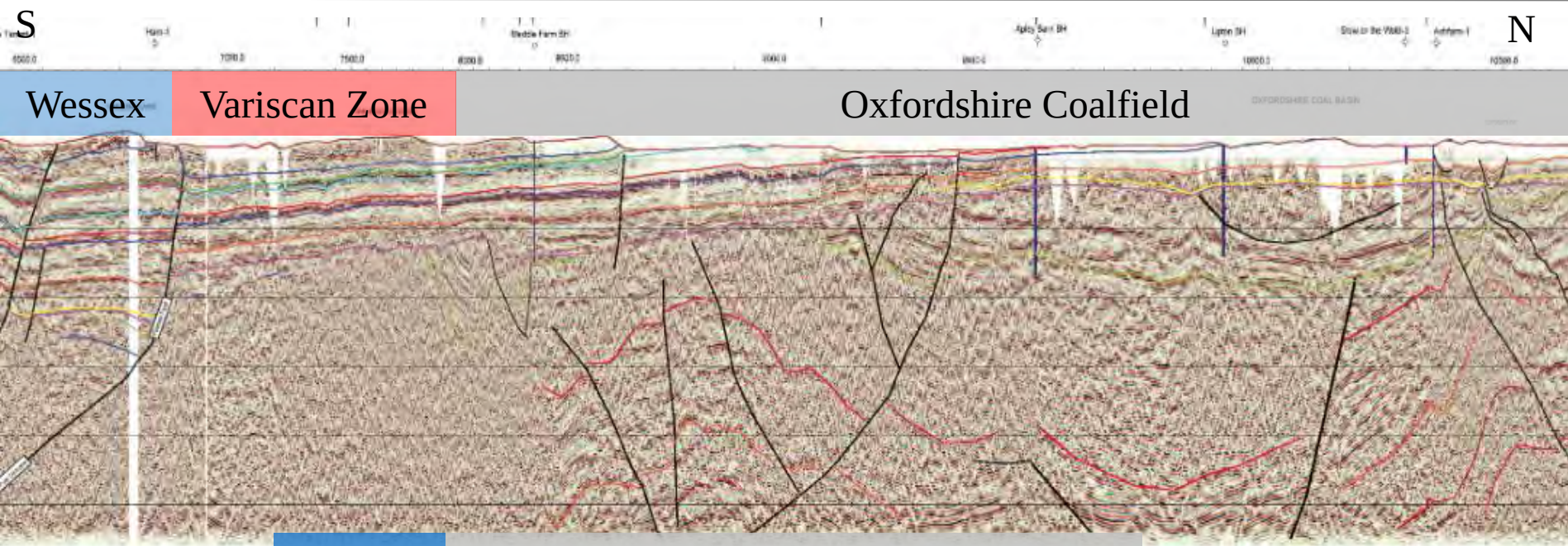
Namurian movement



Central England Anomaly



Variscan Deformation on London Platform



Mendips

