British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

DEPARTMENT OF ENERGY & CLIMATE CHANGE

Bowland Shale Mapping and Resource Estimation (sorry not yet)

PROSPEX conference – London – 13 Dec 2012

toni.harvey@decc.gsi.gov.uk
BGS: Sue Stoker, Ian Andrews

The Telegraph

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Fracking: Whitehall cautious on shale gas revolution

Britain is sitting on an estimated £1.5 trillion of shale gas reserves, a Governm
commissioned report is expected to say.

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Shale gas could redraw the economic map of Britain - but price of houses near wells could fall b 24%

By TOM MCGHIE
PUBLISHE

DATED: 09:41, 4 November 2012

0 Tweet 0 Like 11

eam about. Out of the blue comes a source of energy worth hundreds
Britain.

on foreign imports. No longer will the Russians be able to influence
rely on gas supplies from the war zones of the Middle East or

ld become a curse of the past as plentiful locally produced
e, allowing industry – especially those that are energy
dence.

BER 4 • 2012 The Mail on Sunday

m McGhie
Nick Craven

North Sea Mk II: Britain is sitting on gas goldmine

TAIN is sitting on a £1.5trillion
ale gas bonanza that could be
orth more than the remaining
orth Sea gas.
The amount is bigger than previ-
usly thought and would potentially
bring energy price stability and inde-
pendence from imports for decades.
Although only about ten per cent
of the gas is in unpopulated areas
suitable for extraction, it would still
be worth £150billion.
The level of untapped shale gas will
be confirmed next month in a study
by the British Geological Survey,
commissioned by the Department
of Energy and Climate Change,
according to industry sources.
Ministers are then likely to give
the go-ahead for drilling, hoping the
enormous economic benefits can
win over environmental concerns.
But critics say the environmental
cost is too high for 'fracking' – or
hydraulic fracturing, the controver-
sial method of extracting gas by
forcing water, sand and chemicals at
high pressure 6,000ft underground.
Pilot wells caused two earthquakes
in Lancashire last year and green
campaigners warn the method could
contaminate the water supply.
US research also says that home-
owners within two miles of a frack-
ing site can expect property prices
to plummet by almost a quarter.
Sources close to Energy Secretary
Ed Davey said he was 'quite excited
about the prospect of a new domes-
tic resource and probably wants to
be able to exploit it, but it is quite a

Huge shale reserves may be worth over £1.5trillion... but is it safe?

for drilling companies. Energy

FRACKING AND HOW IT WORKS

Storage tanks

4 Gas is piped to market

3 Natural gas flows out of the well

The Telegraph

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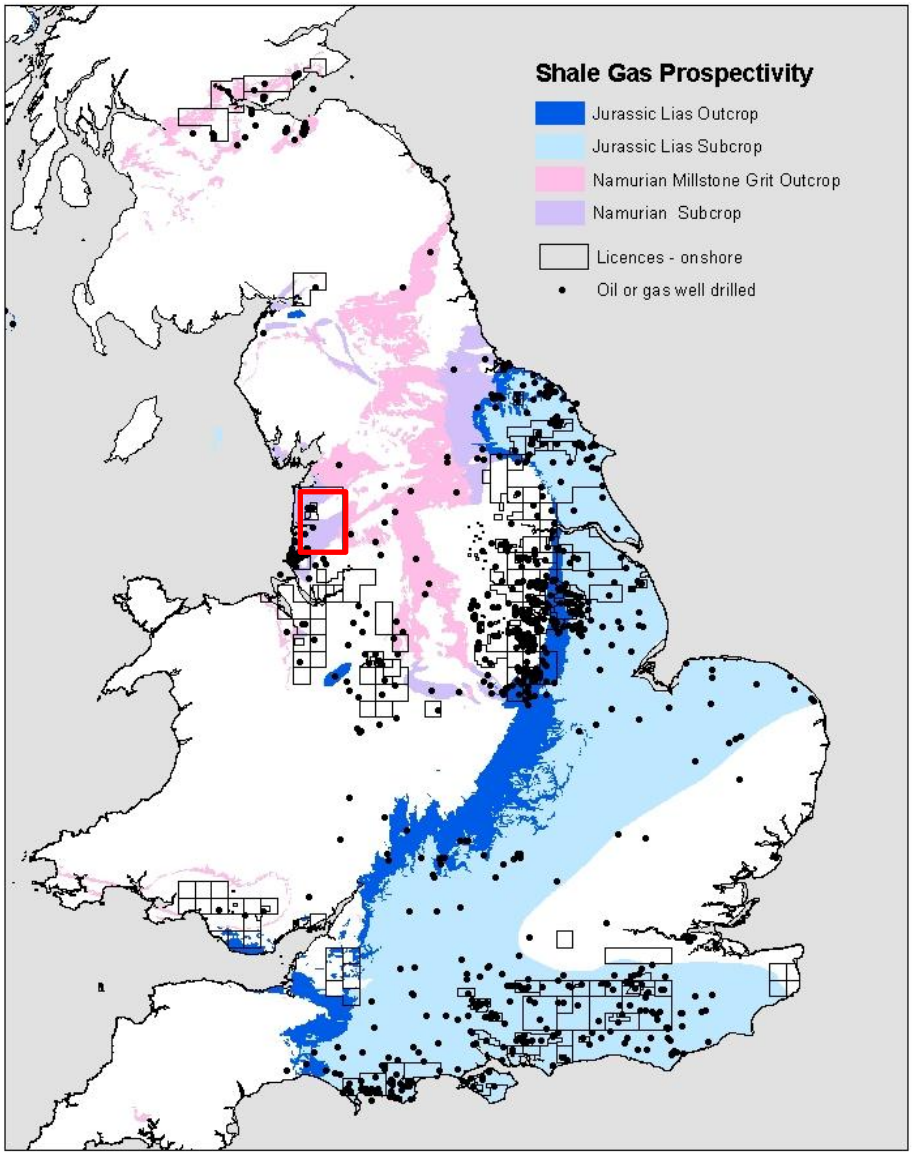
Blackpool shale gas deposit '50pc larger than first thought'

The huge shale gas deposit around Blackpool is 50pc larger than previously thought, according to reports.

Resource Estimates

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

DEPARTMENT OF ENERGY & CLIMATE CHANGE



•2010 DECC estimated potential production-

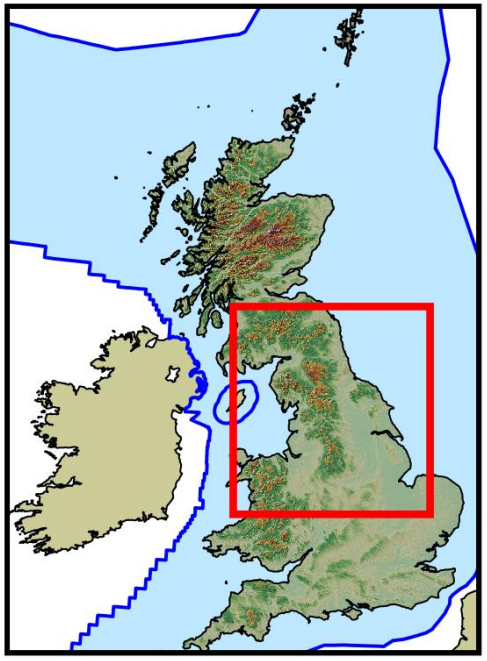
> •*The UK Carboniferous (Upper Bowland Shale) shale gas play, if equivalent to the Barnett Shale of Texas, could potentially yield up to 4.7 tcf shale gas."*

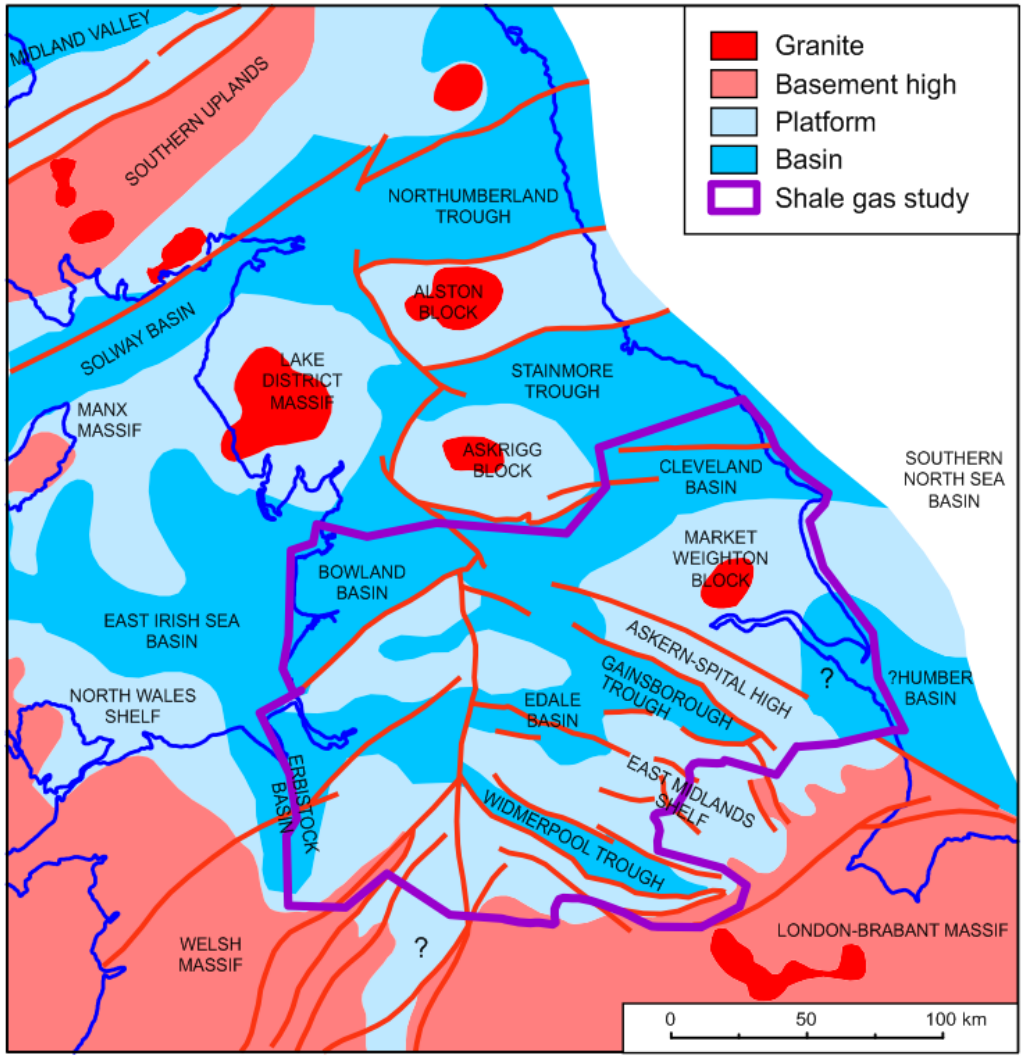
•2011 **Cuadrilla** 200 tcf (5,664 BCM) estimate for Gas in Place

So Cuadrilla claim 200 tcf **gas in place** on their licence where DECC estimate 4.7 tcf could **potentially be produced.**

Both may be right.

