

A tale of ten prospects: from the first UK onshore drilling campaign of 1918-1922 to the present day



D'Arcy-1 well. Midland Valley

Overview

- the background to the first drilling campaign in 1918-22
- drilling results
- subsequent drilling from 1922 to the present day
- relevance of the drilling campaign to the 14th round

Data:

- The story has been largely hidden from geologists view as it was published in The Journal of the Institute of Mining Engineers in 1923.
- PhD thesis: two of the wells were in the North Staffordshire Coalfield

Background to the drilling campaign

- 1911: Winston Churchill, as First Lord of the Admiralty, launched a programme to change the Royal Navy ships from coal to oil power
- 1914: Lots of coal, but no indigenous oil supply , so HM Government acquired 51% of the newly formed Anglo-Persian Oil company to secure oil supplies
- secret 20-year contract with the Admiralty to supply oil for Navy ships under attractive terms.
- However, the supplies were in the Middle East and it was wartime
- decision to explore for oil in the UK



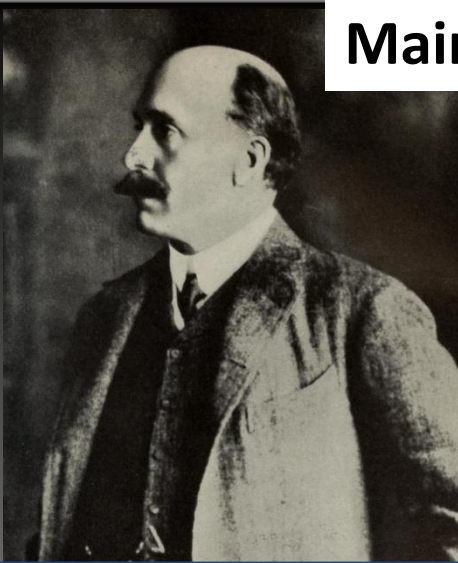
Petroleum (Production) Act 1918

- rights to the oil remained with the Crown
- proposal of a 9 pence per ton royalty to landowners was subsequently rejected in Commons
- free access to land under the Defence of the Realm act (repealed after the end of WW1)
- £1,000,000 allocated by Government for drilling

Drilling Contractors:

- three British oil companies: Shell, Burmah and Anglo-Persian and Pearson and Sons
- Government approached Pearson and Sons for the drilling
- Pearson's team had already commenced the geological work for UK Exploration

Main Characters



Lord Cowdray, Weetman Pearson

- Head of Pearson and Sons and owner of the Mexican Eagle Company: fired his English geological consultants and hired ex-USGS geologists to explore in Mexico
- Potrero del Llano 4 well flowed at 110,000 barrels/day which was the highest flow in the world at that time. Sold Mexican Eagle to Shell for \$75 million in 1918
- Appointed drilling contactor for HM Government in 1918
- American rigs and crew supplied by Pearson and Sons



Sir John Cadman

- Professor of mining at the University of Birmingham
- Government advisor on oil supplies
- Knighted for his services in 1918
- led the drilling campaign



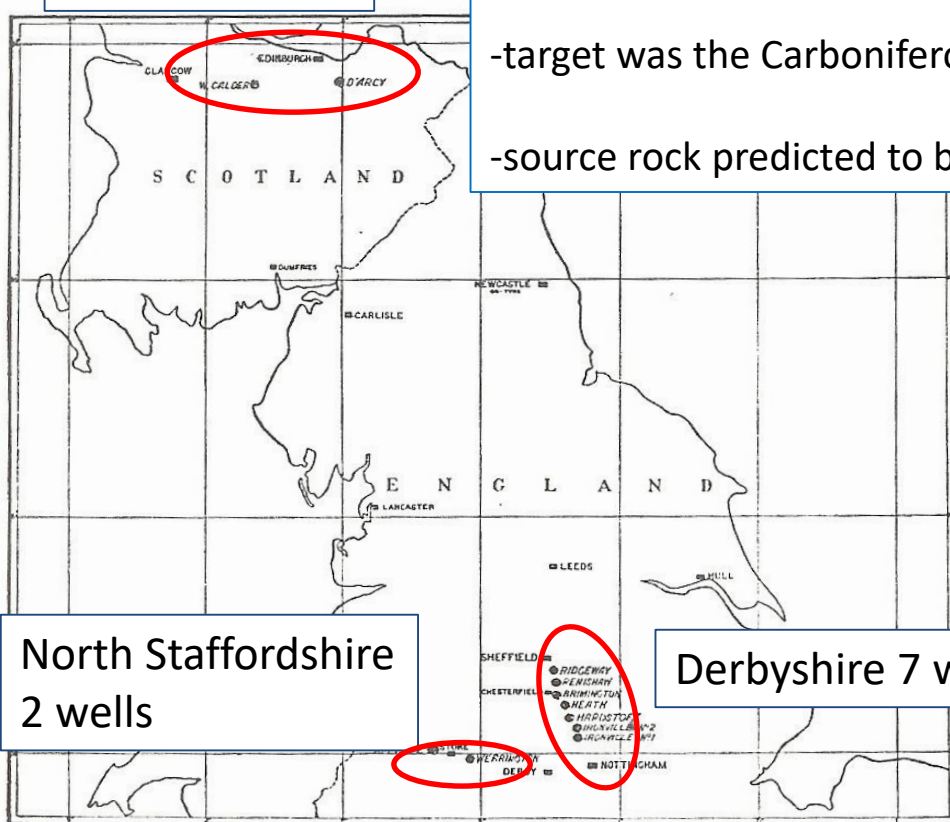
9th Duke of Devonshire

- Governor General of Canada 1916-21
- one of the wells was on his land

Geological basis for the well locations

- Pearson's ex-USGS geologists had already decided that the Carboniferous was most prospective
- similarity to the oil producing areas in West Virginia and Pennsylvania
- abundant oil shows at outcrop and in coal mines
- anticlines proved by coal mining and Geological Survey mapping
- target was the Carboniferous limestone
- source rock predicted to be in the limestone

Midland Valley
2 wells

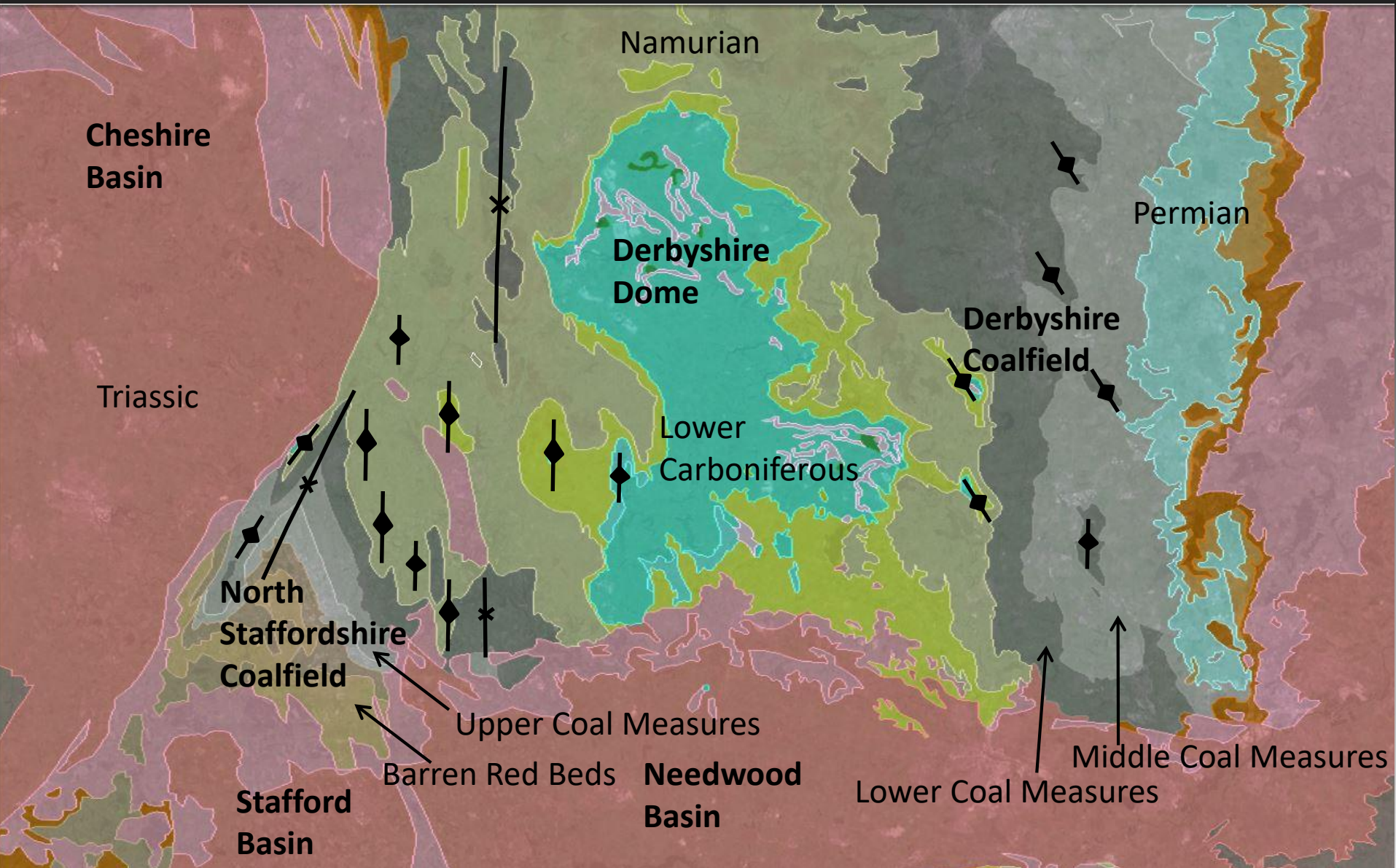


North Staffordshire
2 wells

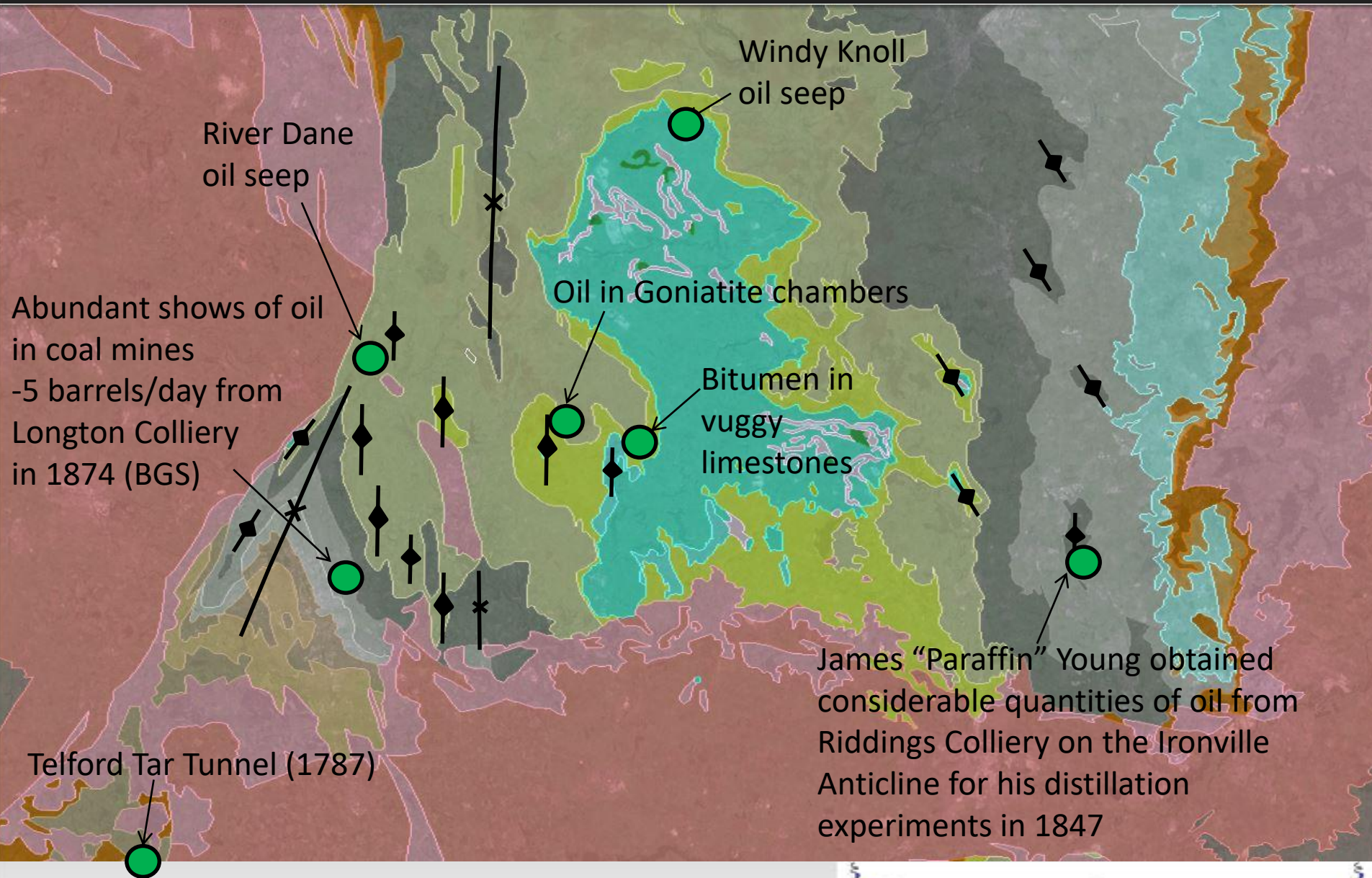
Derbyshire 7 wells

FIG. 1.—MAP SHOWING LOCATION OF OIL-WELLS.