Bristol Coalfield

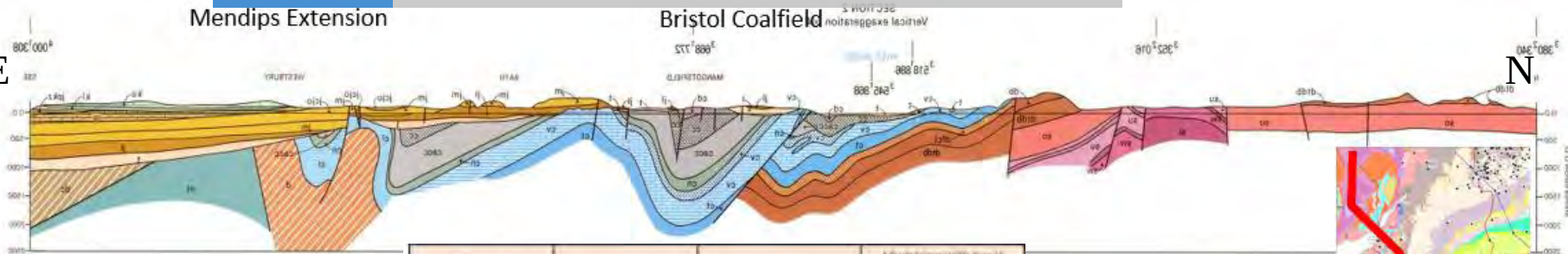
www.ukogl.org.uk

Mendips Extension

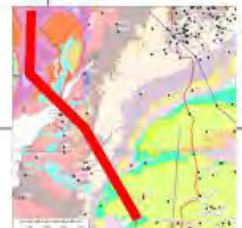