Area of 2012 Study





British Geological Survey
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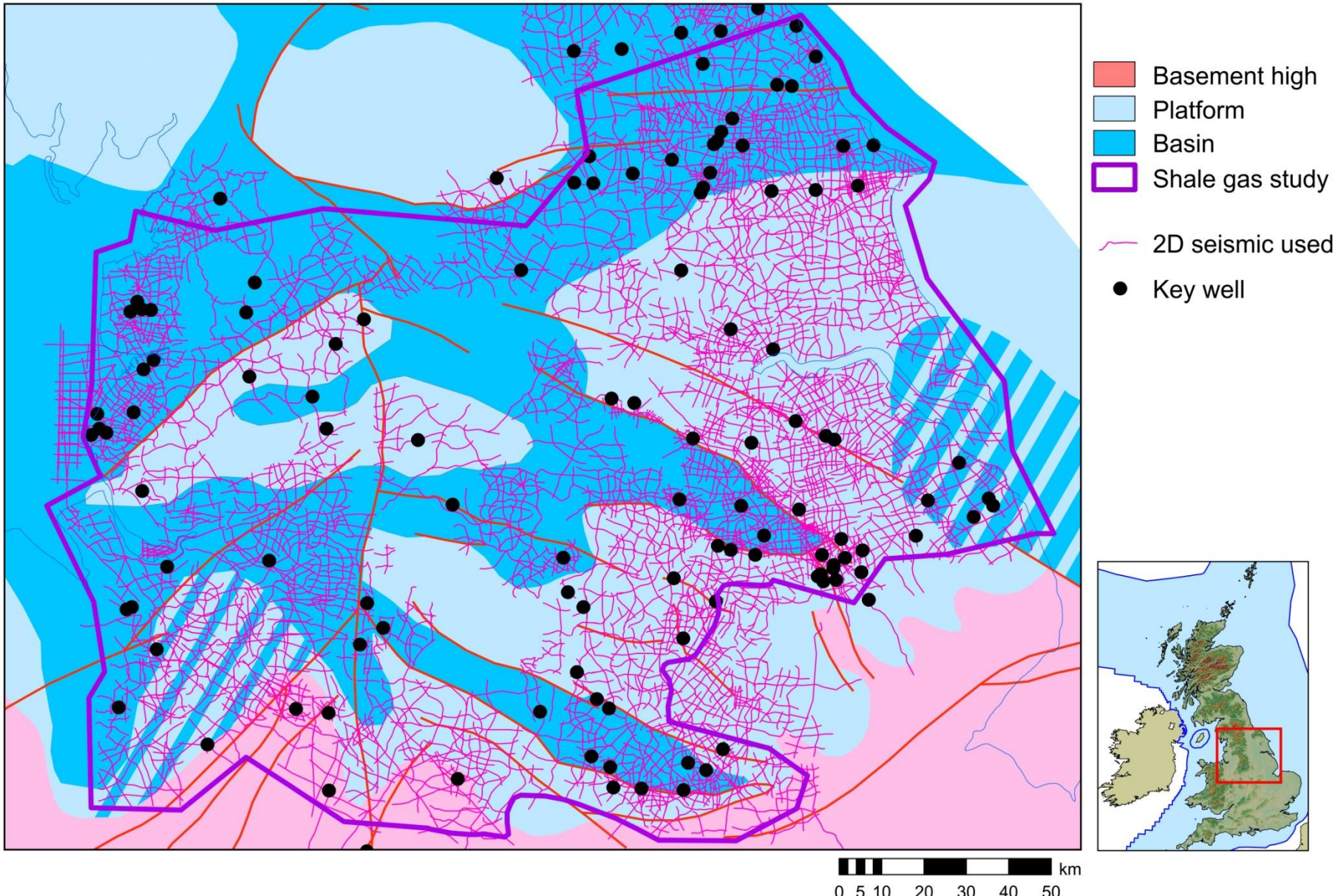
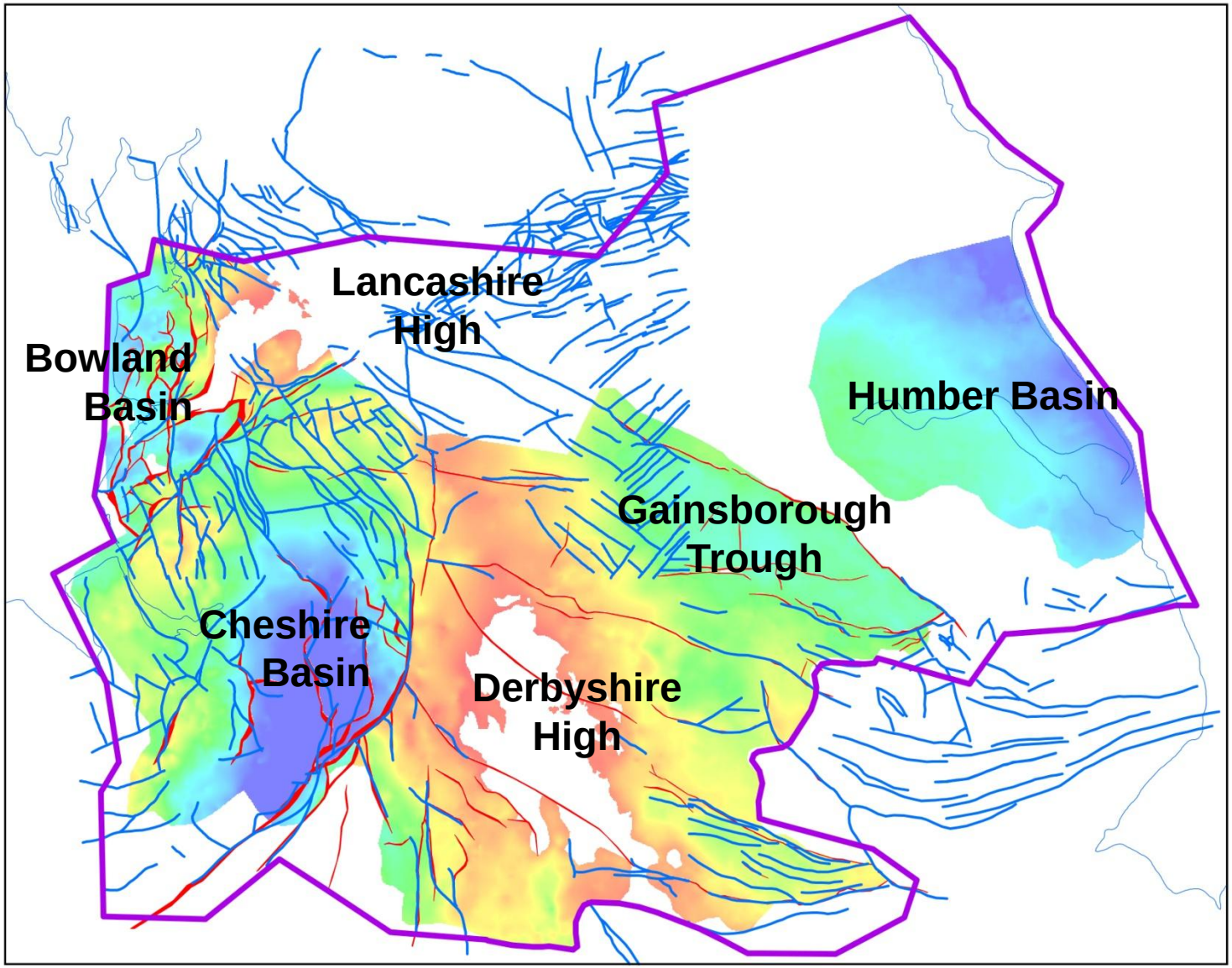
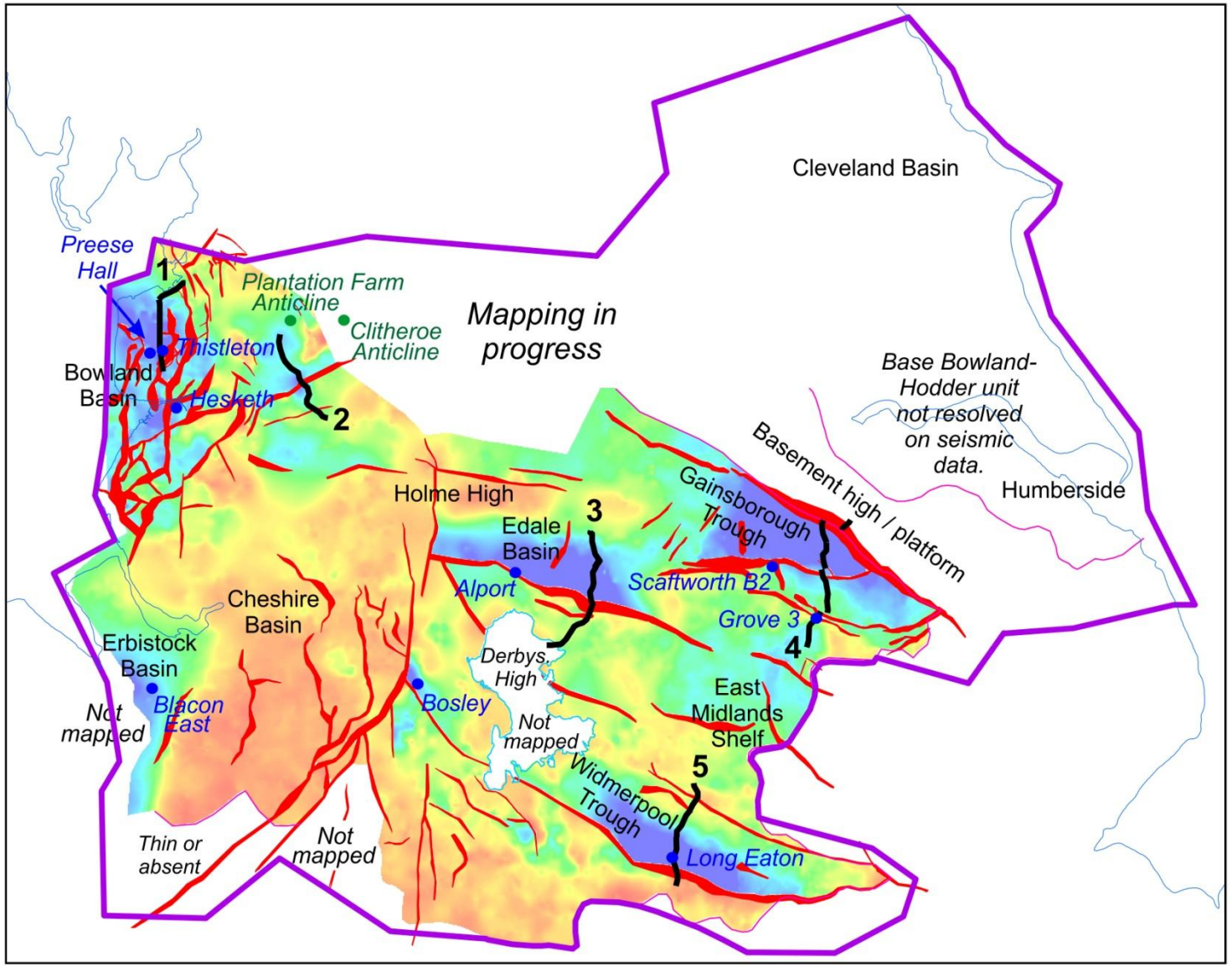
UKOGL seismic and Bowland shale in wells