Geological map of the North Staffordshire and Derbyshire coalfields



Historic oil shows around the Derbyshire Dome

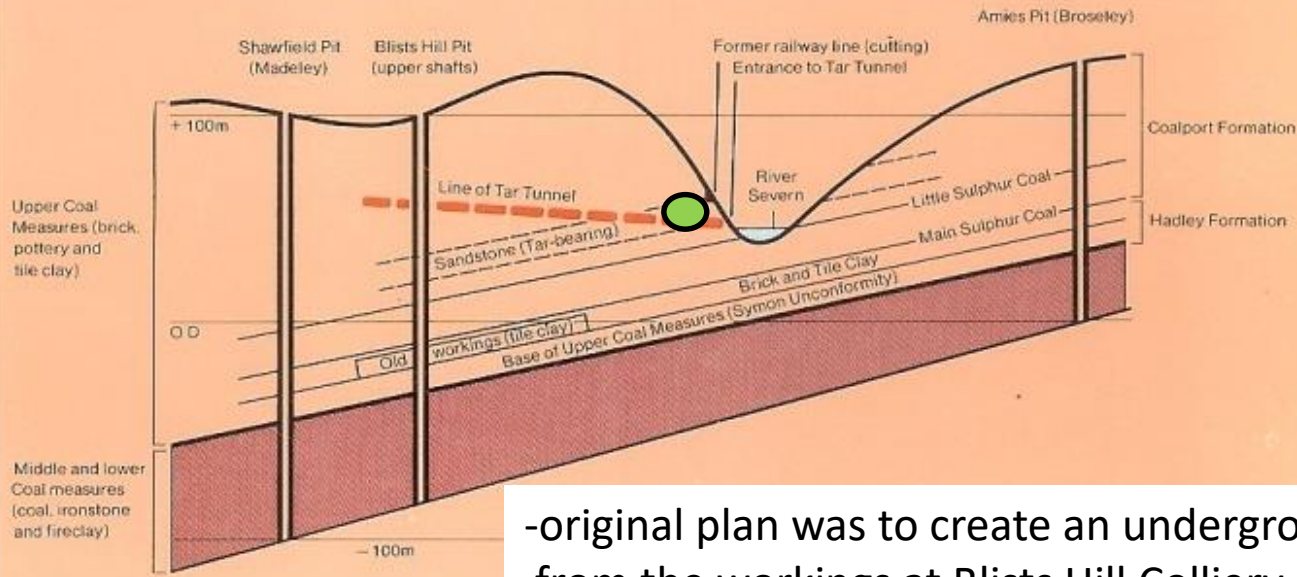


Location of the Tar Tunnel in the Ironbridge Gorge



The tunnel was dug in 1787 to connect the underground coal workings at Blists Hill with Coalport on the River Severn

Telford Tar Tunnel



- original plan was to create an underground canal to transport coal from the workings at Blists Hill Colliery
- heavy oil encountered in first 100m. Total length 988 yards (903m)
- initial flow 4,500 gallons/week (128 barrels/week)
- Scientific curiosity in Georgian England-Erasmus Darwin paid a visit
- used for sealing the hulls of boats. Also sold as *"An oyl extracted from a flinty rock, for the cure of rheumatism and scorbutick and other cases"*



The entrance



10m from the entrance





Enhanced porosity: Cavern dug into the side of the tunnel with pool of bitumen. Twenty of these caverns were excavated for oil production. Two visible at present

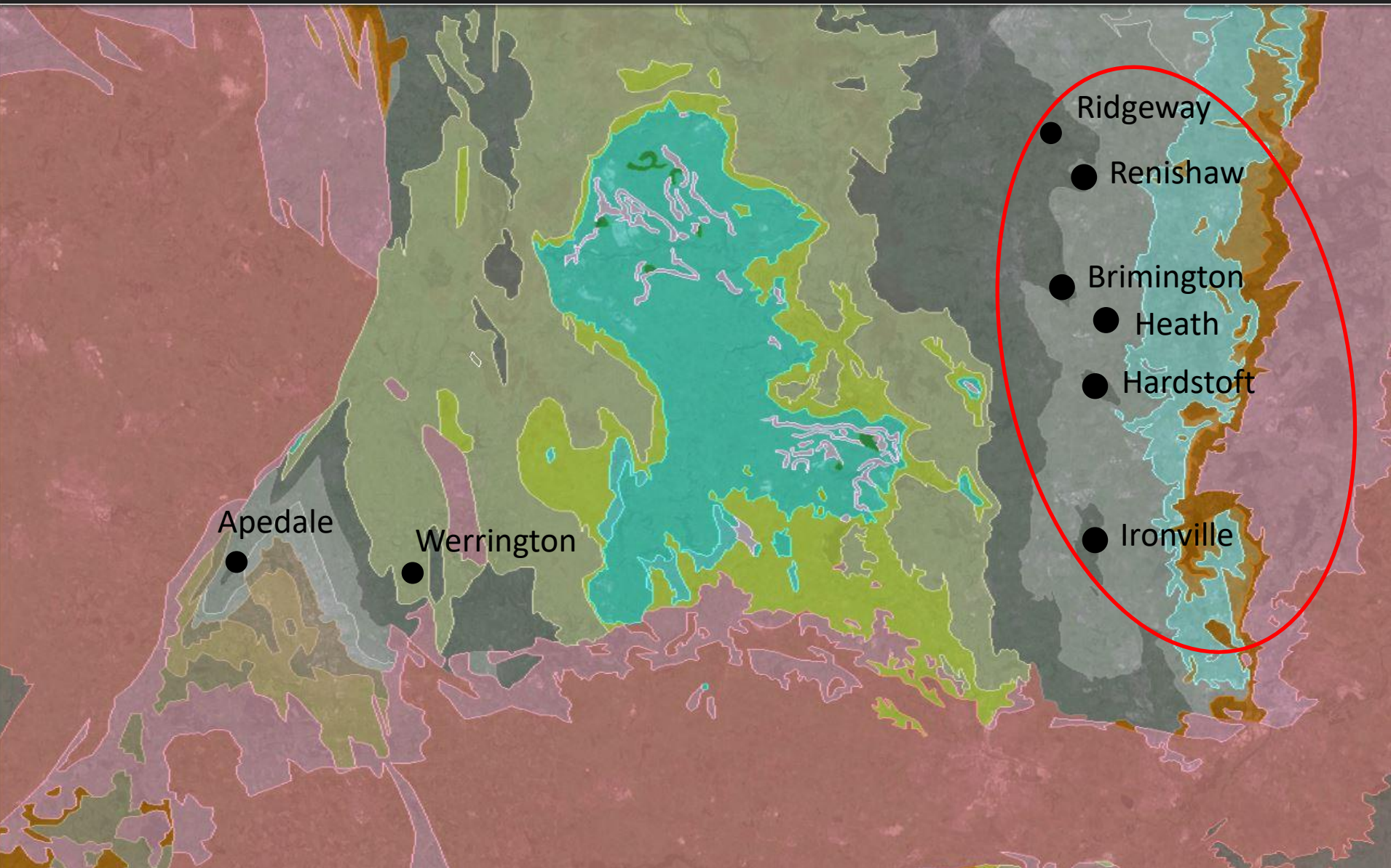
Drilling operations



Prospecting for oil and gas at West Calder in 1919. Image courtesy of British Geological Survey (ref C2887)

- American cable system
- steel derrick 85' high
- powered by steam engines
- wooden walking-beam
- hemp cable for first 500' followed by steel wire
- percussive tools: heavy chisel shaped bit
- chippings removed by patent suction-bailer

Derbyshire wells



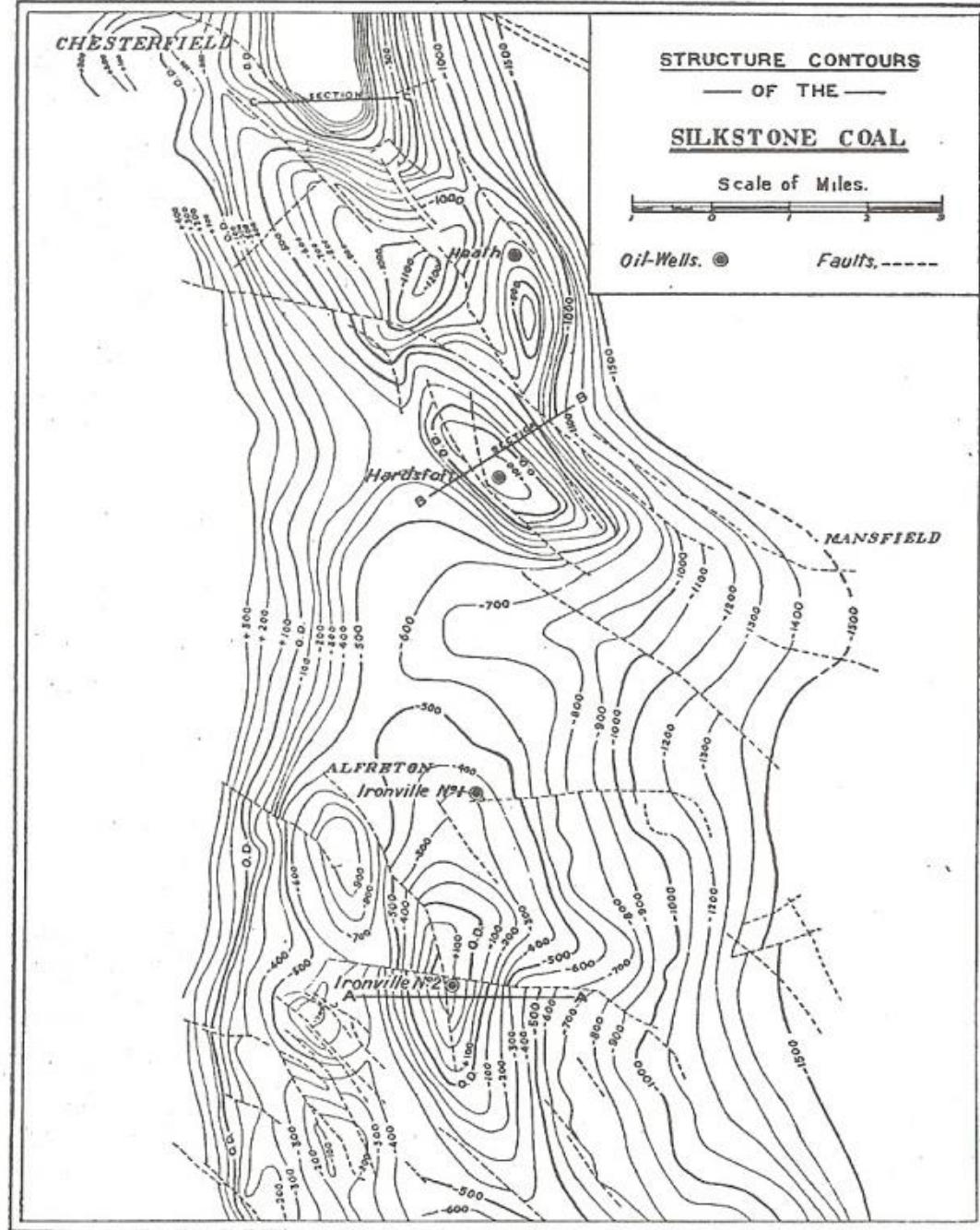


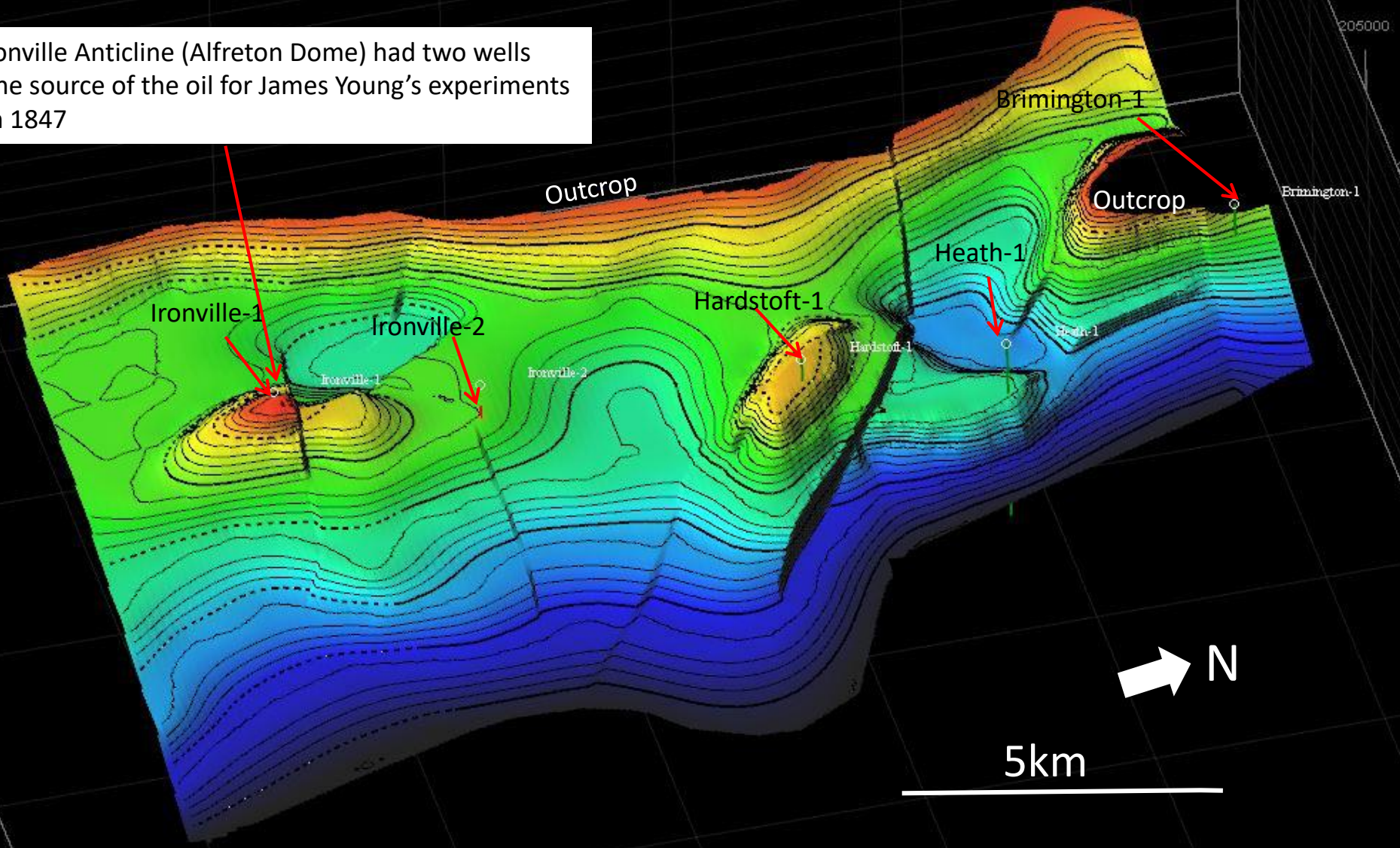
FIG. 2.—STRUCTURAL CONTOURS OF THE SILKSTONE COAL.