Bristol Coalfield

SE

N

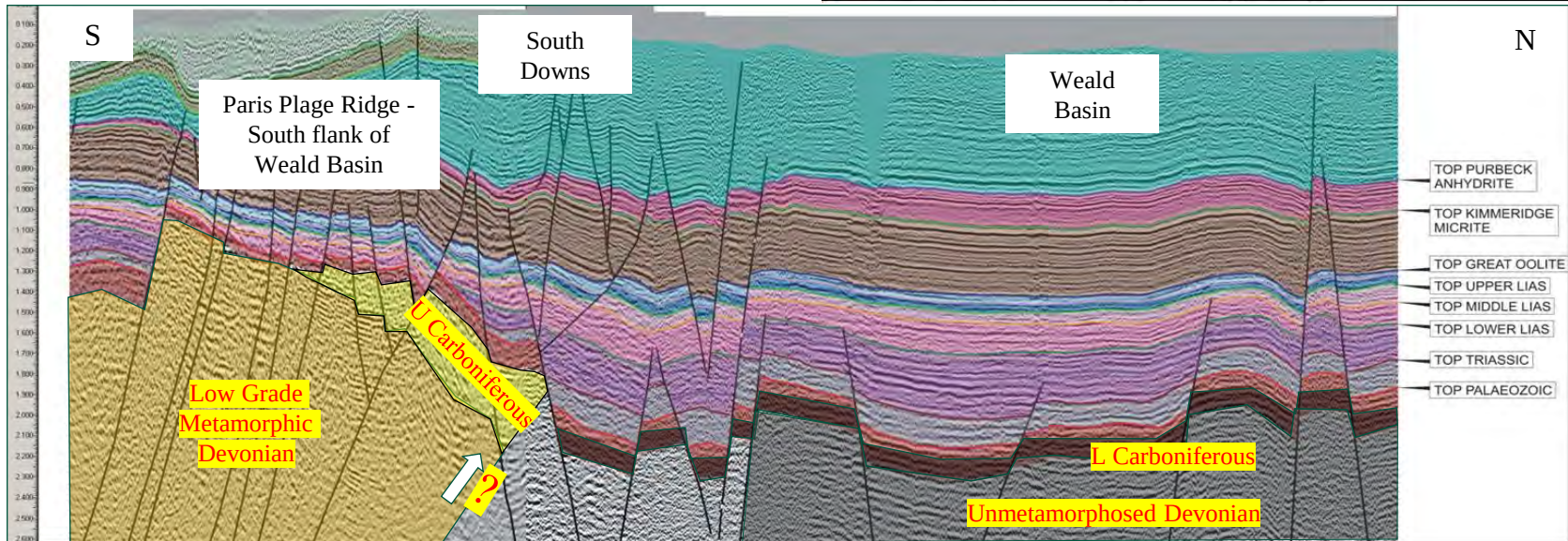
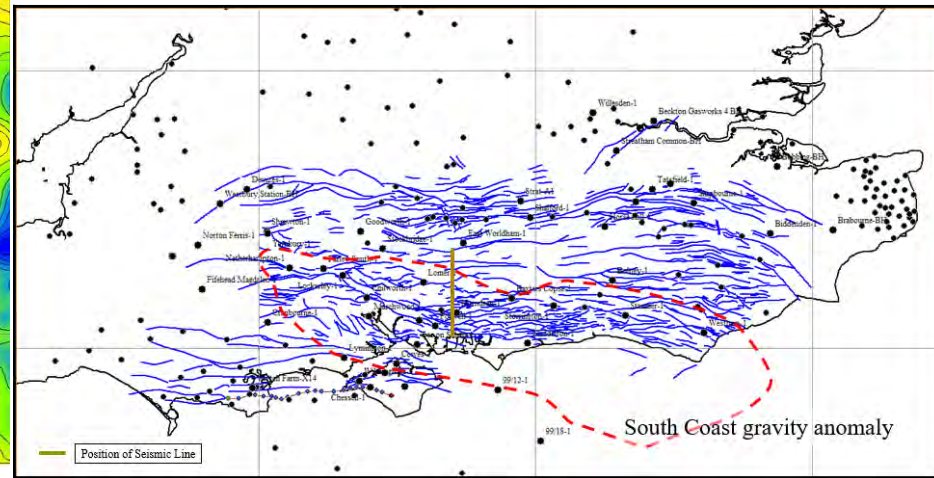
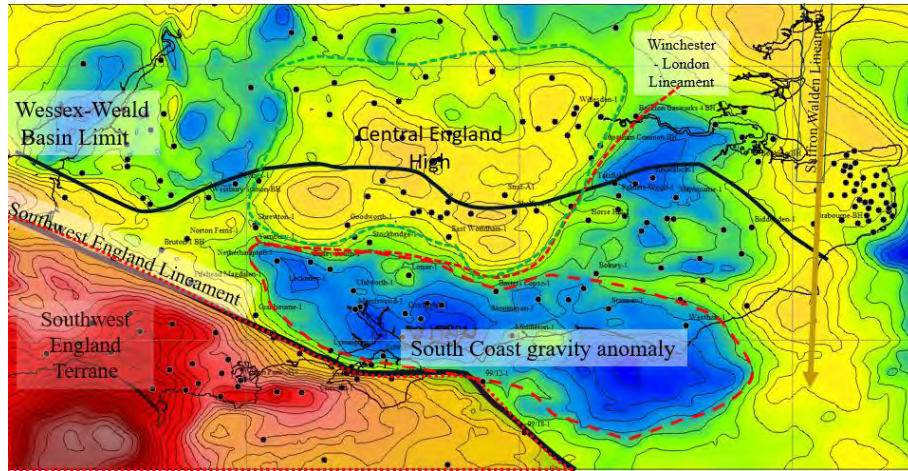