Depth to Top Bowland



Thickness of Bowland-Hodder Unit

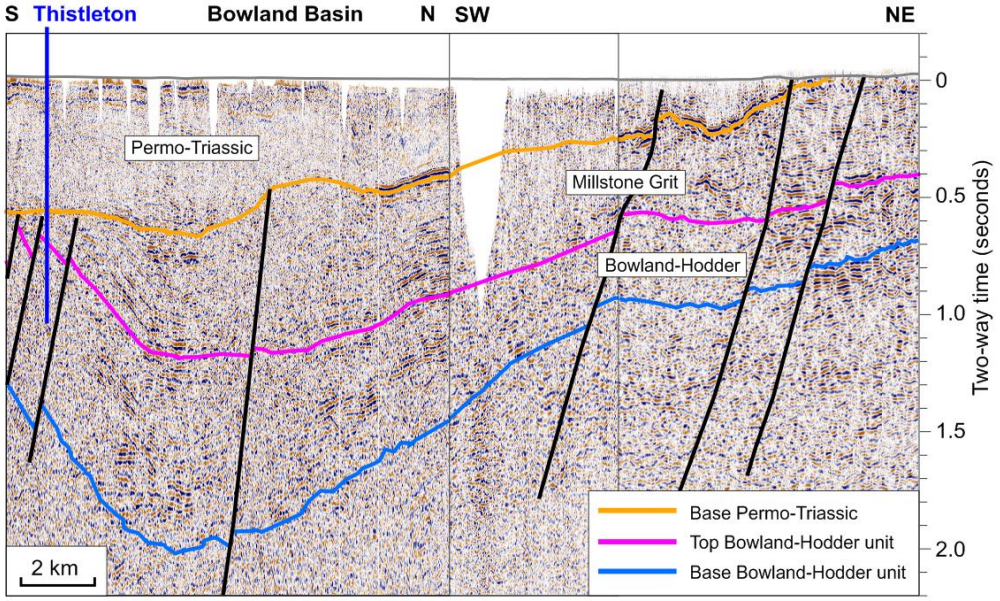


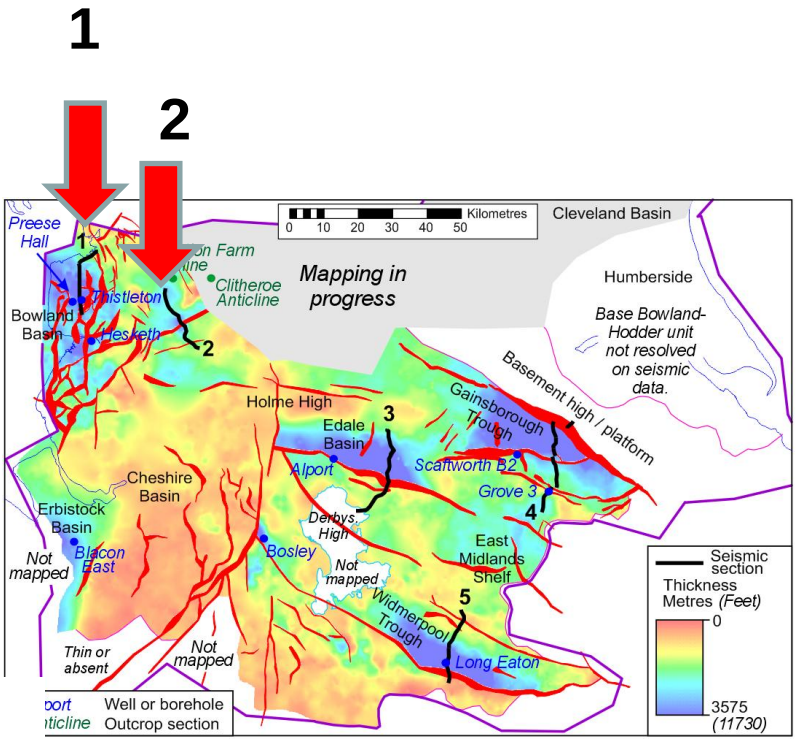
North American Shale Gas Analogies

Shale Gas	Barnett - Fort Worth Basin	Eagle Ford – South Texas	Haynesville - Texas/Louisiana	Horn River – NE British Colombia	Marcellus - Appalachia	Bakken – Williston Basin
Age	Mississipian 340 MYA	Cretaceous 100 MYA	U Jurassic 170 MYA	U. Devonian 370 MYA	M Devonian 385 MYA	U Dev/L Mississ. 360 MYA
Lithology	Siliceous mudst	Bituminous shales	Argill/ Calcareous	Brittle Shale	Argill mudst	Sst/Siltst/ Carbonate
Depth (ft)	7,500	11,500	12,000	8,800	7,000	10,000
Thickness (ft)	**300**	**250**	**225**	**450**	**350**	**150**

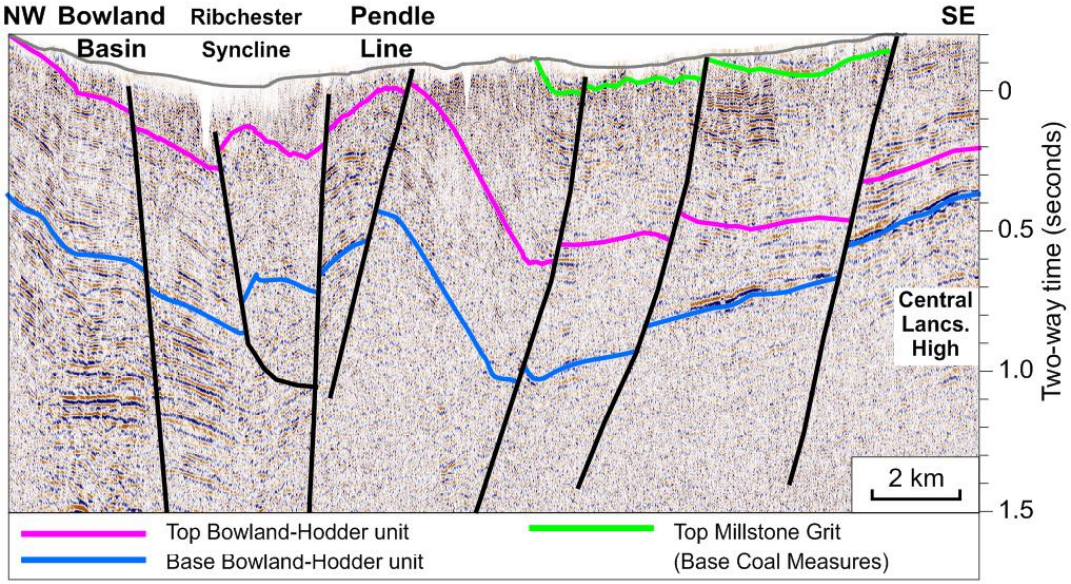
source: www.transformsw.com/papers-and-presentations/studies.html