Structure Map from the 1923 paper

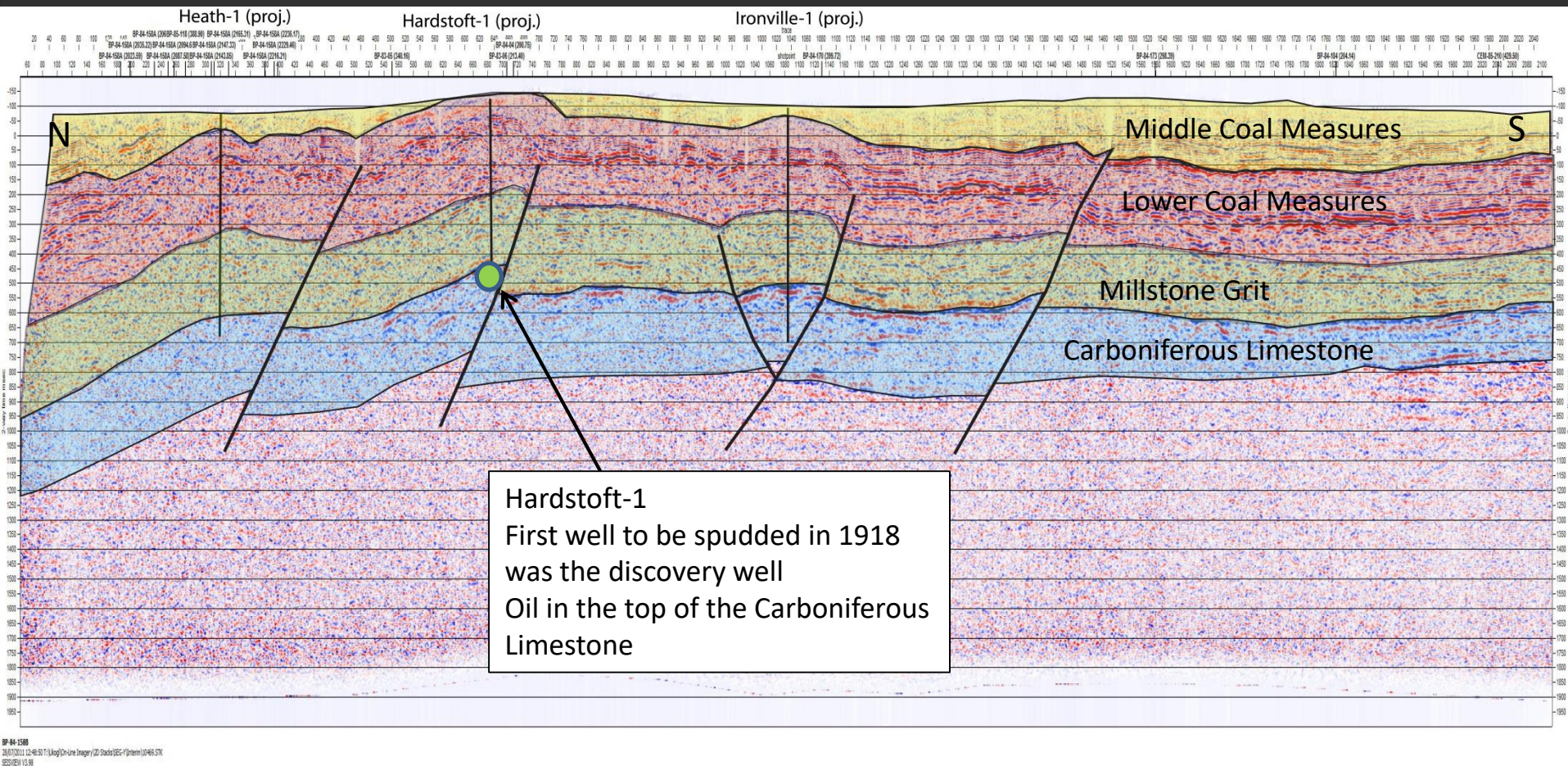
- no problem with the definition of prospects as the mapping had been done by the colliery owners and the Geological Survey in the exposed coalfield
- accurate depth maps of numerous coal seams available
- five of the wells appear on this map

Structure map of the Silkstone Coal

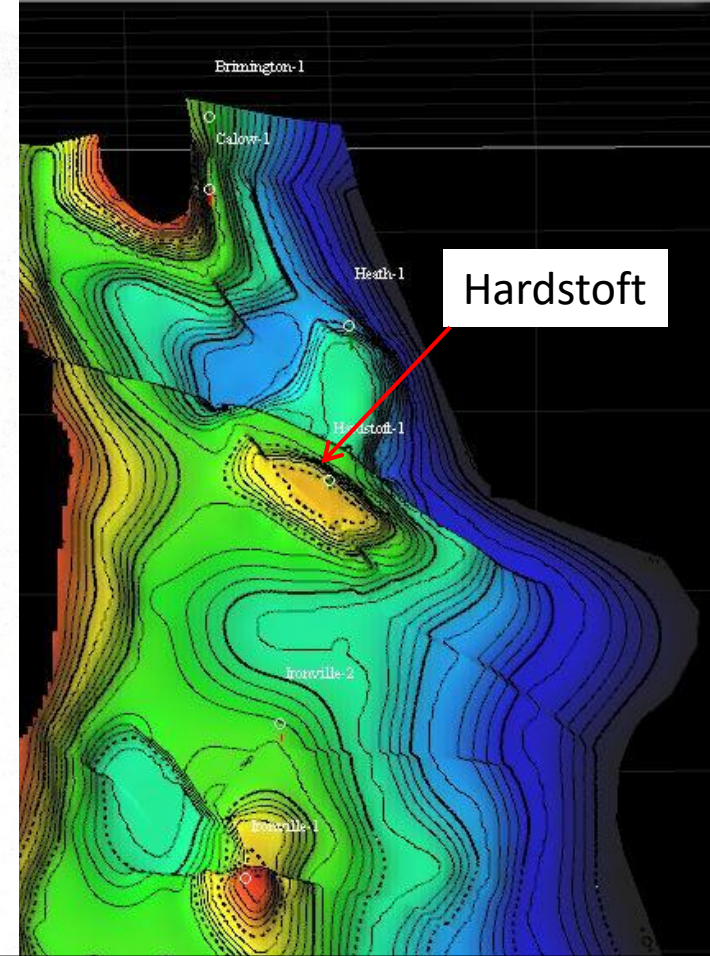
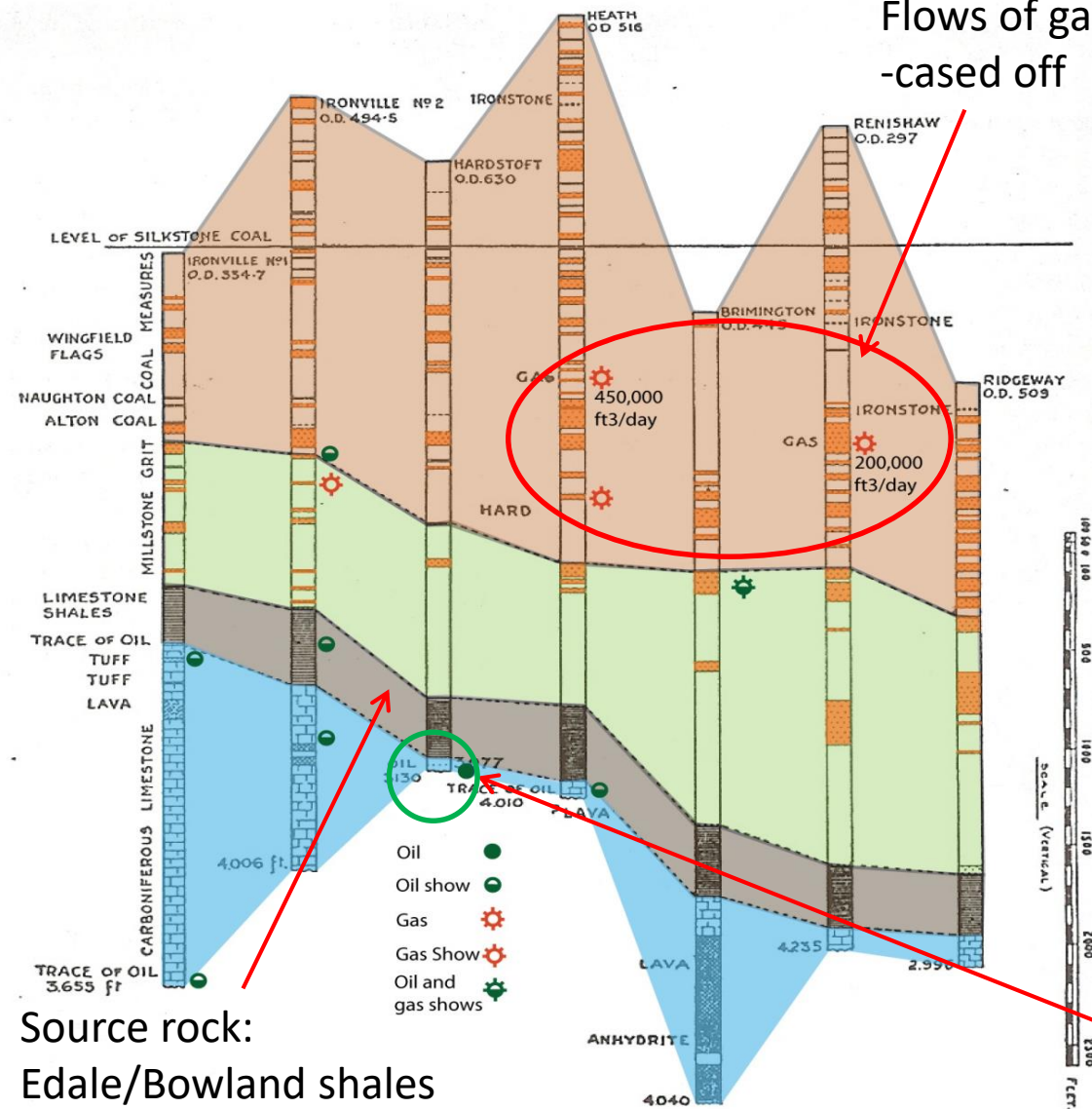
Ironville Anticline (Alfreton Dome) had two wells
-the source of the oil for James Young's experiments
in 1847



1984 BP seismic line across the Heath, Hardstoft and Ironville anticlines



Flows of gas
-cased off



Hardstoft oil discovery

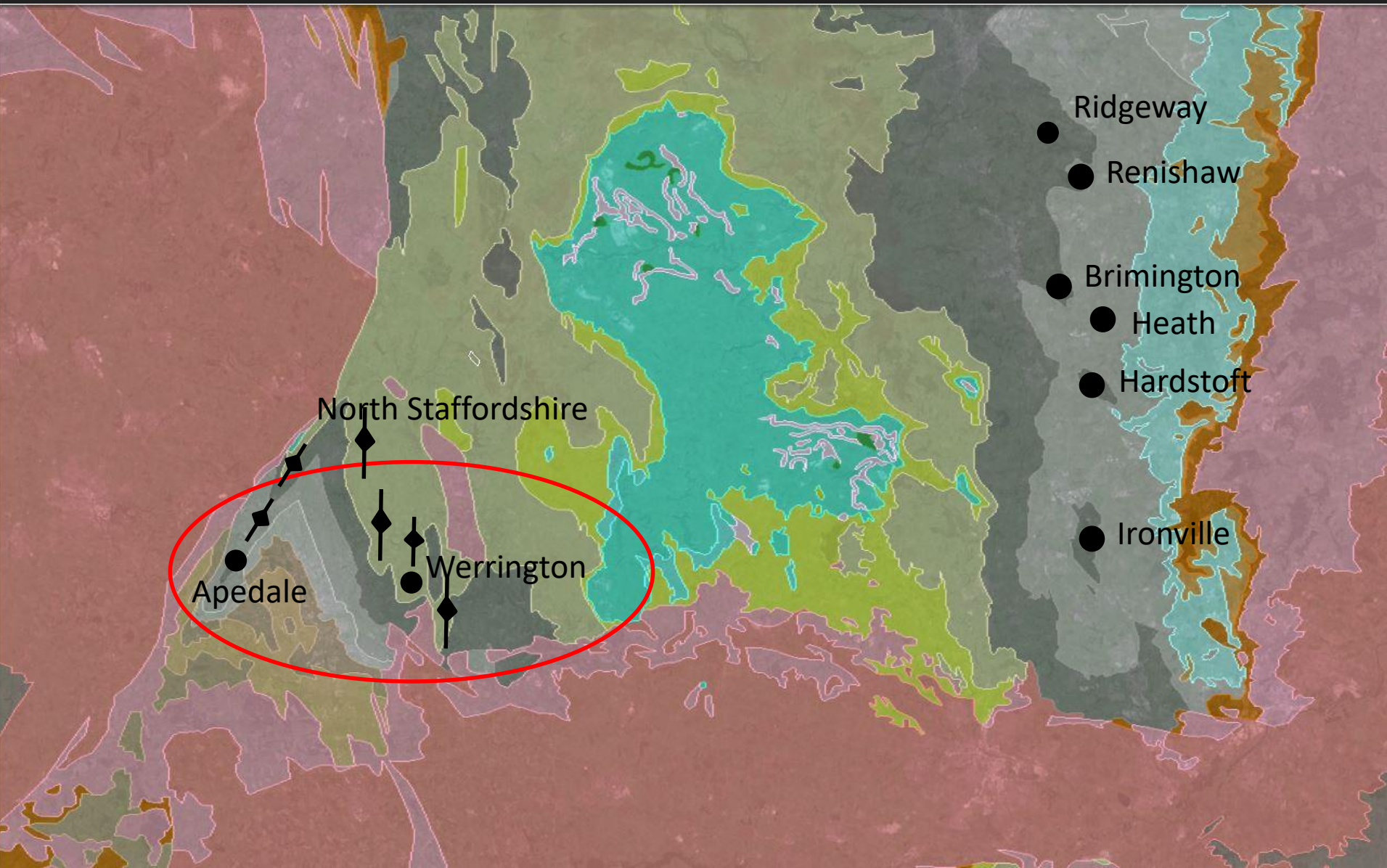
- Not a Spindletop type gusher
- Oil rose 90' in the first hour
- Took another day to flow to surface
- 50 barrels/week for first two years
- On the Duke of Devonshire's land

FIG. 7.—SECTION OF DERBYSHIRE BORINGS, AND CORRELATION OF THE GEOLOGICAL FORMATIONS IN THE DISTRICT.