Permian			Mudstone with basal sandstone
 Variscan Unconformity 			
Carboniferous	Stephanian	Warwickshire Group	Mudstone, sandstone, siltstone
	Westphalian	 Symon Unconformity 	
		Perinine Coal Measures Group	Mudstone, sandstone, siltstone, coal
	Namurian	 Unconformity 	



Contains British Geological Survey materials © UKRI.

South Coast Anomaly



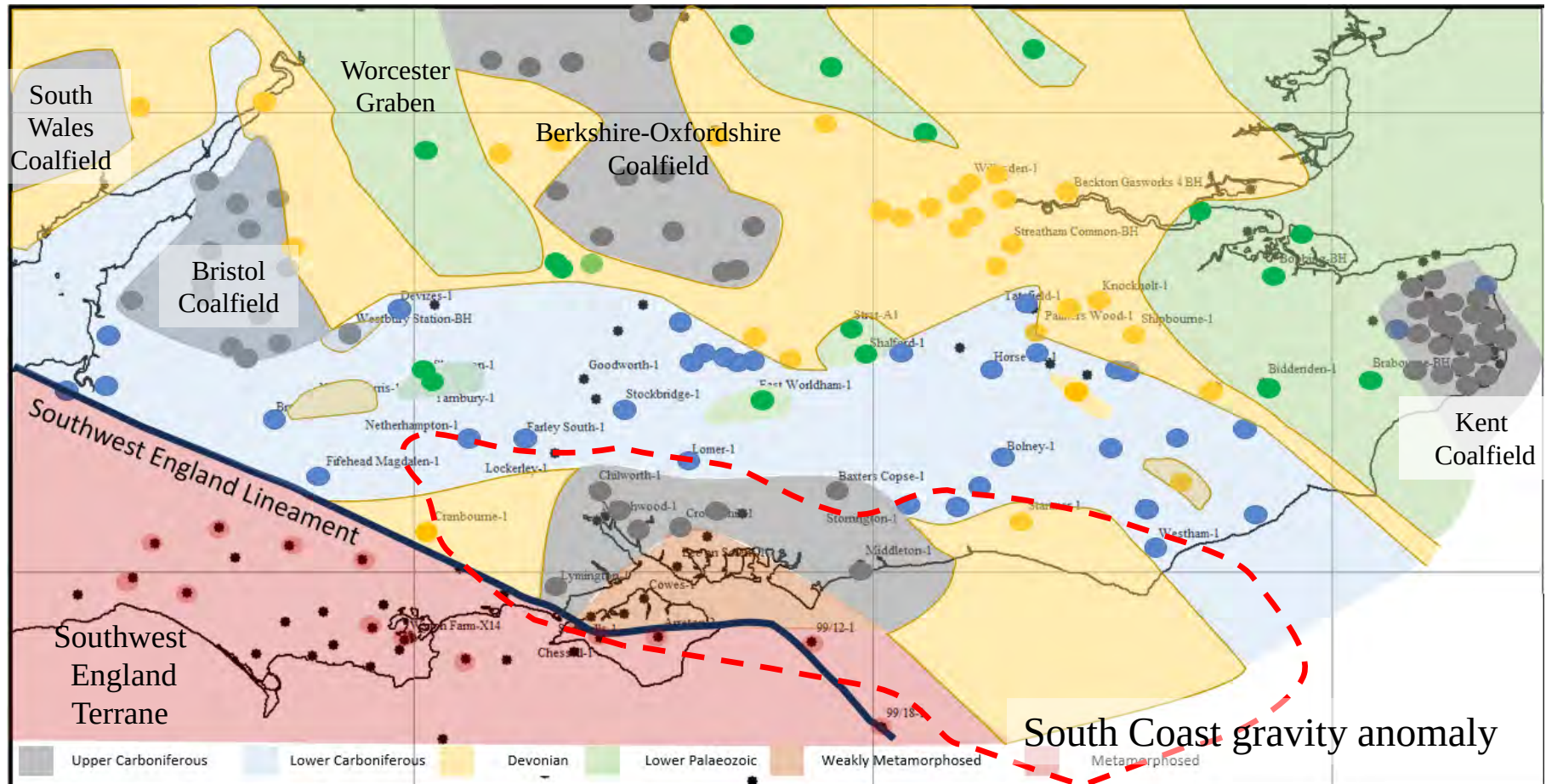
Relief on the ridge of 1.2 secs TWT equivalent to over 8000ft of Upper Palaeozoic section

The South Downs fault zone reflects the reactivated surface trace of the thrust zone. It also represents the hinge point where the floor of the Mesozoic Weald Basin rises to the Paris Palge ridge