1 Northern Bowland Basin

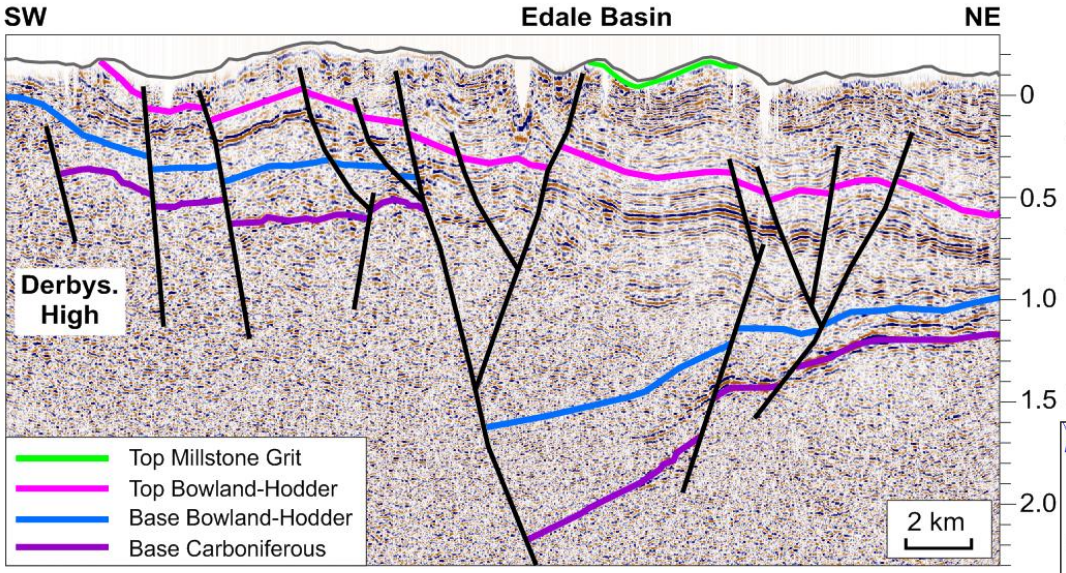




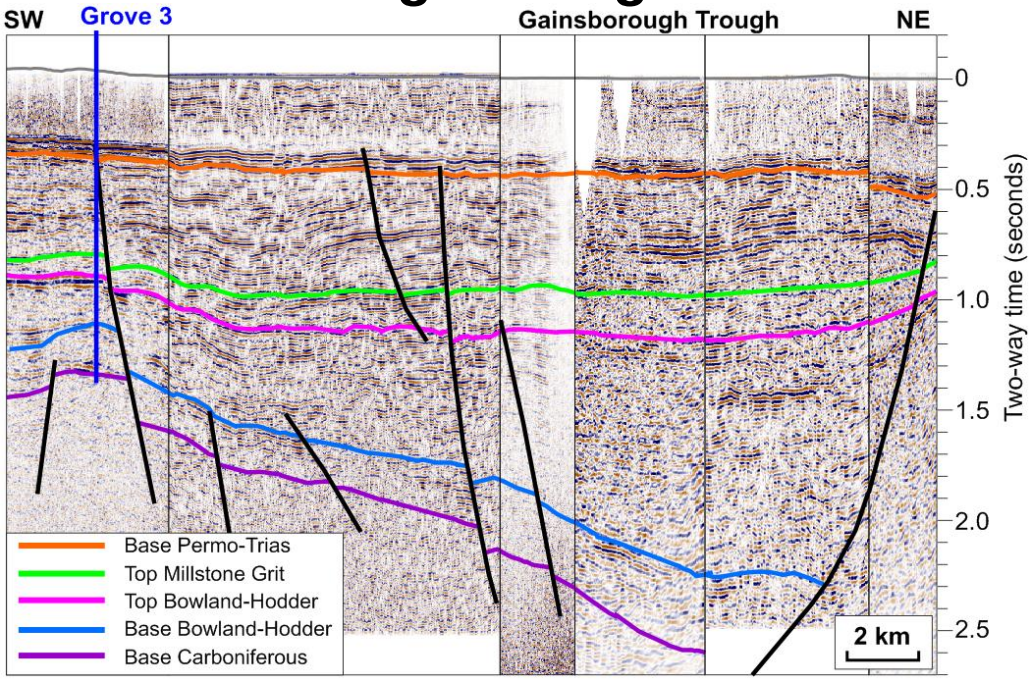
2 Eastern Bowland Basin

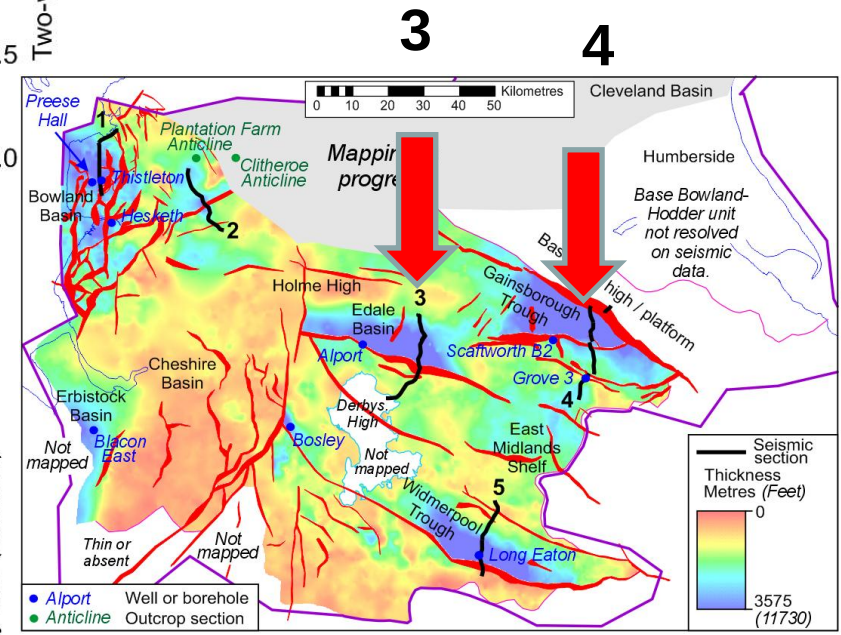


3 Edale Basin

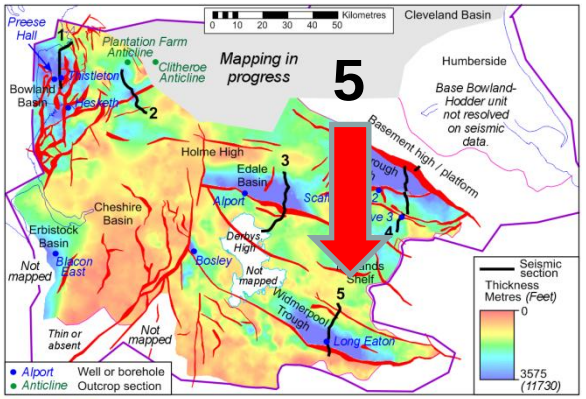


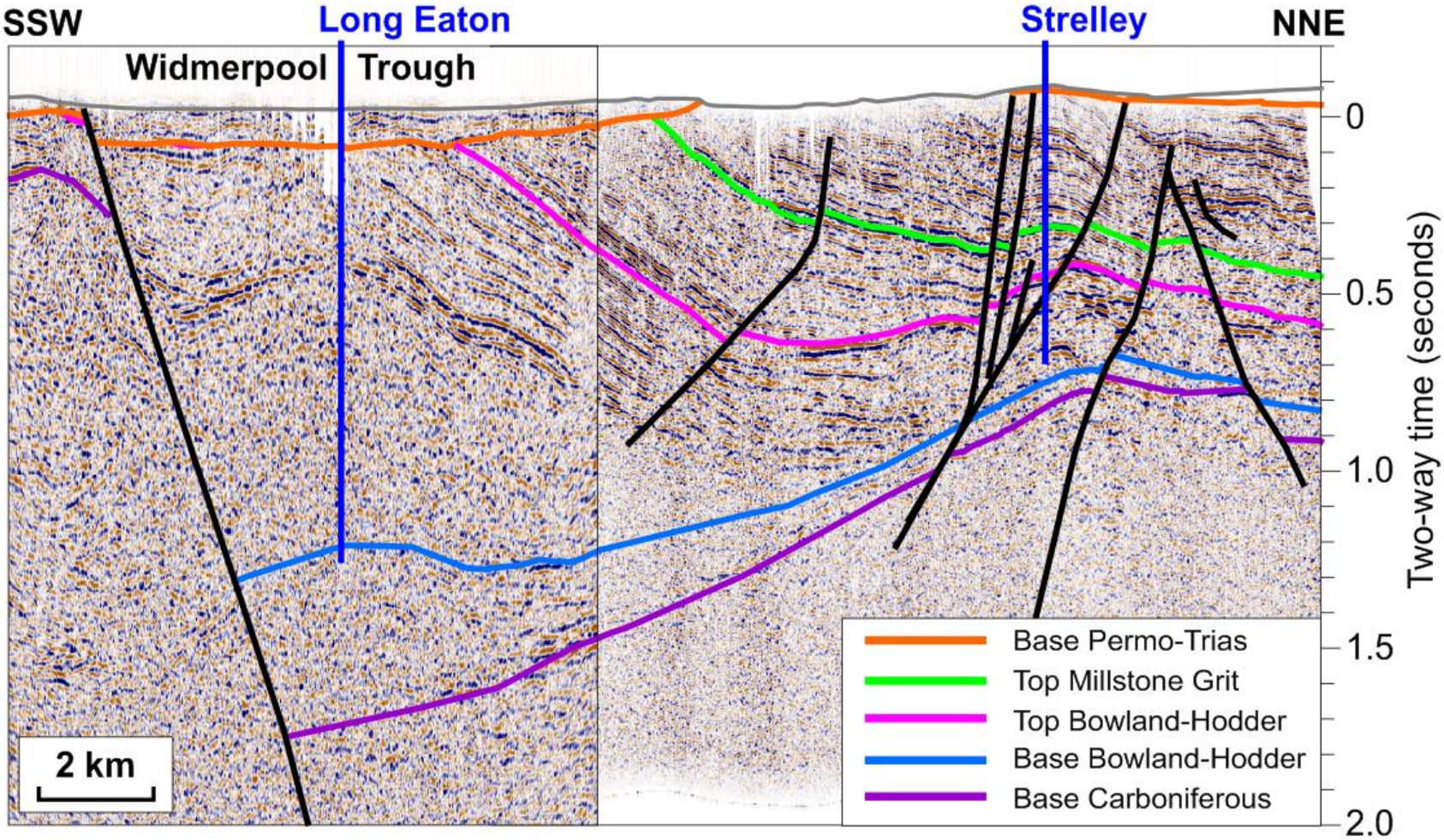
4 Gainsborough Trough



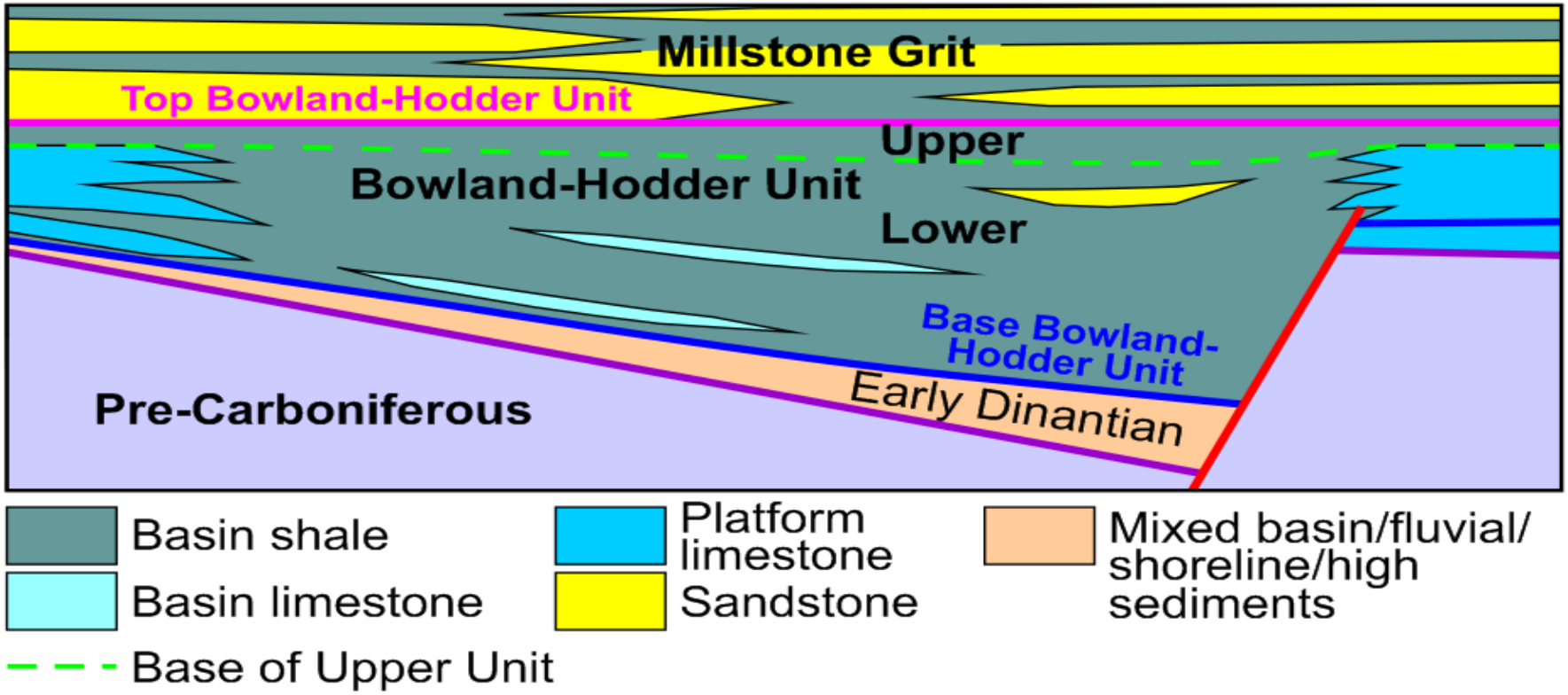


5 Widmerpool Trough





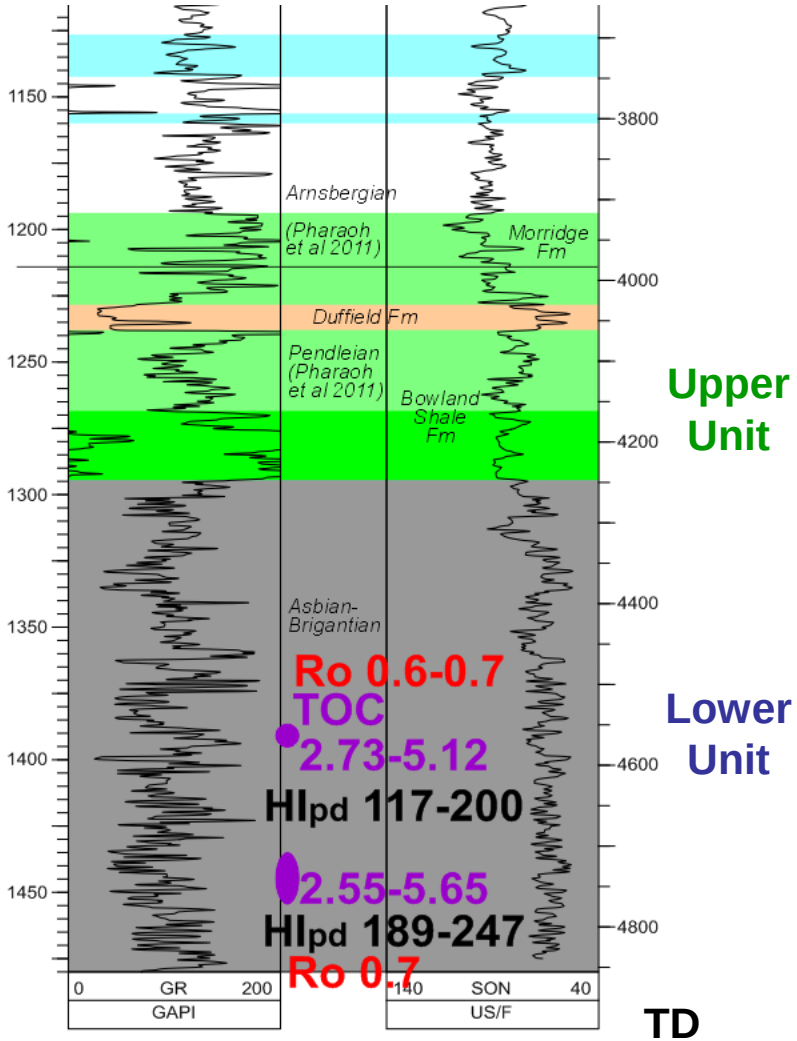
The Bowland Shale does not look like North American producing plays



- Upper part is thin but widespread marine shale unit drowning most platform highs
- Lower part is very thick rift-basin fill shales with mass-flow carbonates and rare mass-flow sandstones, passing laterally to platform carbonates on highs

Bowland-Hodder Unit: (Widmerpool Trough)