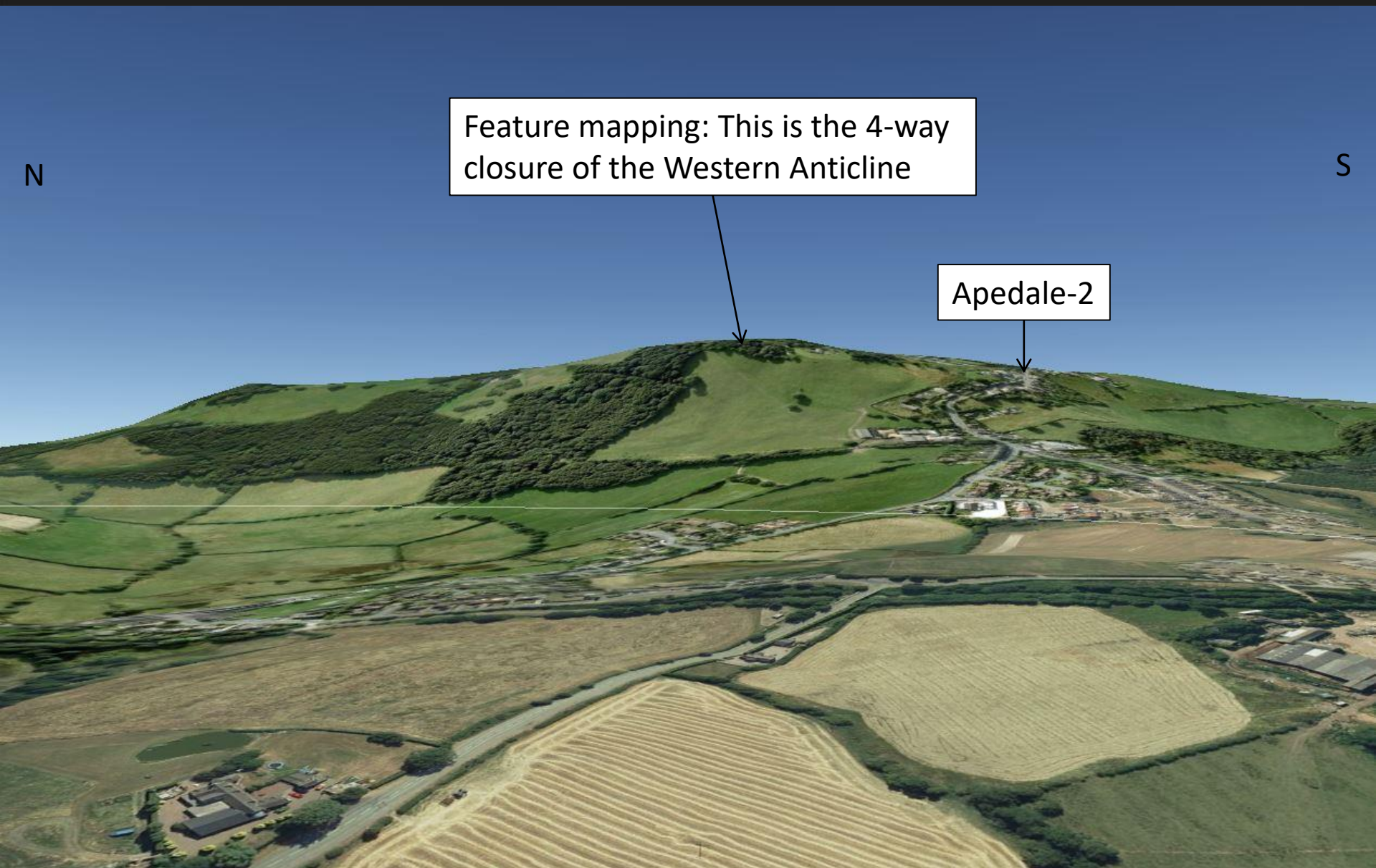
Heath-1 Fracture stimulation

- 1920: a small flow of light oil at 4000' at the top of the Carboniferous limestone
- first attempt** at well stimulation using 110 pounds of dynamite in a steel tube and detonated by means of a hand dynamo
- this destroyed the cable which had to be chopped up by a specially made bit and fished out in pieces
- small quantity of oil
- second attempt** Messrs Nobel were contracted to supply nitro-glycerine. Restrictions on movement of nitro-glycerine so it was extracted onsite from dynamite using warm water and a canvas frame.
- ten 8' long canisters filled with 1200 pounds of nitro-glycerine were lowered into the hole and detonated by a charge of dynamite
- Limestone was shattered by the blast but no flow of oil so well was plugged and abandoned

North Staffordshire wells



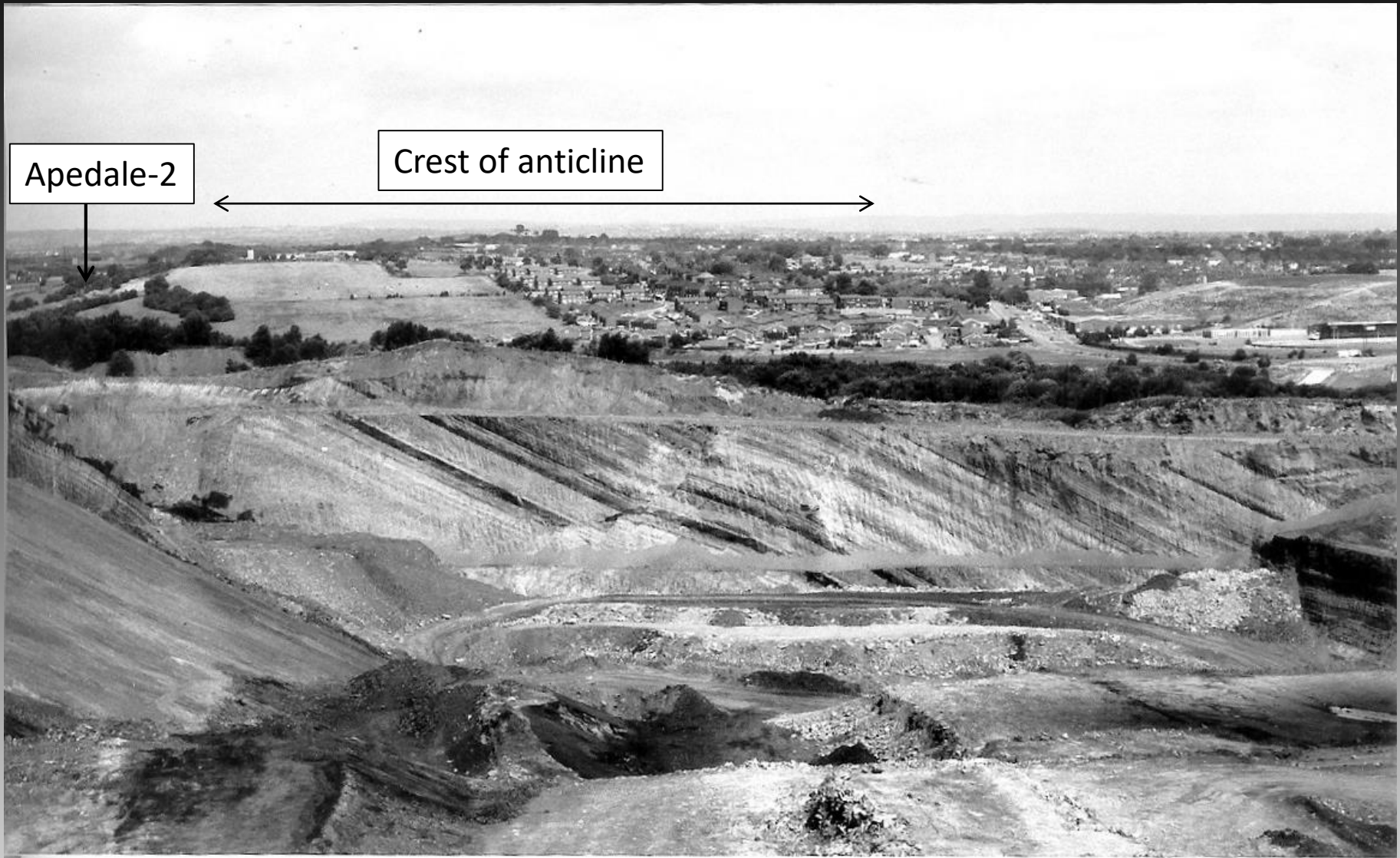
Apedale-2 well location



Feature mapping: This is the 4-way closure of the Western Anticline

Apedale-2

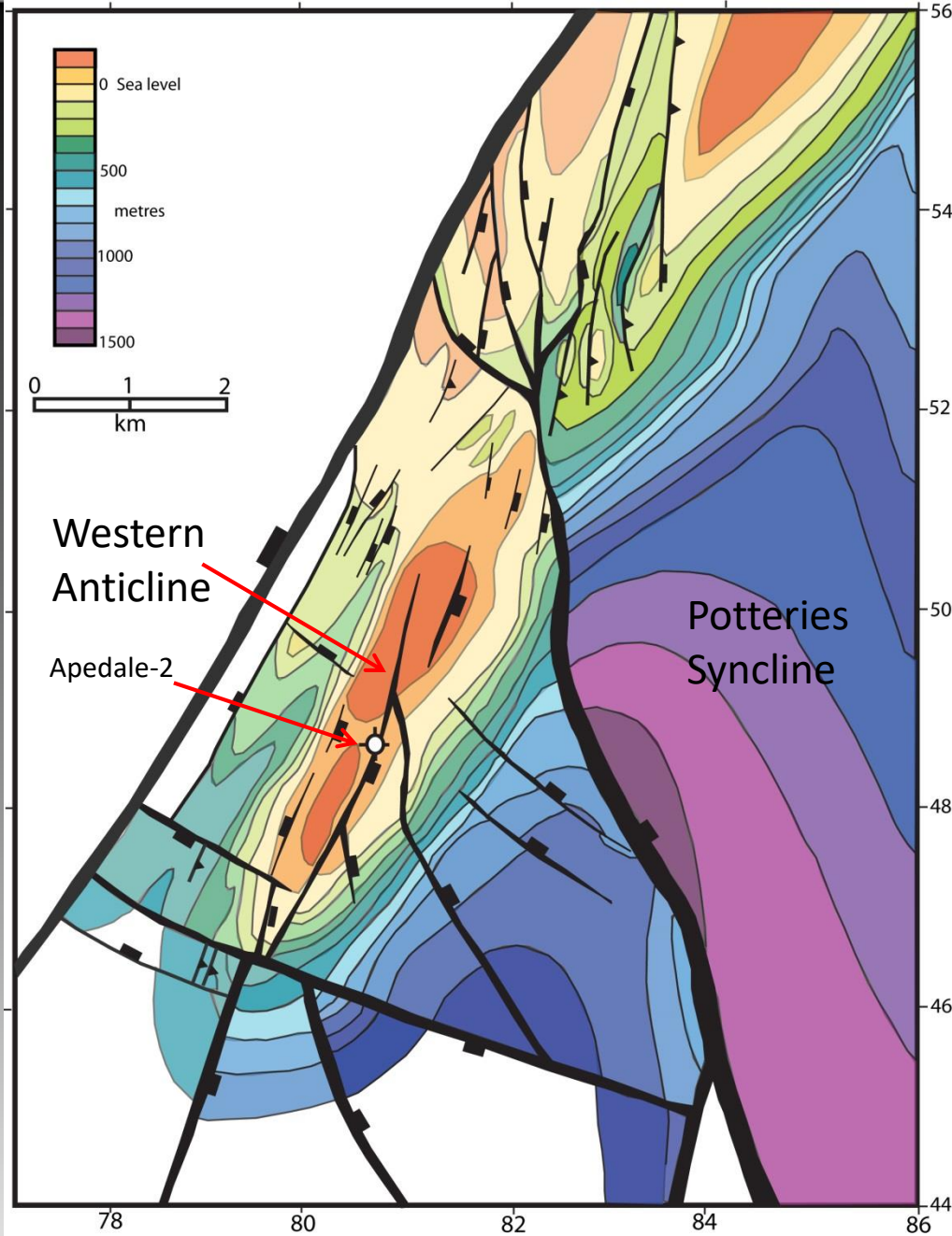
Note: Apedale-1 was abandoned due to problems



Eastern limb of the Western Anticline, North Staffordshire Coalfield
Westphalian C coals exposed in the High Lane
Opencast site, 1988. Now the Silverdale Country Park

Structure contour map of the Bullhurst Coal (Westphalian A) compiled from British Coal mine plans in 1988-89

Very old mine plans dating back to the 19th Century. Pearson's would have used the same data



Carboniferous Limestone plus thick Namurian sands (Rough Rock and Chatsworth Grit) at outcrop in the core of this anticline to the north

Structure contour map of the Bullhurst Coal (Westphalian A) compiled from British Coal mine plans