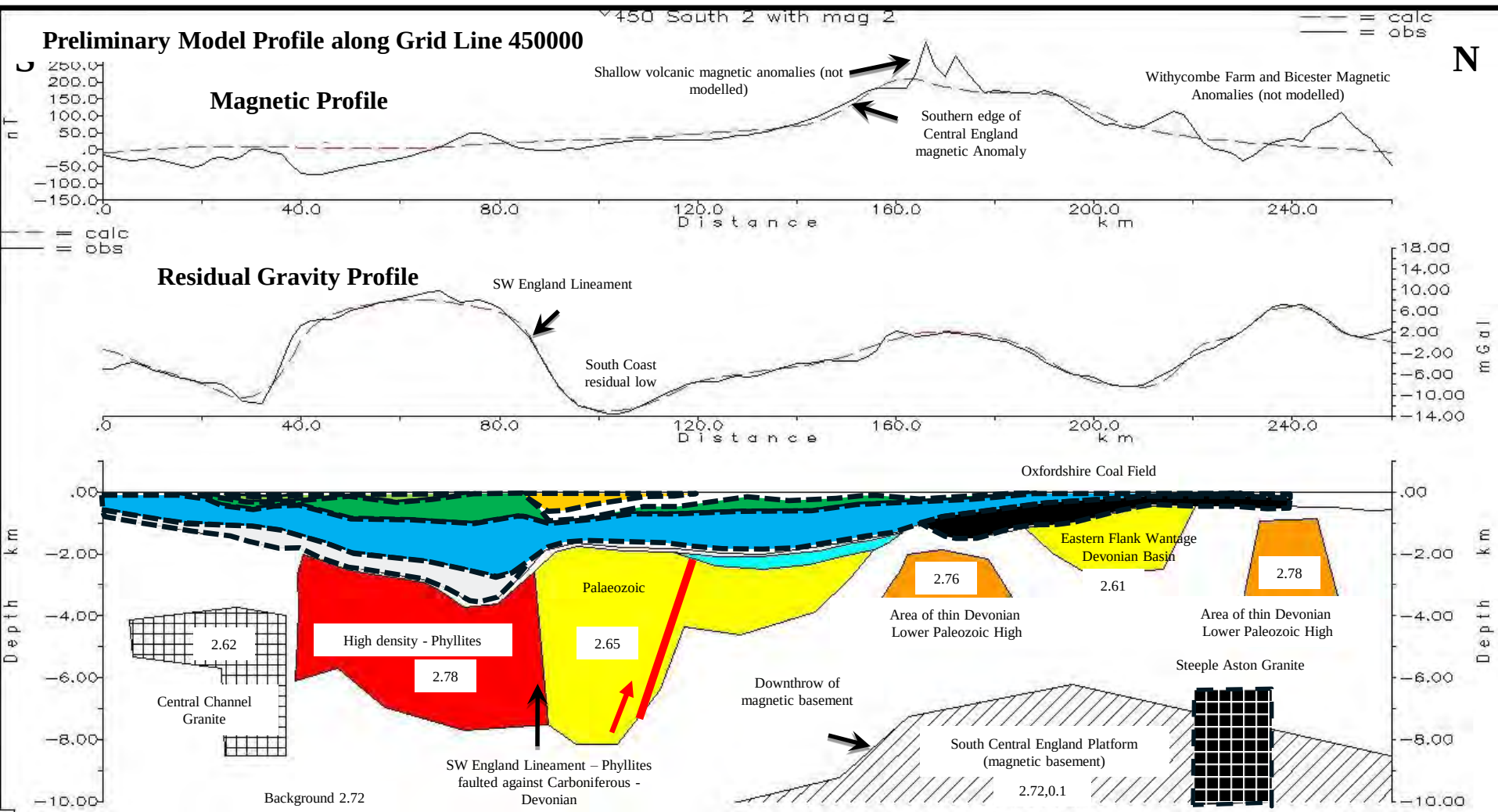
Fault intensity is greater over the Paris Plage ridge than the Weald Basin

Well data confirms Weald Basin underlain by Palaeozoic section of lower maturity. Fault and deformation styling is completely different from that on south flank.