Old Dalby Widmerpool Trough

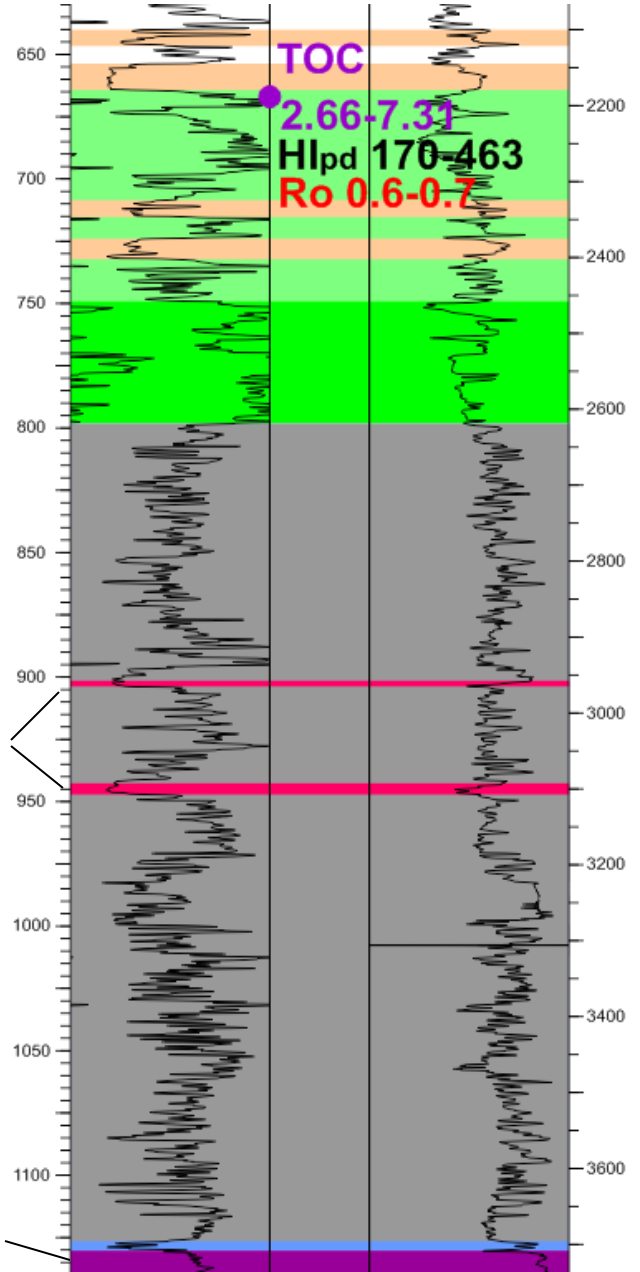


Upper Unit

Lower Unit

TD

Rempstone Widmerpool Trough



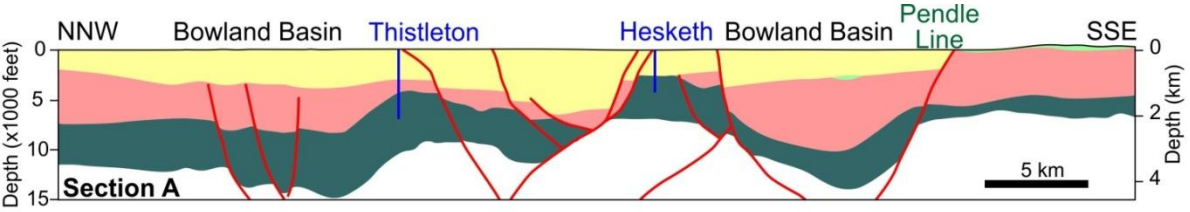
Upper Unit

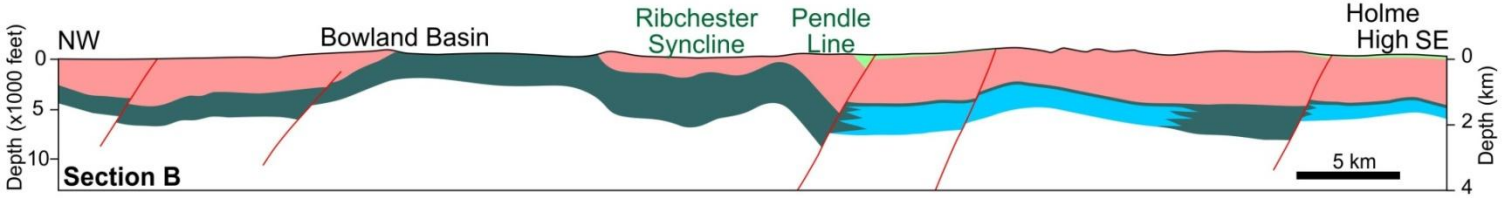
Lower Unit

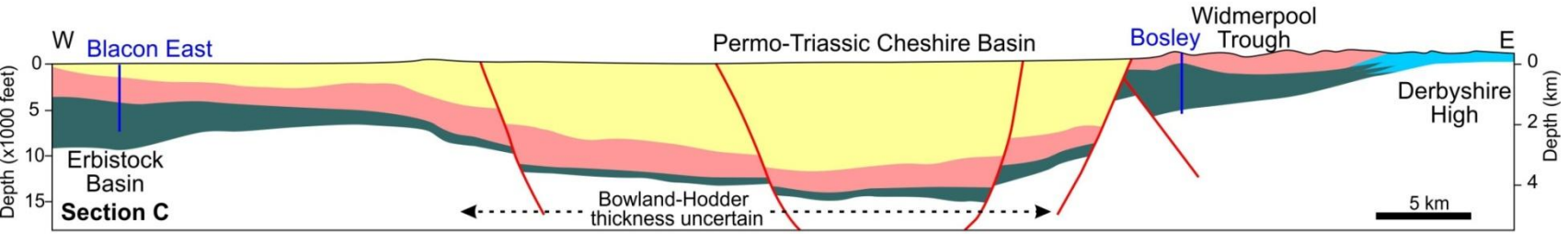
Intrusions

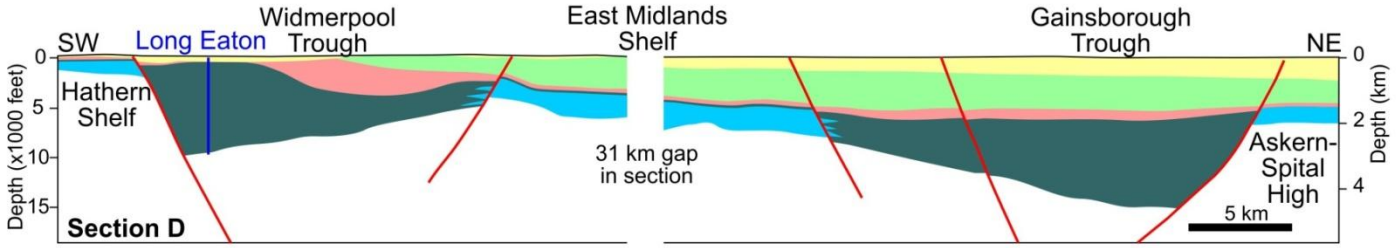
Basement

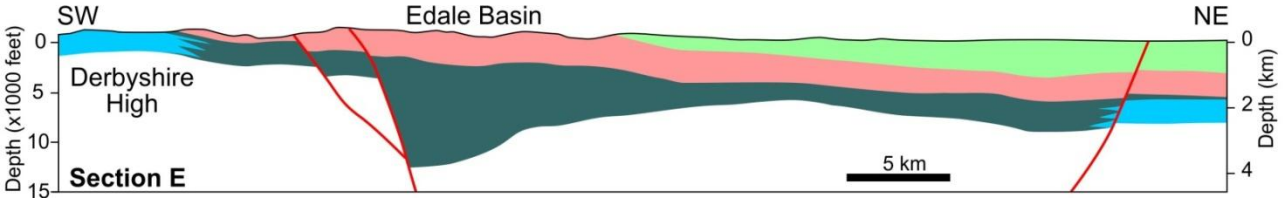
Depth cross-sections

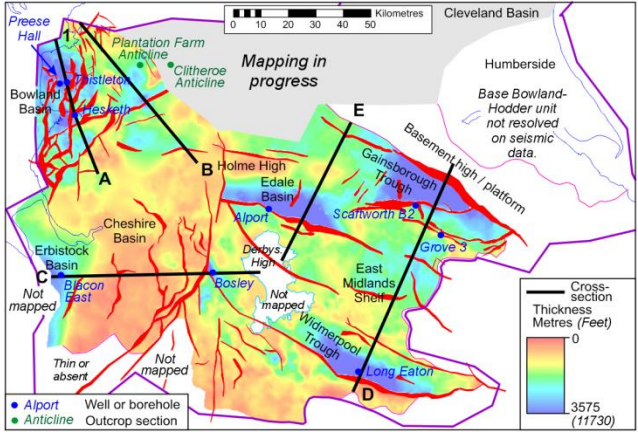












Permo-Triassic

CARBONIFEROUS