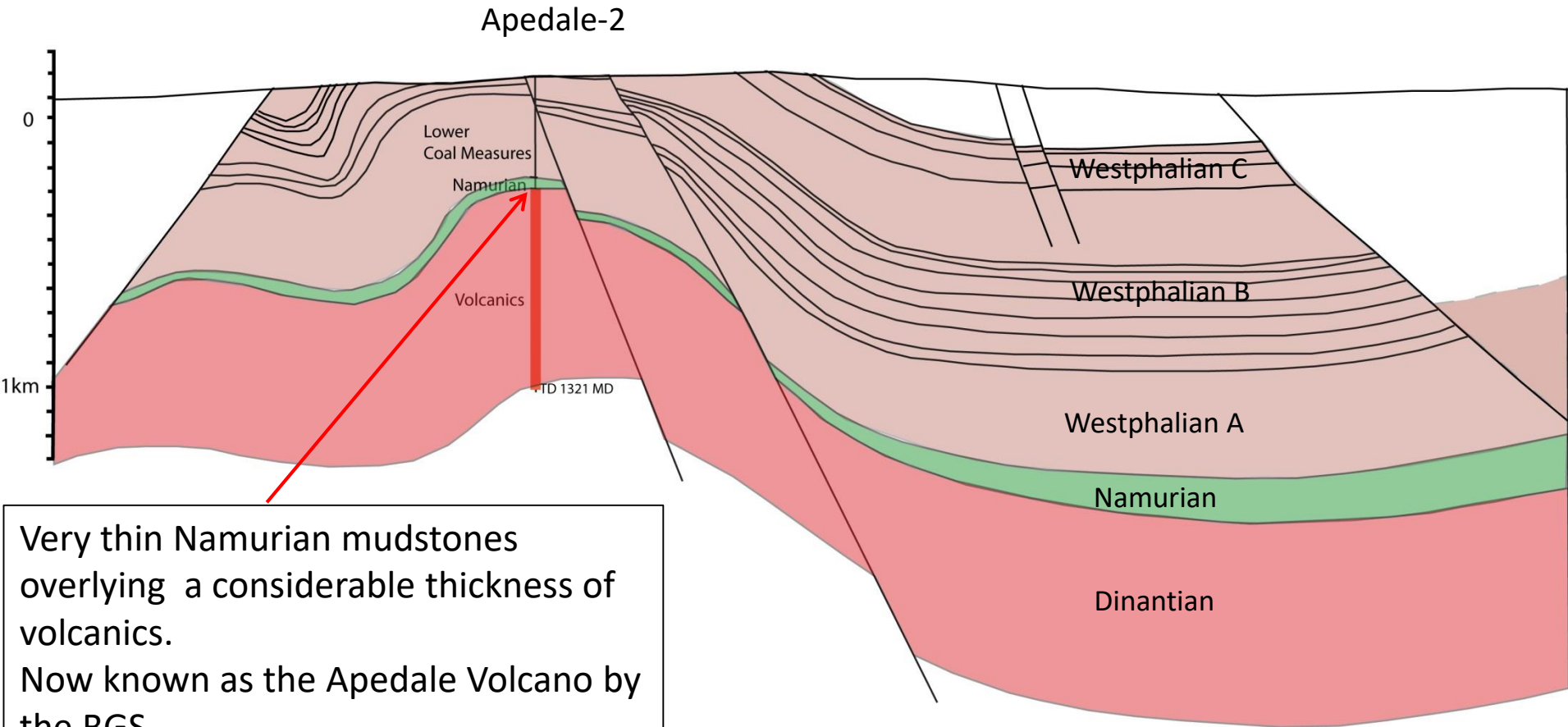
Apedale-2

Easily mapped 4-way closure

Oil in coal mines in the Potteries syncline

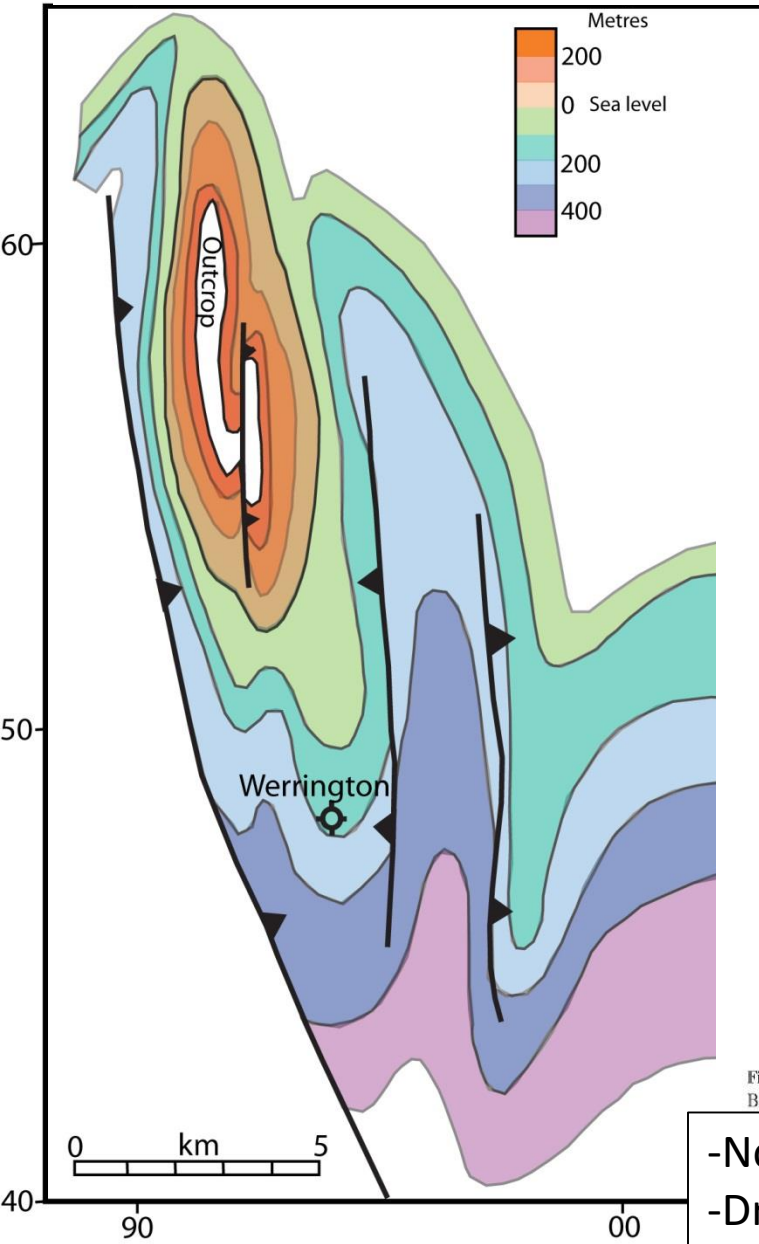
Sir John Cadman was born in the mining village of Silverdale

Cross-section of the western Anticline derived from British Coal mine plans



Werrington-1

Minn Sandstones (Namurian) structure map



Feature mapping: This is the 4-way closure of the Lask Edge Anticline



VARISCAN INVERSION

25

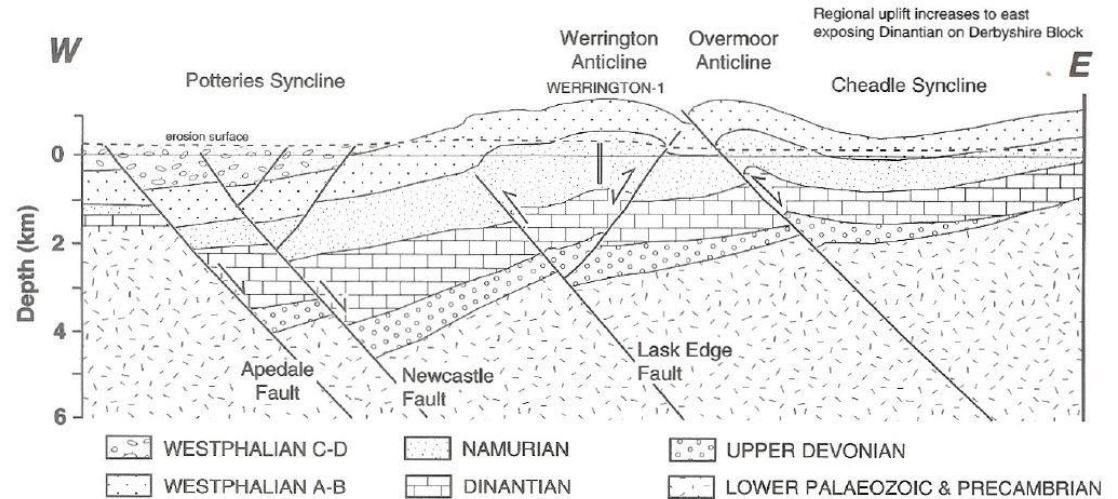
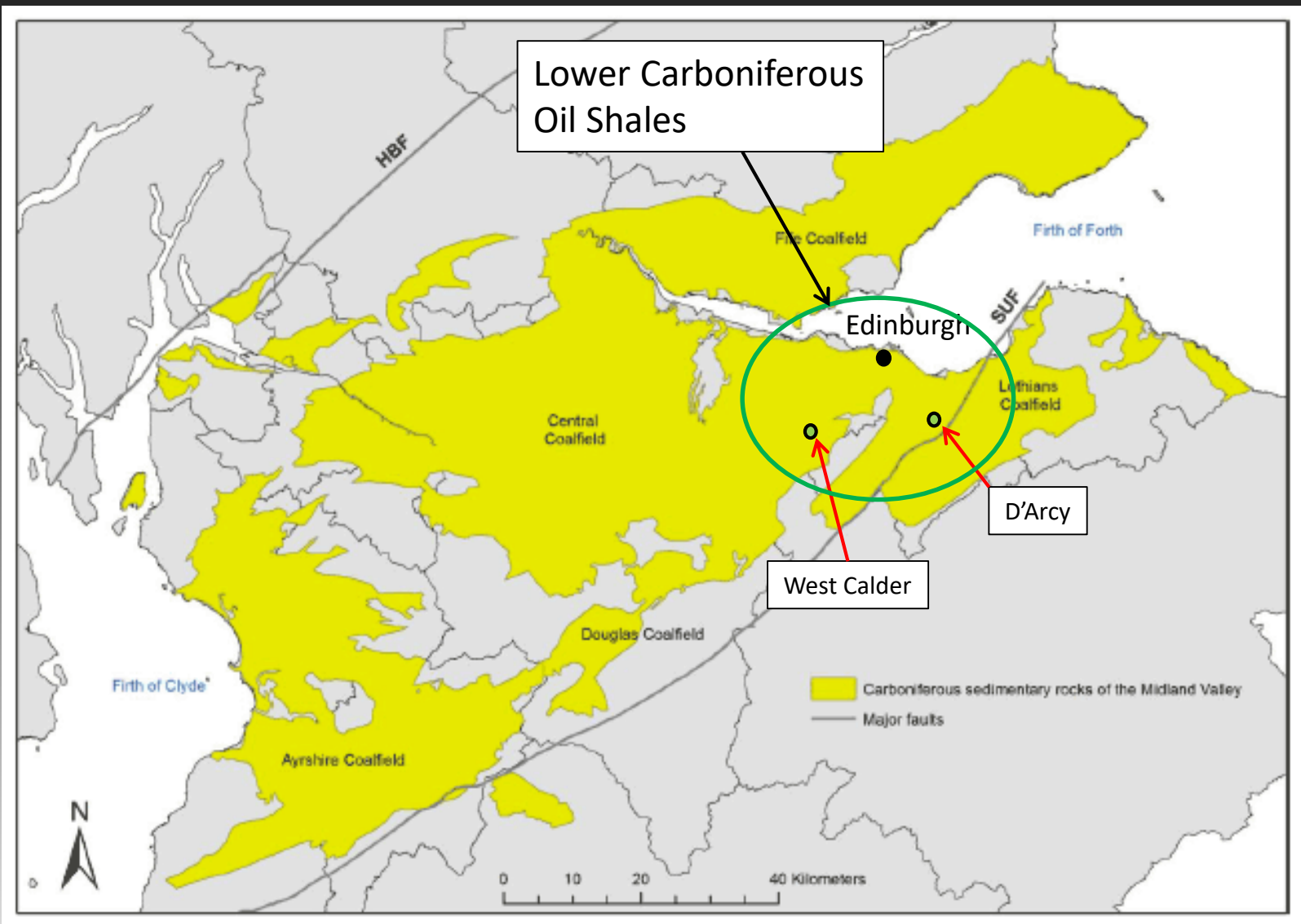


Fig. 8. E-W cross-section across the western margin of the moderately inverted North Staffordshire Basin. Compiled from outcrop studies, British Coal mine plans, and seismic data (see Fig. 7a for location).

-No shows
-Drilled off-structure

Midland Valley Wells





Prospecting for oil and gas at West Calder in 1919. Image courtesy of British Geological Survey (ref C2887)

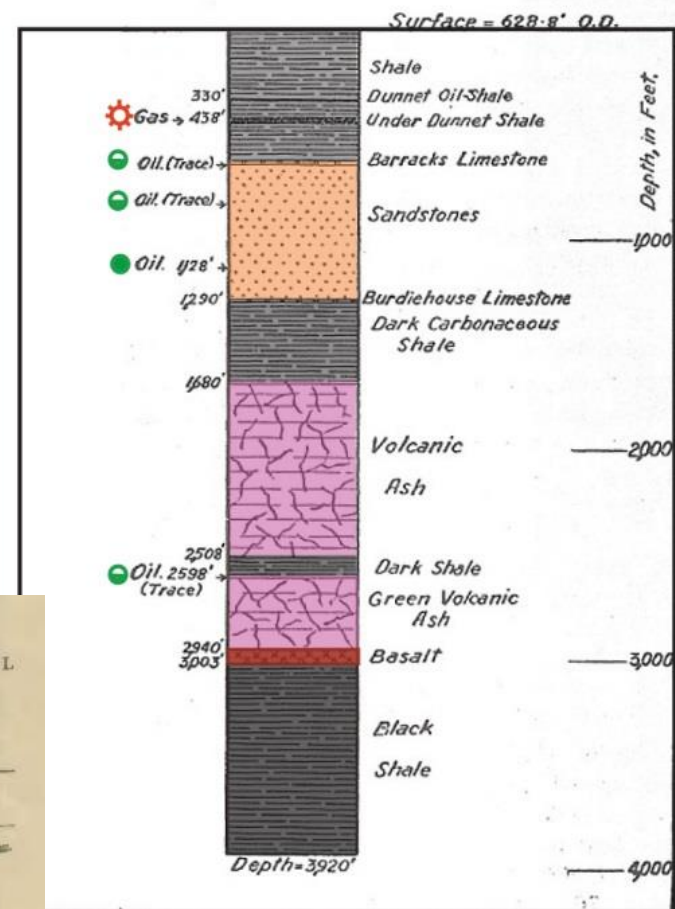
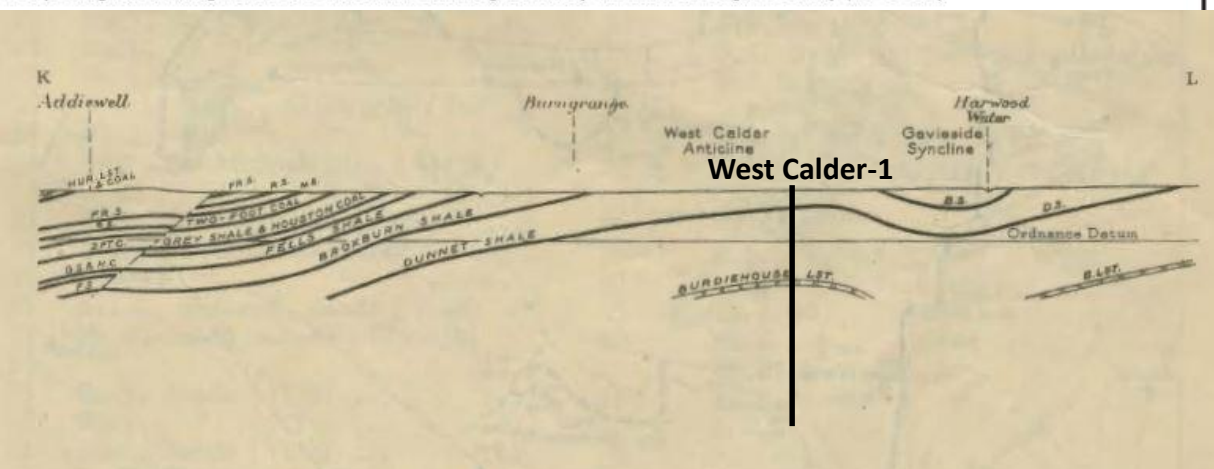


FIG. 8.—LOG OF THE WEST CALDER WELL.

West Calder-1

Drilled on an anticline in the Oil Shale Group of the Lower Carboniferous.

Oil and gas shows

D'Arcy-1 oil and gas discovery

Spudded in December, 1919, on the Cousland – D'Arcy anticline in the Lower Carboniferous oil shales.

300,000 ft³/day of gas at 724' (cased off)

Light oil with 12% wax at 1810' which took a week to rise to 320'.

Produced 7 tons of oil (ca. 51 barrels) by bailing over a 9 week period after which the well was plugged and abandoned in September, 1922.