Variscan Subcrop Map

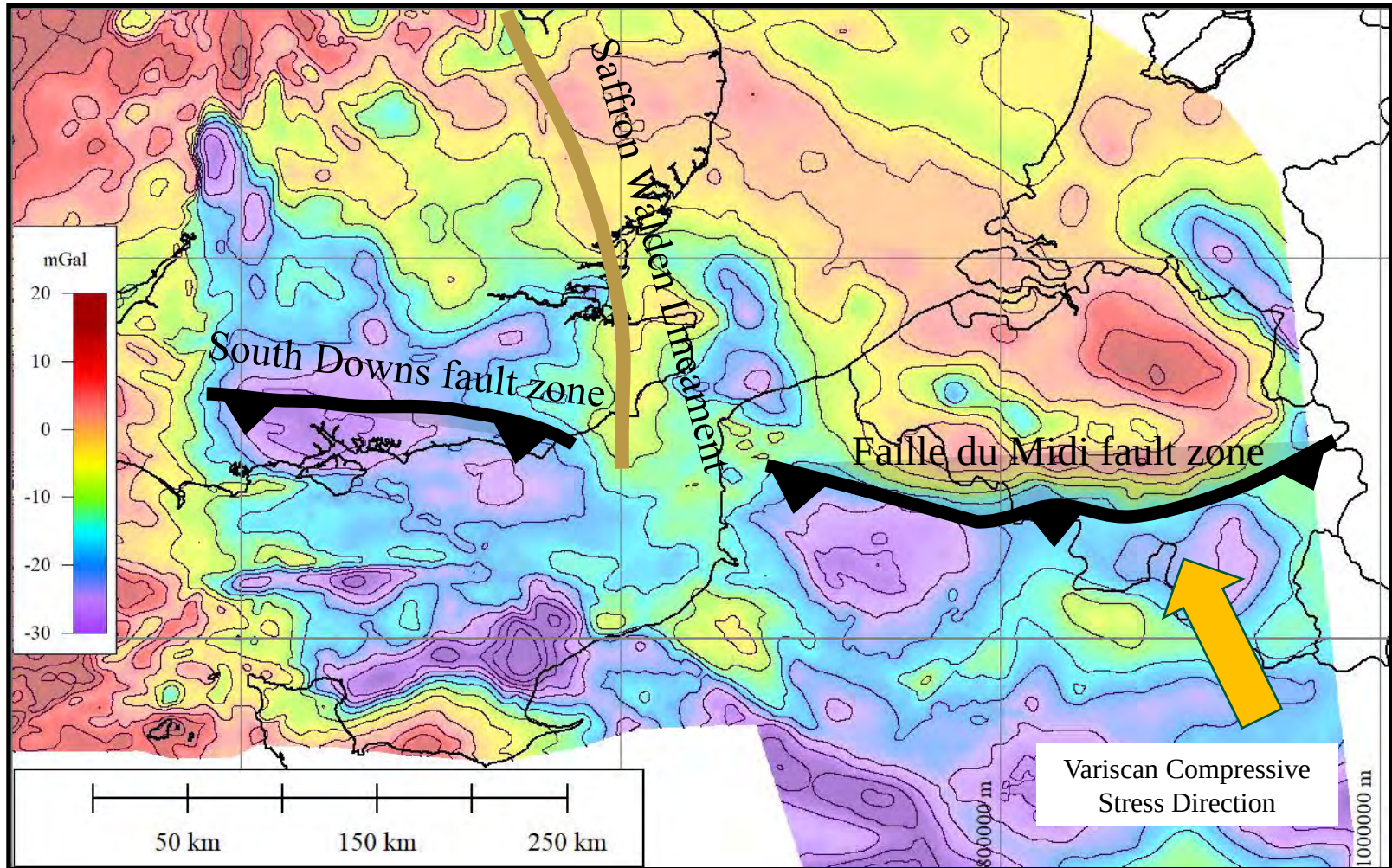


South Downs Gravity Anomaly

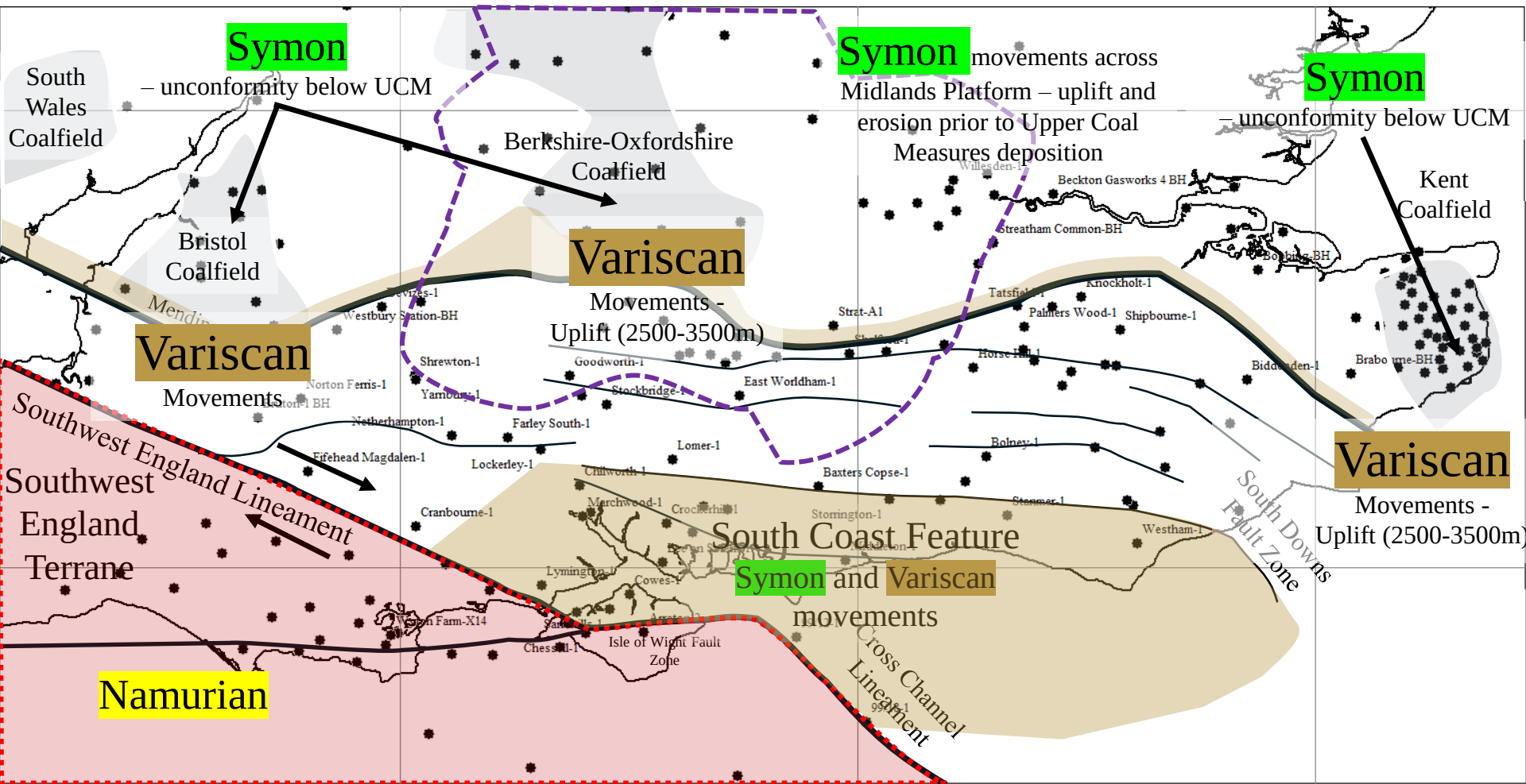


The residual profile has then been modelled using the deeper polygons outlined with the solid lines.

Southern England Gravity – Possible Connection to Faille du Midi



Southern England – Variscan Structural Elements



Approximate extent of Central England Gravity anomaly



Extent of South West England Terrane



Approximate extent of South Coast Gravity anomaly

Thanks

Contact Details

Wiltshire Office : Butts Farm Barn
The Butts
Potterne
Devizes
Wiltshire
SN10 5LR

E Mail : chris.pullan2018@gmail.com

Disclaimer: The information in this presentation is for guidance only. Neither CP Exploration nor any director, or officer or employee of CP Exploration accepts responsibility for or makes any representation or warranty, express or implied, with respect to the accuracy or completeness of the information, estimates and opinions contained in this document.