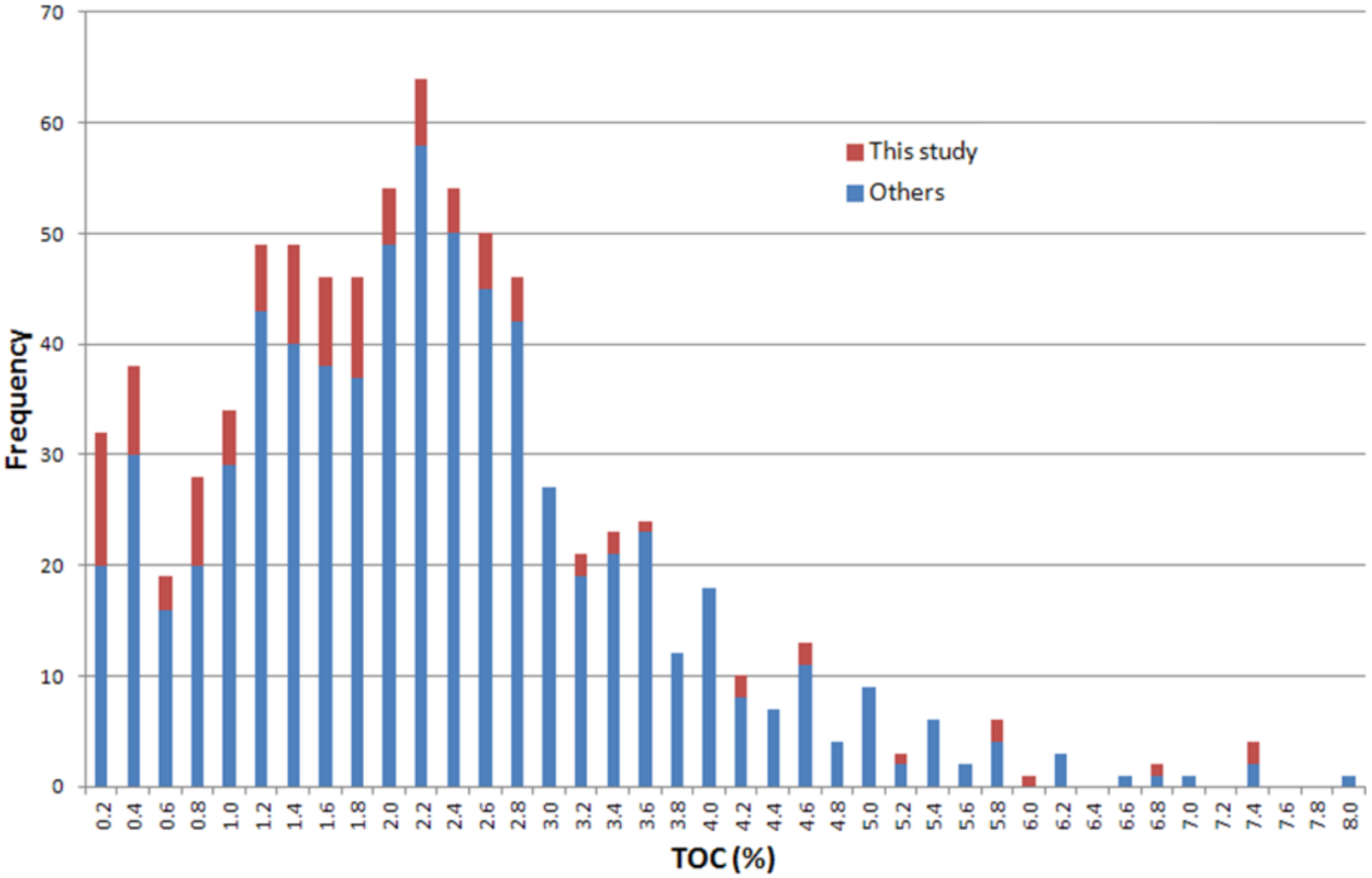
Coal Measures

Millstone Grit

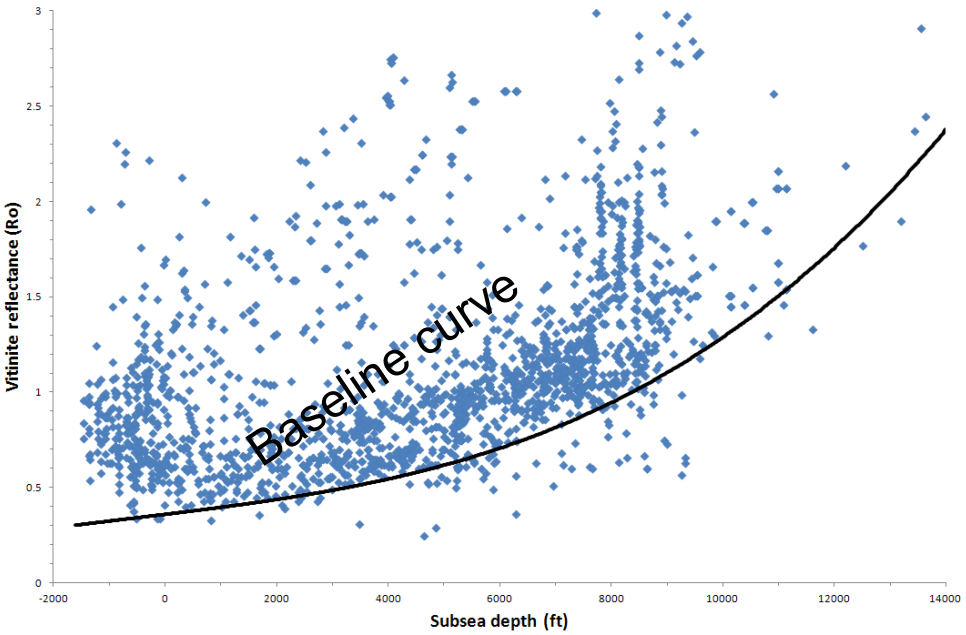
Bowland-Hodder unit basin shales

Bowland-Hodder unit platform limestones

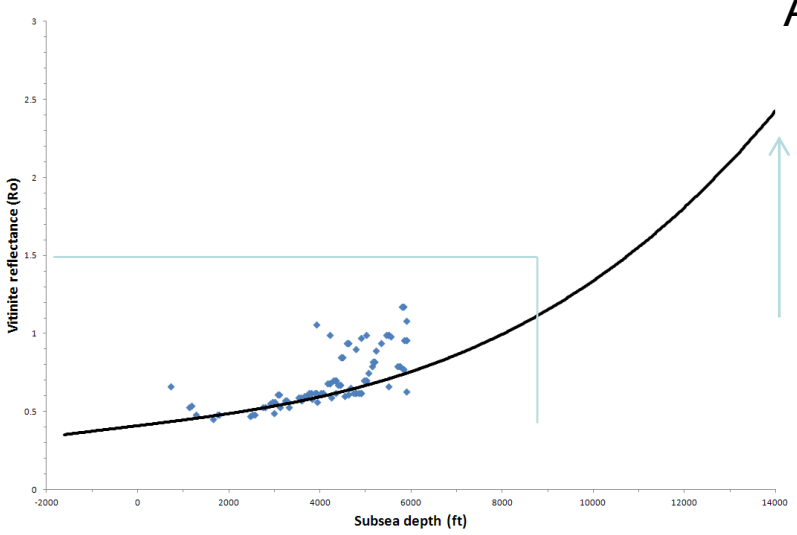
TOC in Bowland/Hodder

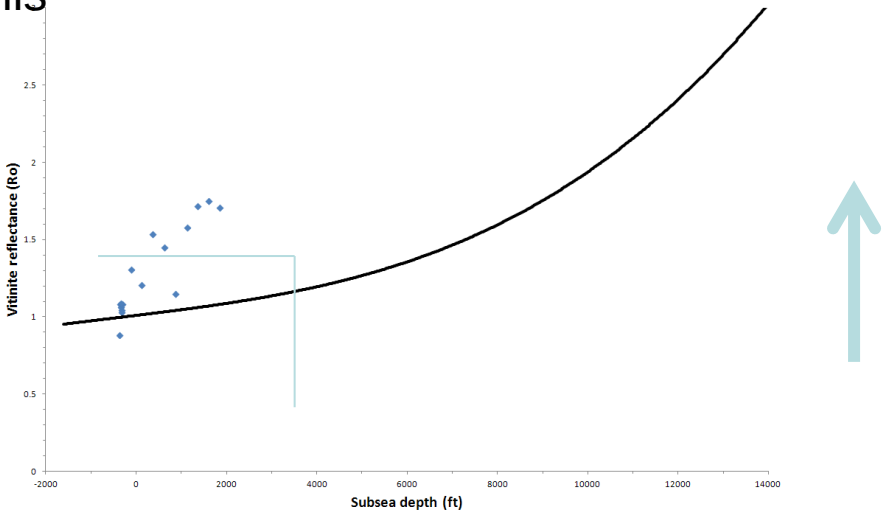


Vitrinite Reflectance vs. Depth



All wells

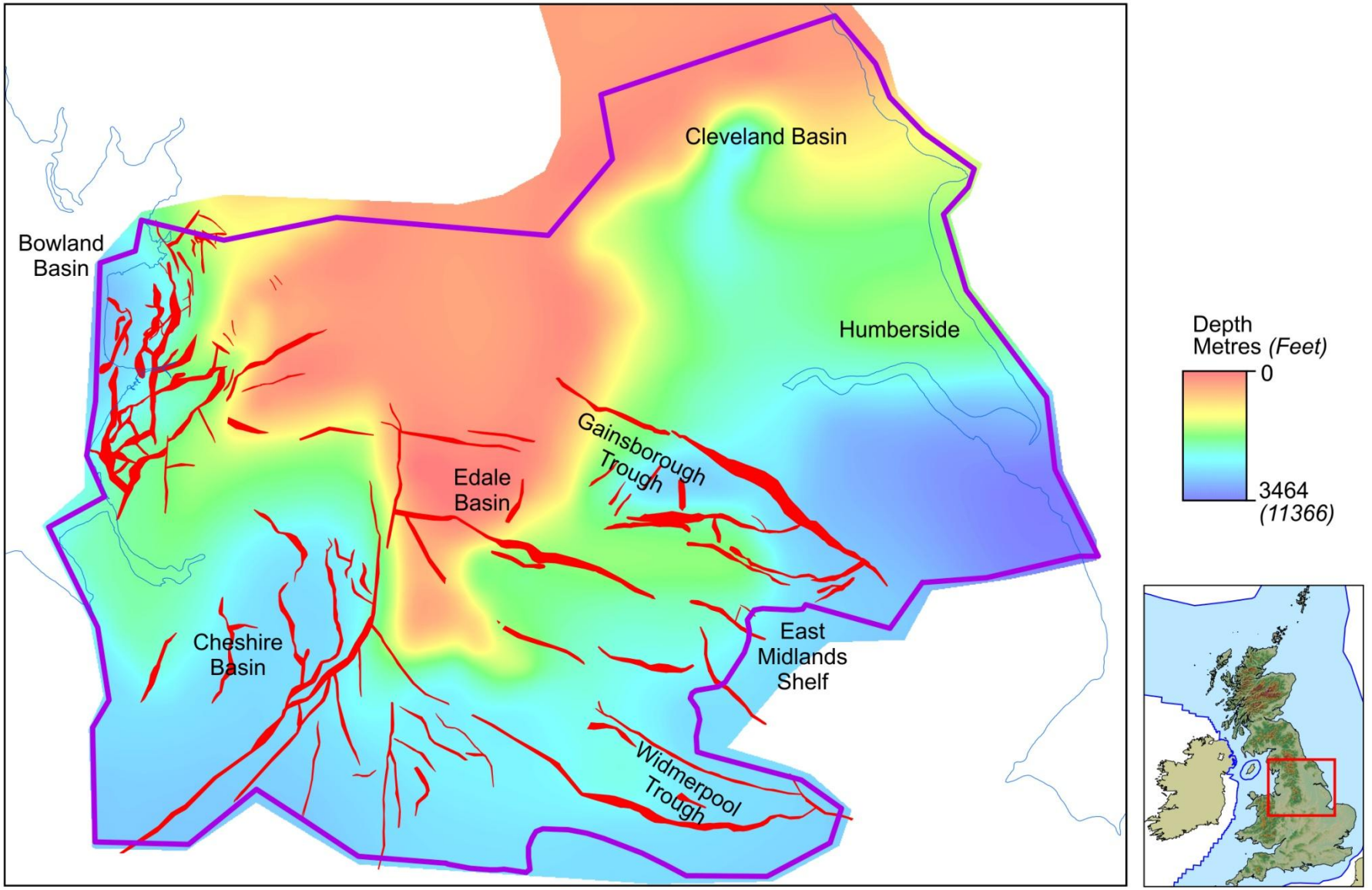




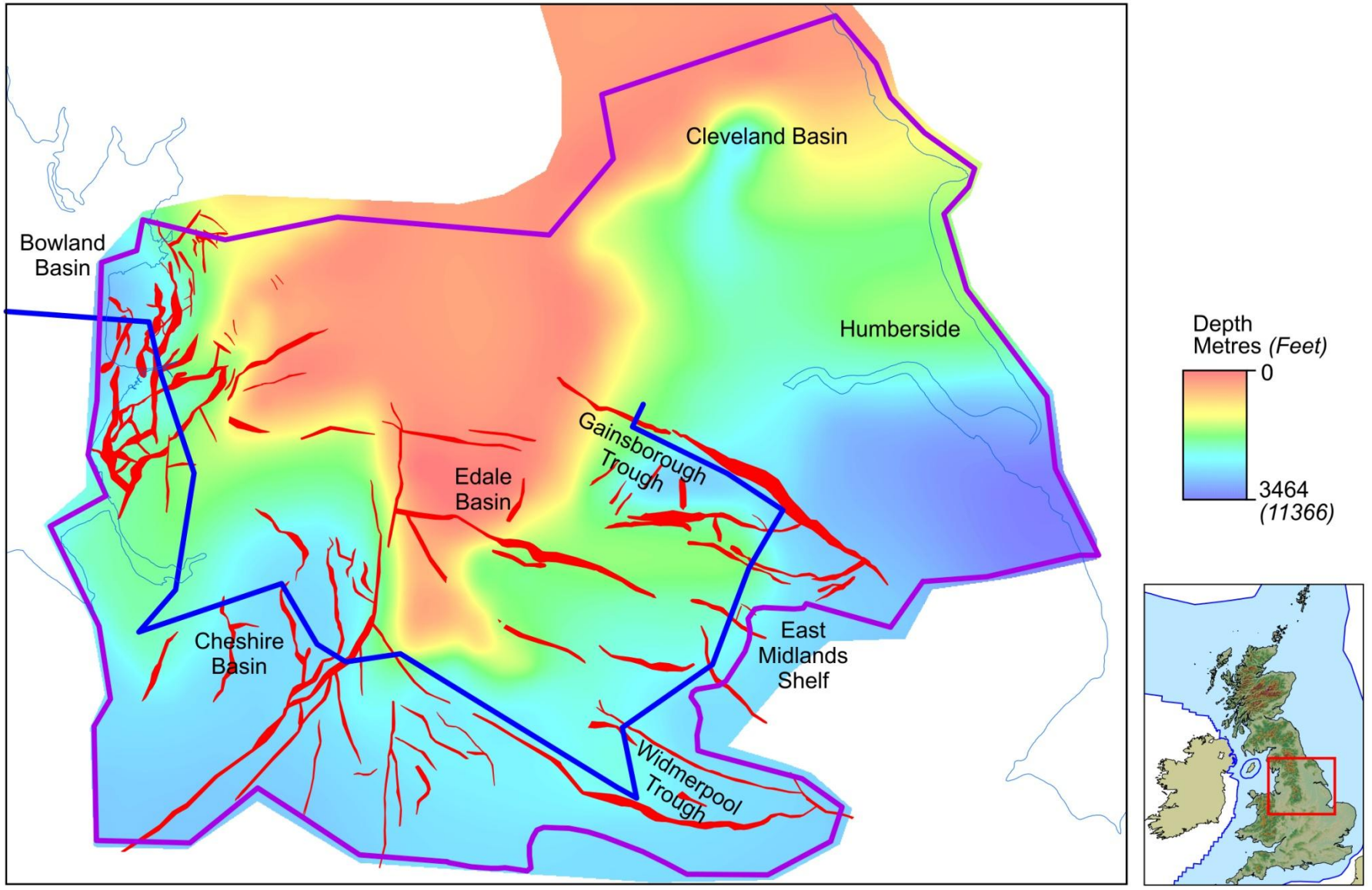
Widmerpool 1 – minor uplift

Swinden 1 – major uplift

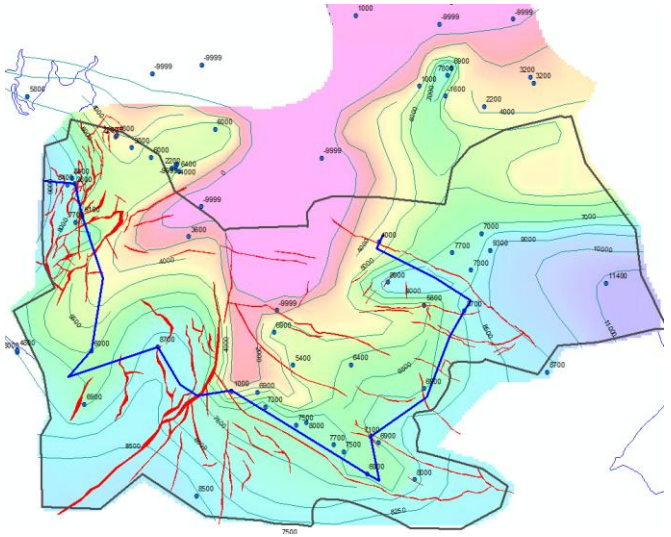