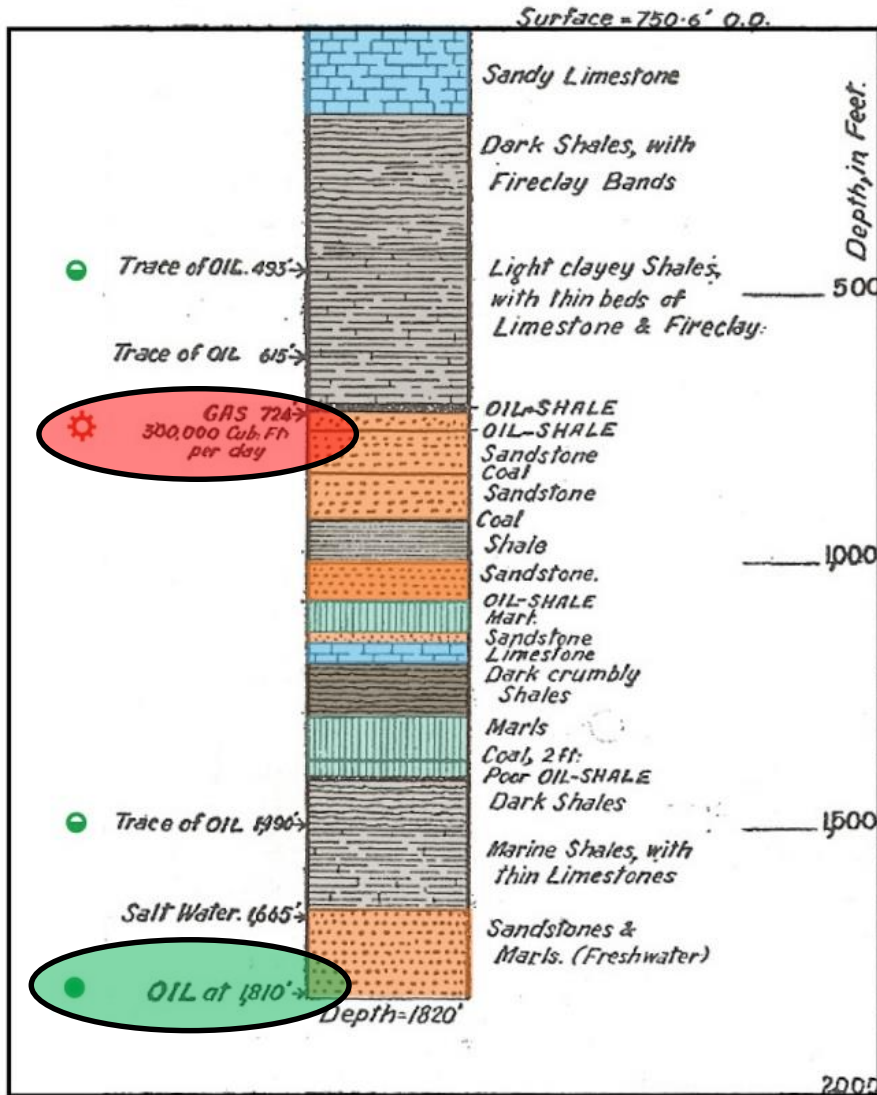


FIG. 9.—LOG OF THE D'ARCY WELL.

Note: Named after the well location near D'Arcy Wood and not the D'Arcy company



Figure 8.1 D'Arcy well derrick in 1919, in East Lothian (Cousland-D'Arcy Anticline) in Midland Valley of Scotland (© NERC).

The results at the end of 1922

Abundant shows, two oil discoveries and three wells with substantial flows of gas

Derbyshire

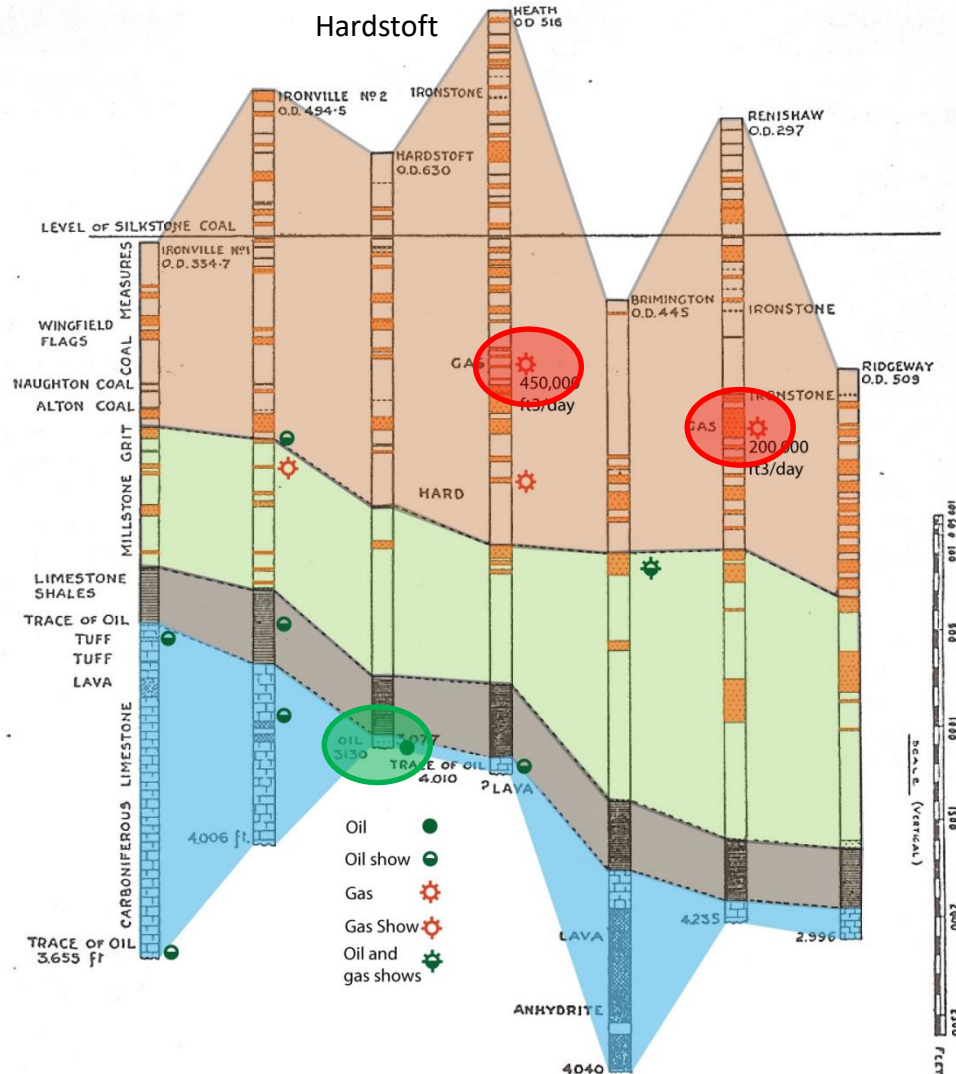


FIG. 7.—SECTION OF DERBYSHIRE BORINGS, AND CORRELATION OF THE GEOLOGICAL FORMATIONS IN THE DISTRICT.

Midland Valley

West Calder



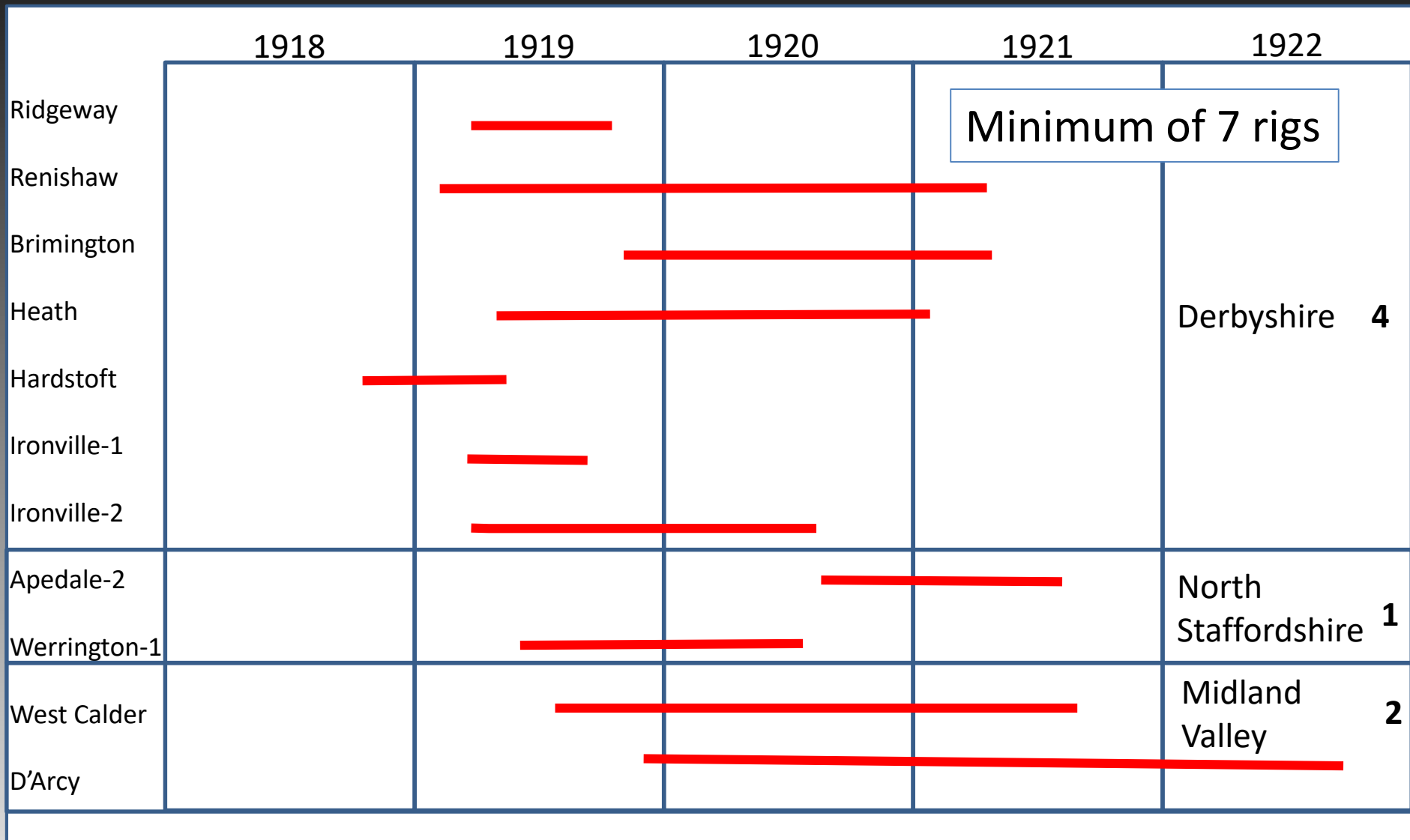
D'Arcy



V.—CLOSING DOWN OF OPERATIONS.

During 1921, when all the wells with the exception of D'Arcy had been completed, it was decided that operations should be closed down and that no further drilling should be undertaken by H.M. Government. Arrangements were made to plug all the wells except Hardstoft and D'Arcy and to recover as much of the casing as possible, except where it was cemented in place for the protection of coal-seams. The method of plugging varied in different cases, but the general principle adopted was to shut off the water-bearing strata by driving down oak plugs with cement in between, above which was placed scrap-iron to anchor the plugs securely in position. The remainder of the hole was filled up with broken rock and *débris*. In certain cases where a strong volume of water had to be dealt with, as at Ridgeway, a lead plug 3 feet in length was used and firmly driven into place.

Drilling timelines and rig count





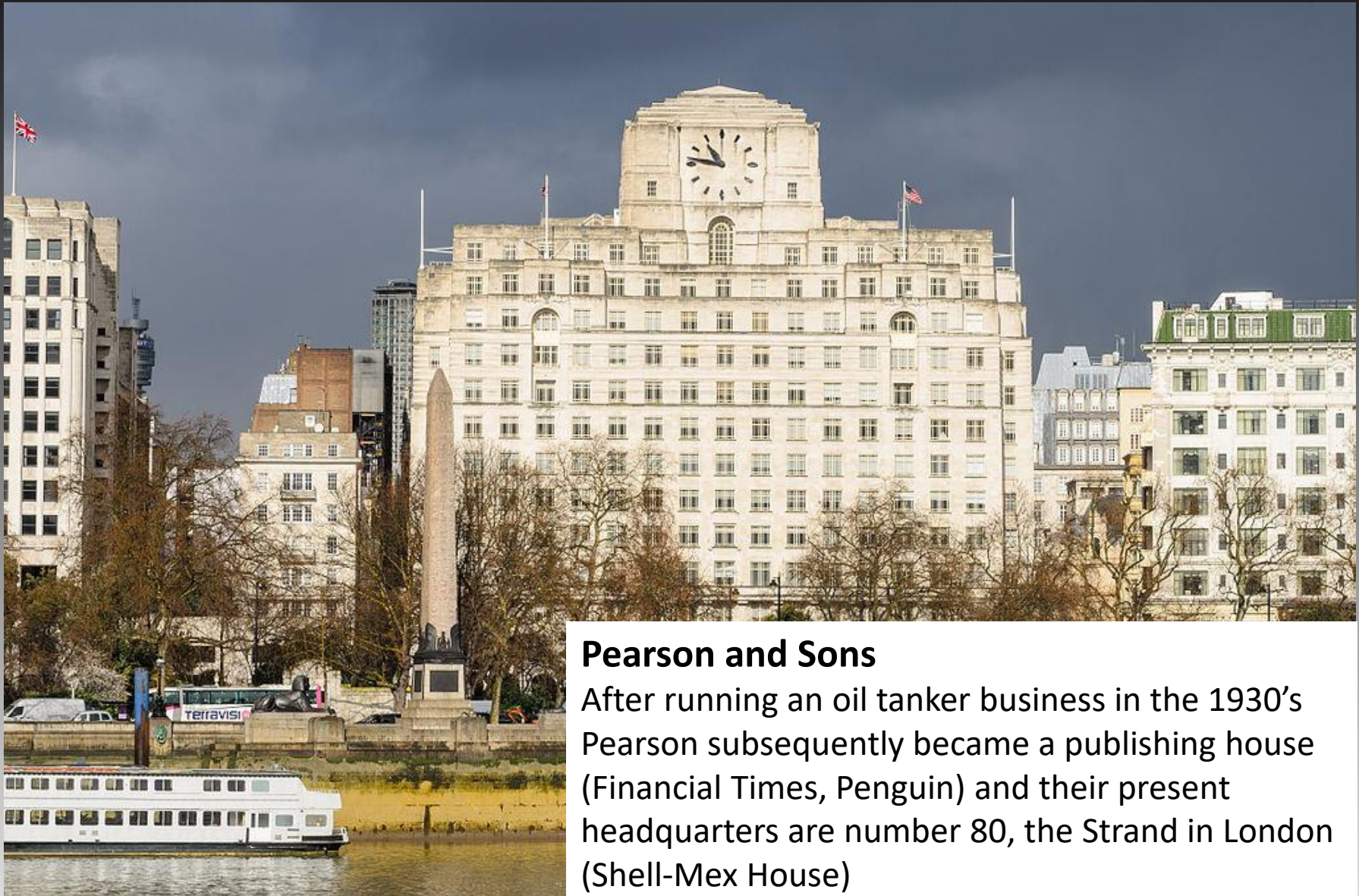
9th Duke of Devonshire

- Returned from Canada in 1921
- 1923: Won an injunction against HM Government regarding the mineral rights to the Hardstoft discovery.
- gained the mineral rights to his land after paying the Government for the equipment and the cost of the pillar of coal around the well to the colliery owner
- the present Duke of Devonshire remains the only UK landowner with mineral rights to his land



Sir John Cadman

- 1921: Technical advisor to the Anglo-Persian Oil Company
- 1923: Director
- 1925: Deputy Chairman
- 1927: Chairman



Pearson and Sons

After running an oil tanker business in the 1930's Pearson subsequently became a publishing house (Financial Times, Penguin) and their present headquarters are number 80, the Strand in London (Shell-Mex House)

Early attitude to exploration

The need for indigenous petroleum sources during the First World War led to a brief drilling campaign mainly aimed at the Carboniferous Limestone in anticlinal traps on the flanks of the Pennine uplift. By the time the drilling was under way the war was ending, but operations continued from 1918 to 1922, eleven wells being drilled but only one small oil discovery made at Hardstoft in north Derbyshire (Giffard, 1923; Ickes, 1923; Wade, 1928).

With strategic pressures this campaign came to an end and belief in the possibility of UK oil discovery faded, to the extent that an article in *Nature* (March 31, 1934, p.488) concluded:

‘Oil pools of commercial magnitude cannot reasonably be anticipated in any known area of Great Britain. Many years of official survey together with much independent work, leave few spots unknown, if not in detail, at least in sufficient outline to preclude even faint hope.’

From the first campaign to the present day: re-drilling the original prospects



First Licensing Round: 1985
CGG vibroseis crew acquiring seismic
for Fina Exploration near the University
of Keele in 1987

The 1930's and the rise of D'Arcy Exploration

- 1934: Sir John Cadman of Anglo-Persian proposed that the Government should simplify the ownership of oil and gas to make onshore prospecting practicable
- 1934: The Petroleum (Production) Act 1934 nationalised the oil and gas rights of the country. The exception being those belonging to the Duke of Devonshire
- 1935: Persia changed its name to Iran and Anglo-Persian followed suit, becoming the Anglo-Iranian Oil Company
- 1936: D'Arcy Exploration Company, the exploration subsidiary of Anglo-Iranian, acquired UK exploration licenses covering 6946 square miles (17,990 km²). Equal to approximately 74 UK North Sea blocks.

The licenses covered parts of:

Dorset, Hampshire, Wiltshire, Surrey, Sussex, the whole of the Isle of Wight, Nottinghamshire, Lincolnshire, Yorkshire, and the Midland Valley of Scotland.

Three other companies were awarded licenses.

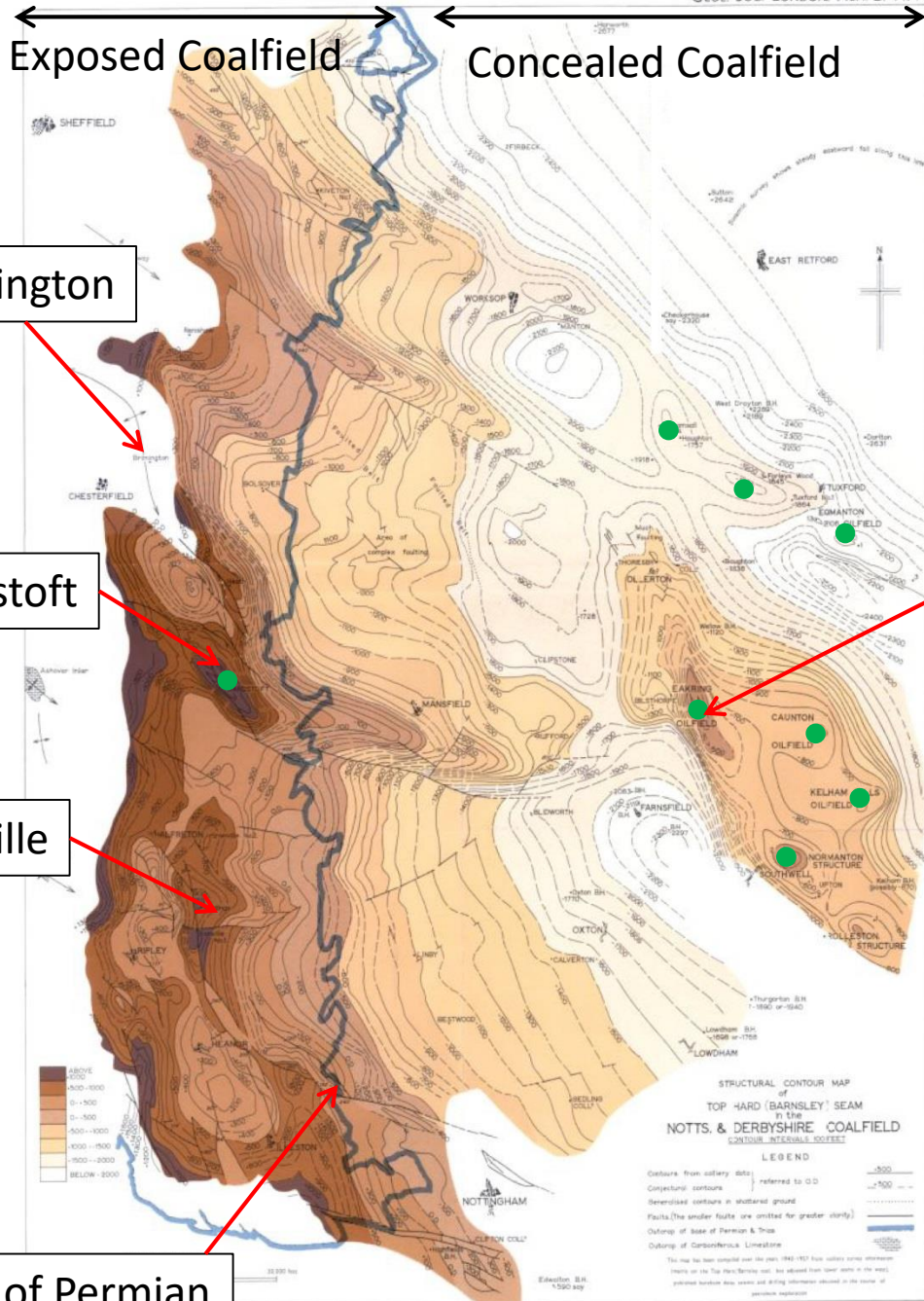
Exposed Coalfield Concealed Coalfield

Brimington

Hardstoft

Ironville

Base of Permian



Re-drilling the
Derbyshire structures

Eakring

- discovered in 1939 by D'Arcy
- required the use of Geophysics
- mainly gravity methods and refraction seismic

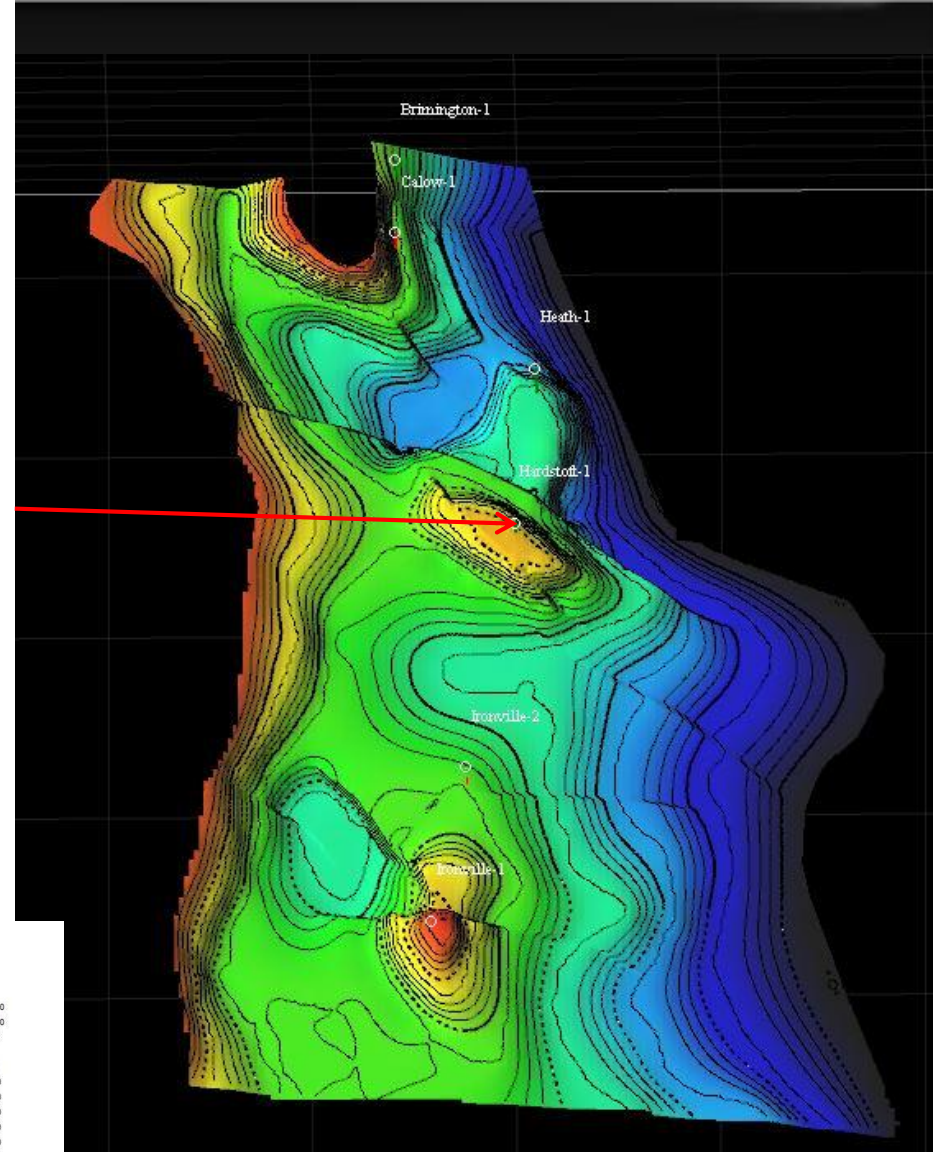
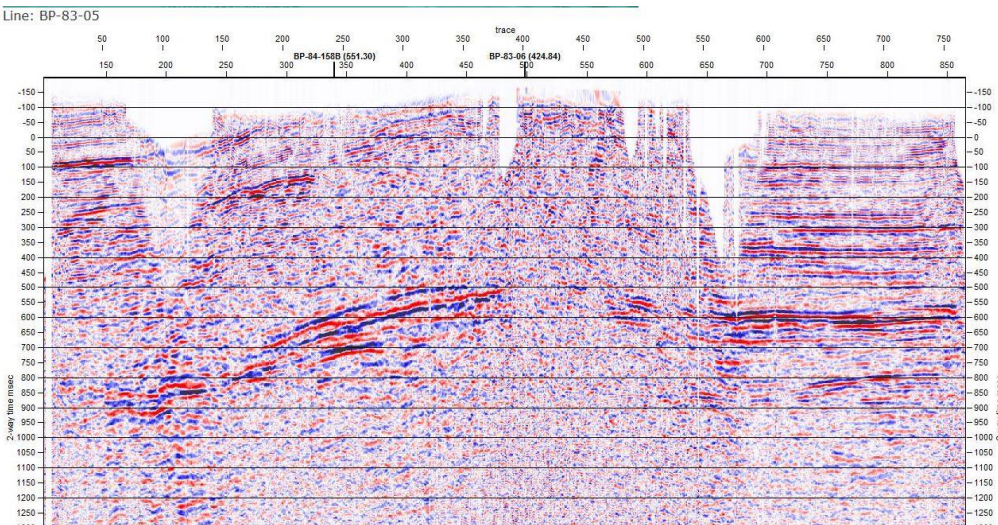
From Geol Soc Memoir 2.

Falcon and Kent (1960)