Depth to top gas window at VR = 1.1

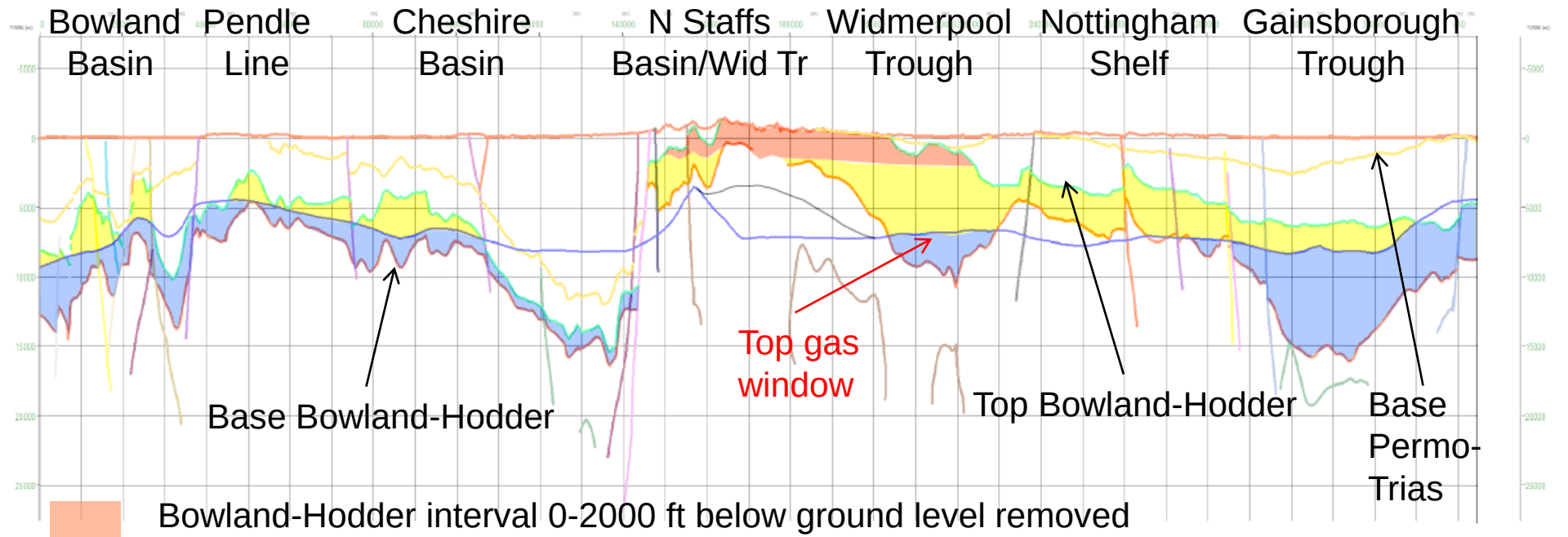


Depth to top gas window Cross Section



Depth cross-section showing the effect of the sub-ground level and isomaturity cut-offs



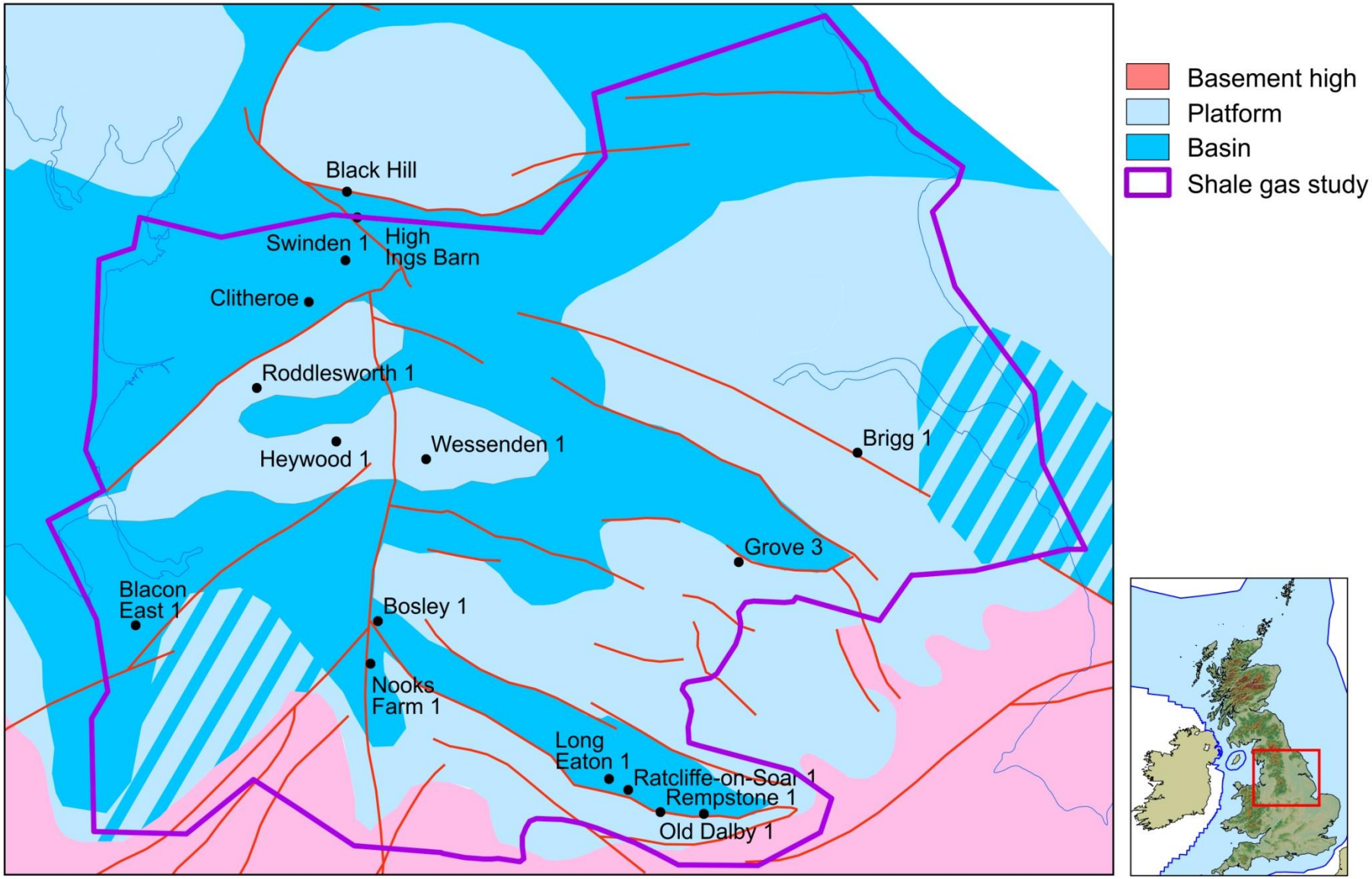


Bowland-Hodder interval 0-2000 ft below ground level removed

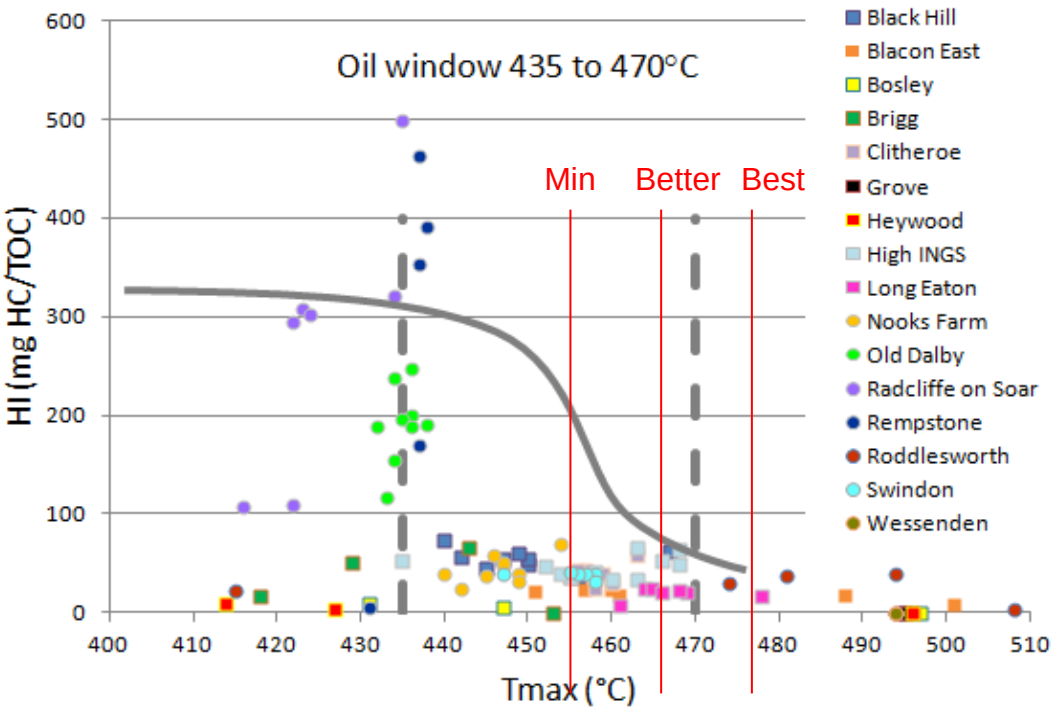
Bowland-Hodder interval within oil window removed (VR <1.1%)

Bowland-Hodder interval within gas window (VR >1.1%) – used for volumetric estimation

Location of DECC/BGS Rock-Eval samples



BGS Rock-Eval work: HI (pd) vs Tmax

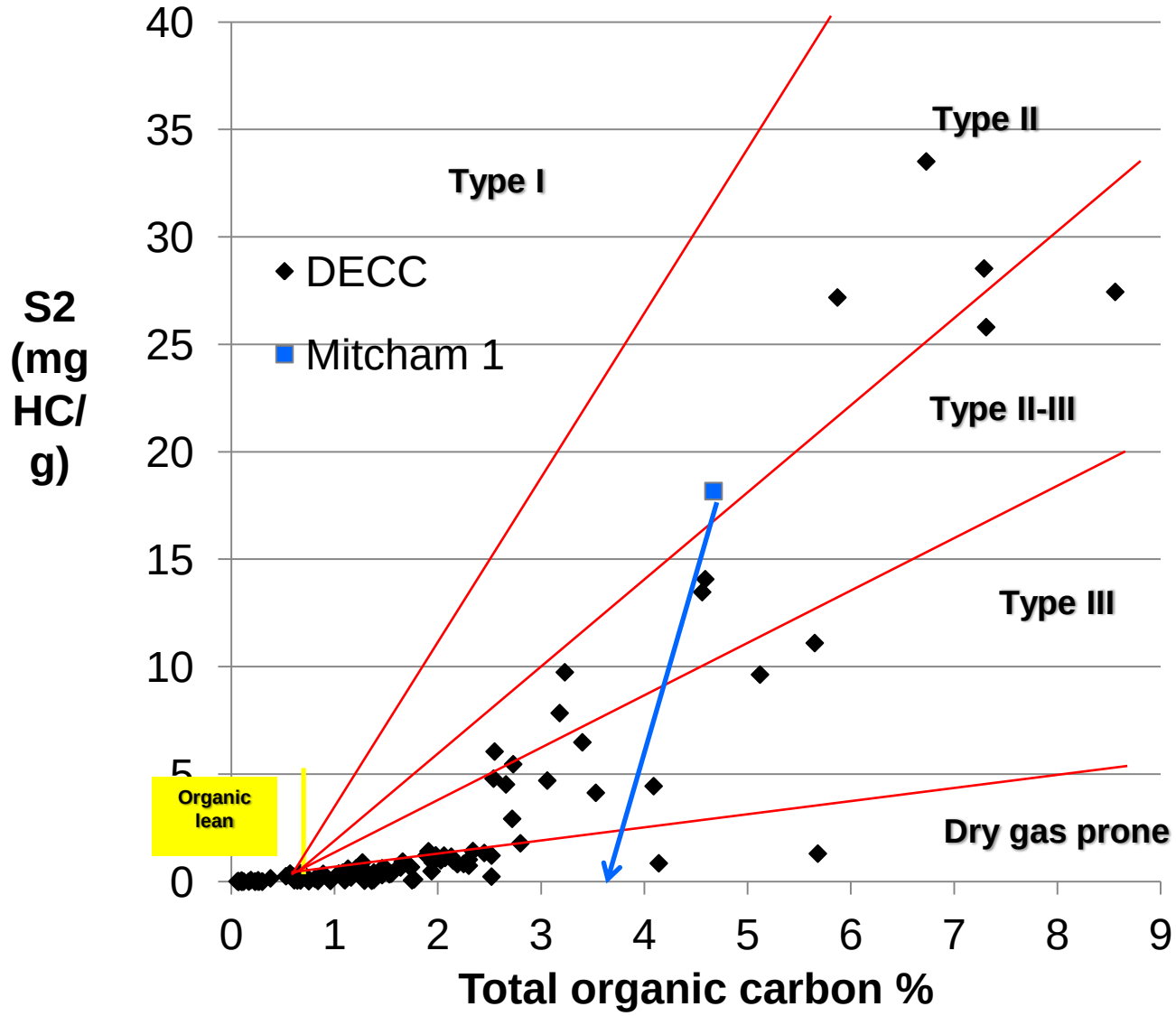


Jarvie et al, 2007

Table 3. Minimum and Best Values for Determining Whether a Low-Porosity, Low-Permeability Shale Has High Thermal Maturity Using Both Visual and Chemical Maturity Parameters

	R_o (%)	T_{max} (°C)	TR (%)	HI_{pd} (mg HC/g TOC)	Dry Gas (%)	C_{20+} (%)
Minimum	1.00	455	80	76–100	80	5
Better	1.20	465	90	50–75	90	3
Best	1.40	475	95	<50	95	1

Generation potential vs organic richness for DECC Bowland Shale samples



Blue line is Barnett Shale well maturation trend (Jarvie, 2008)

Jarvie et al, 2012 – Characteristics of best shale gas resource system

DEPARTMENT OF ENERGY & CLIMATE CHANGE

Wells in *best-producing* areas (in terms of initial production and ongoing production) :

Marine shales, commonly described as type II organic matter

Organic rich source rocks; >1% TOC present day

In gas window (>1.4% Ro)

Have low oil saturations (<5% So)

Have significant silica content (>30% with some carbonate)

Have non-swelling clays (are brittle)

Have <1000 nanoD permeability

Have < 15% porosity, typically 4-7%

Have GIP values of more than 100 bcf/section

Have 150+ ft (45+m) of organic rich mudstone

Are slightly to highly overpressured

Have very high first year decline rates

Have consistent or known principal stress fields

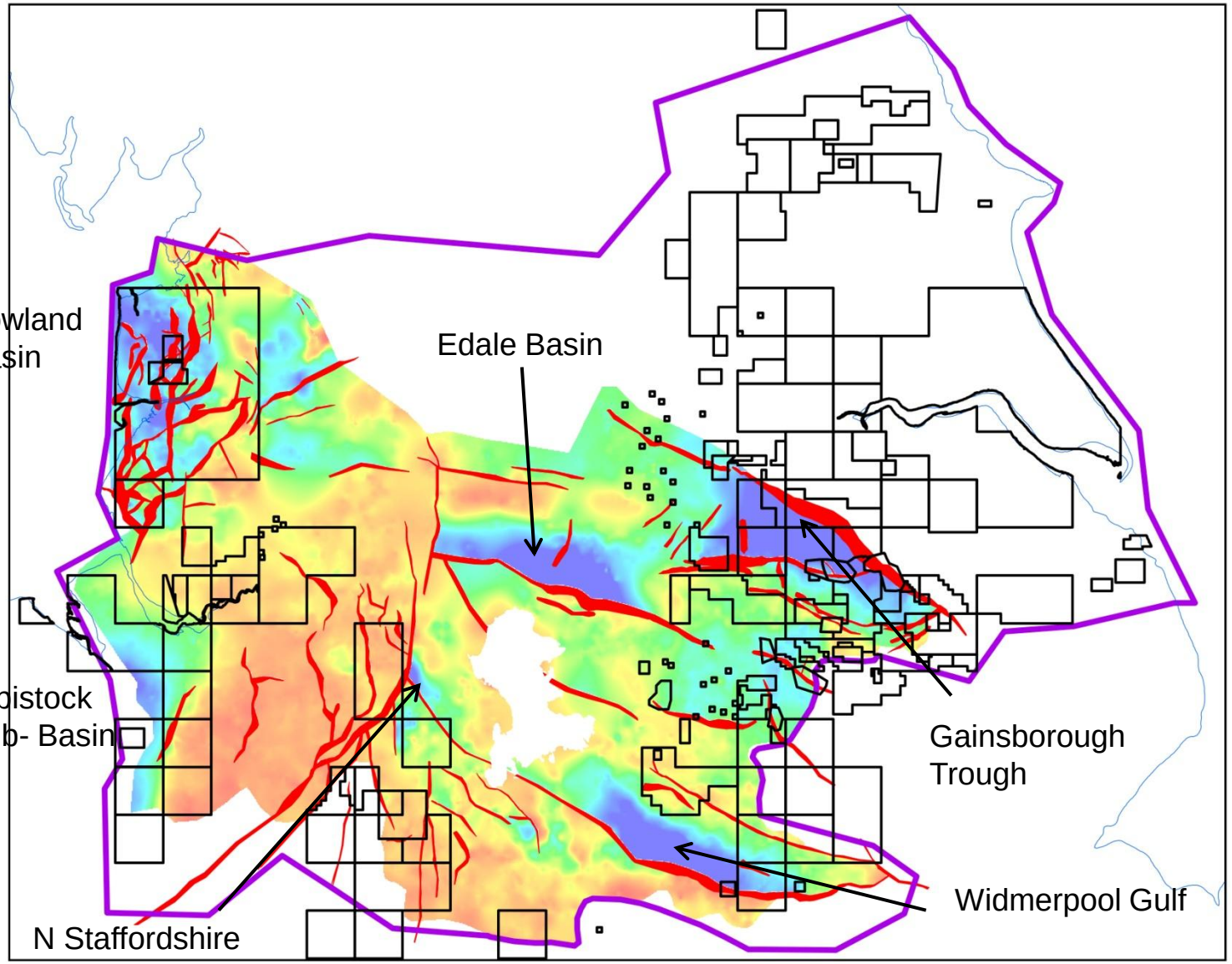
Are drilled away from structures and faulting

Are continuous mappable systems

So, will the Bowland Shale produce shale gas?

Positive factors	Negative factors	Unknown or poorly known
Thickness of >2.5% TOC intervals	Variable organic content in lower unit isopach thick areas.	Limited well penetrations in lower unit isopach thick areas.
Some Type II kerogen	Some Type III kerogen	Gas yield
Brittle shale (interbedded w/brittle limestones)	Structural complexity and inversion	IP and decline rate
Thermal maturity >1.1 R_0 >3.5 R_0	Relatively low gamma response compared to North American analogues	Extent of over-pressuring
Evidence of gas in shale wells and producing fields sourced from Bowland Shale	Lower unit isopach thick areas have no North American shale gas analogues	

Bowland/Hodder Shale Isopach



Conclusions

- **BGS Mapping, geochemical analysis still underway**

- **Fault-bounded thicks do not look like North American analogies, but have few well penetrations**

- **Bowland /Hodder has condensed zones of high-TOC, laterally correlative high gamma, brittle shale**

- **Basins are mature for gas, but some for liquids, too**

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DECC will publish Bowland Tech report and GIP estimation early in 2013

Thanks to Sue Stoker, Ian Andrews, Mike Sankey at BGS!

Wells
Fields and field development
Measurement of petroleum
Operatorship
Infrastructure
Onshore
Cuadrilla Geomechanical and DECC report
Decommissioning
Taxation

NEW CONTROLS ON SEISMIC RISKS PERMIT A RESUMPTION OF SHALE GAS EXPLORATION

Hydraulic fracturing operations for shale gas in the UK have been suspended since May 2011, pending the investigation of two seismic tremors experienced near Preese Hall, Lancashire during fracking operations.

In the light of the recommendations of a panel of independent experts, of comments received in response to a public consultation, and of the recommendations of an authoritative review of the scientific and engineering evidence on shale gas extraction made by the UK's science and engineering academies, the Royal Society and the Royal Academy of Engineering, the Secretary of State for Energy has announced the introduction of new regulatory requirements to ensure that seismic risks are effectively mitigated.

A copy of the Secretary of State's statement to Parliament is available at the following link. [link].

Subject to these new requirements, DECC is prepared in principle to consider new applications for consent to such operations, and the suspension is therefore lifted. As before, final consent to any well or well operations is dependent on confirmation that all other necessary permits and consents have been obtained. A wide range of other issues were raised in the responses to the public consultation, and DECC together with other relevant bodies has prepared a full Q&A brief on these issues, which can be found at [Q&A link....]

The full Government response to the recommendations made on the scientific and engineering evidence by the Royal Society and the Royal Academy of Engineering can be found via the following link [RS/RAE response]

Here is further background information on Shale Gas

- Environment Agency' guidance note on exploratory shale gas operations