Geological results of Petroleum
Exploration in Britain 1945-1957

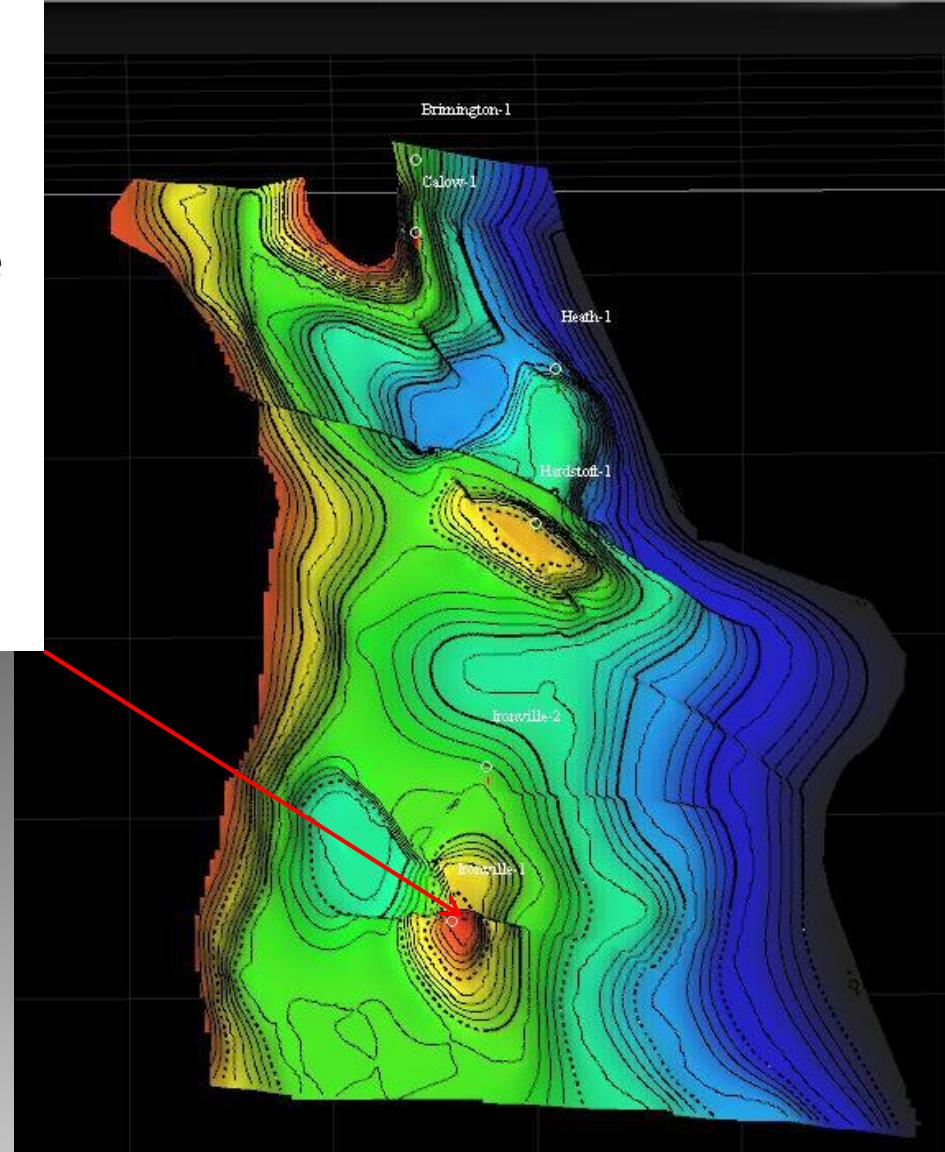
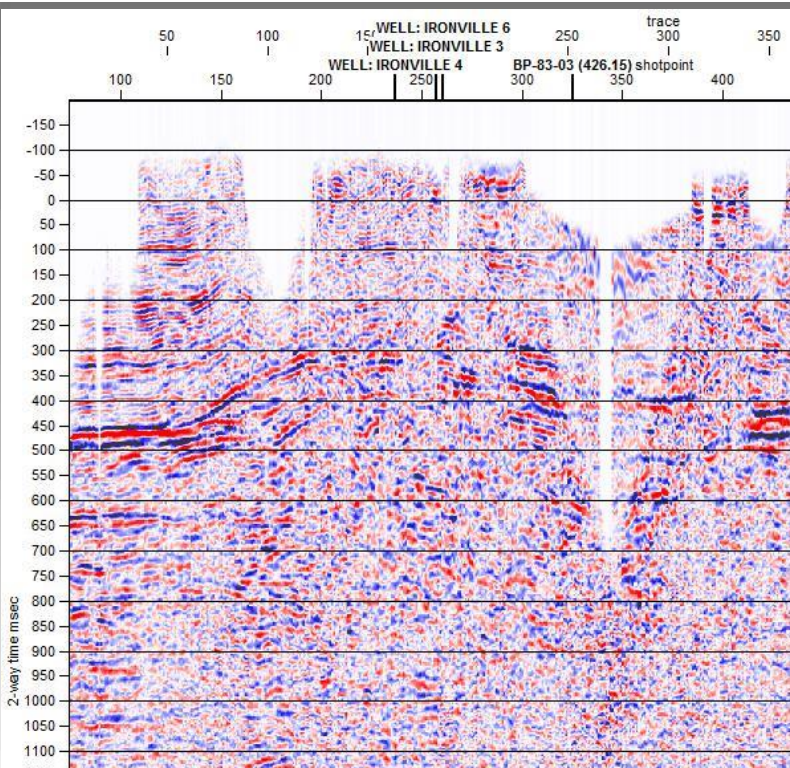
Hardstoft

- two more wells in the 1920's. No oil, but one produced gas at 20,000 cubic ft/day. Used to fuel boilers to heat the workers houses.
- pumped from 1927-37
- Subsequently acquired by D'Arcy and the well was acidised in 1938 which resulted in an initial increase to 75 barrels/day followed by a rapid decline to 15 barrels/day
- ceased production in 1945 and finally plugged and abandoned in 1952 after 27 years of production.



Ironville

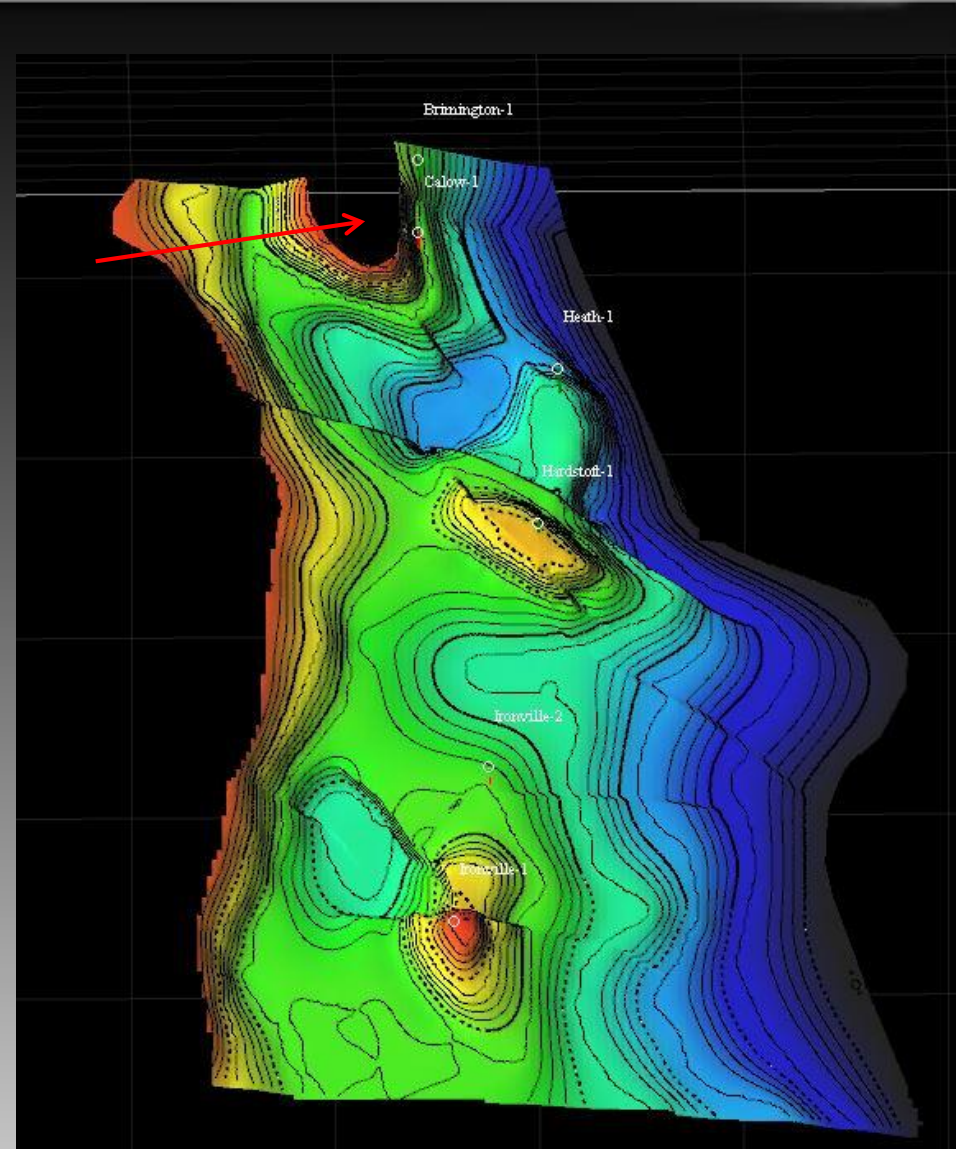
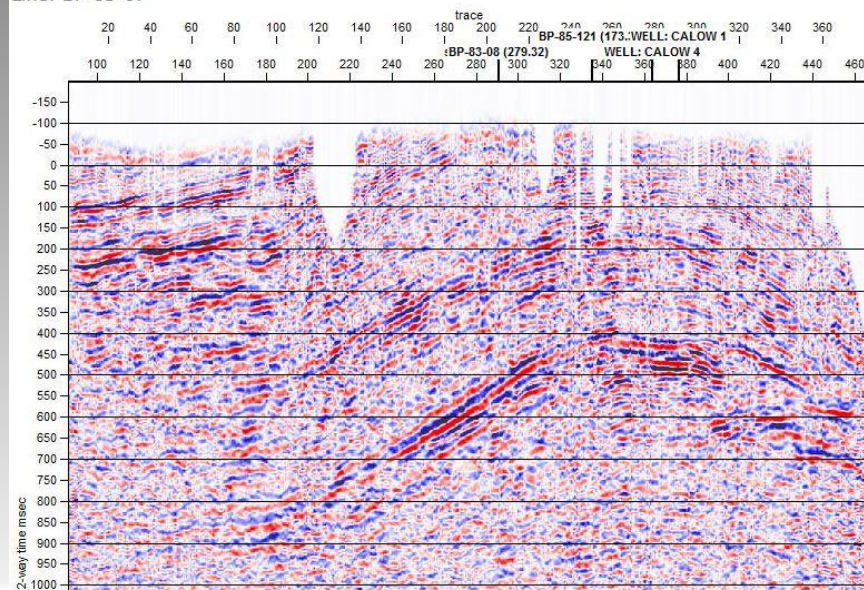
- drilled by BP in 1957-58 with gas and oil shows
- 2002: developed by Warwick Energy with onsite electricity generation from gas in the Lower Westphalian Crawshaw Sandstone
- sandstone was fracked
- Now depleted and the site has been restored



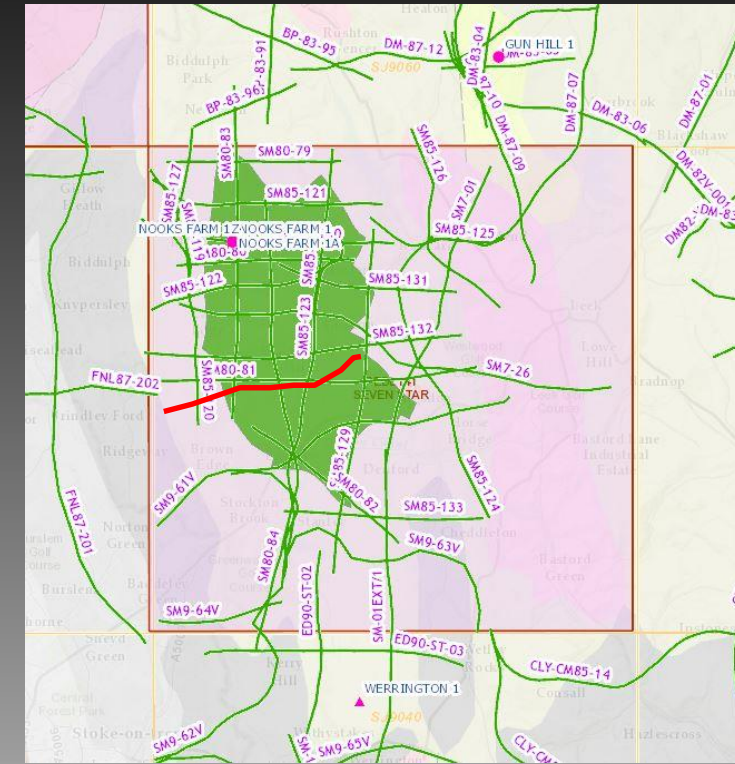
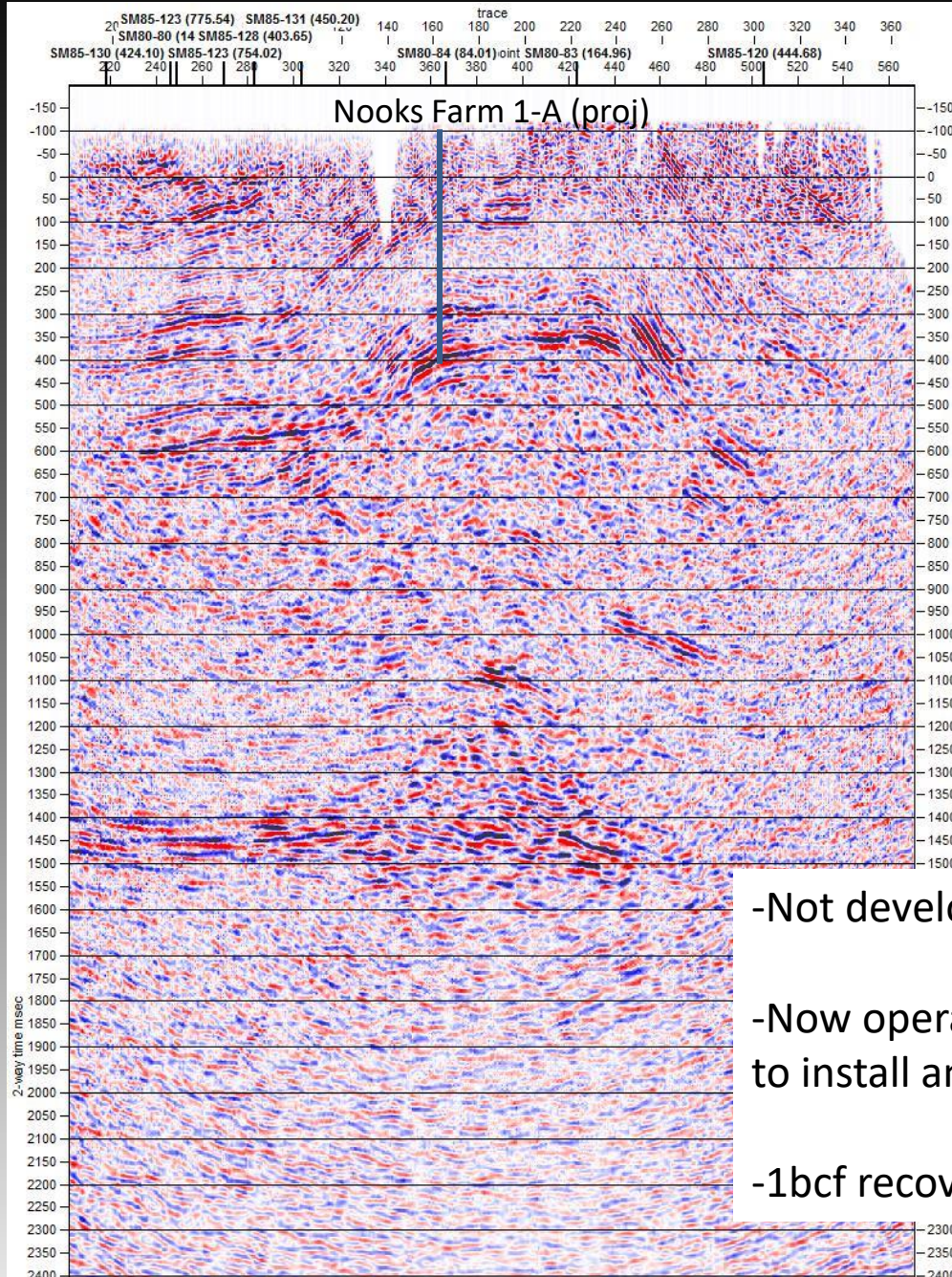
Calow (Brimington-1)

- drilled by BP with gas in the Upper Namurian Chatsworth Grit and the Lower Westphalian Crawshaw Sandstone. Re-named as the Calow gas field
- Gas supplied to Avenue Coke Works in Chesterfield, production of 280 million cubic feet from 1965-67
- Currently owned by Alkane Energy with plans for onsite electricity generation. Not granted planning permission in June 2014

Line: BP-83-07



Nooks Farm

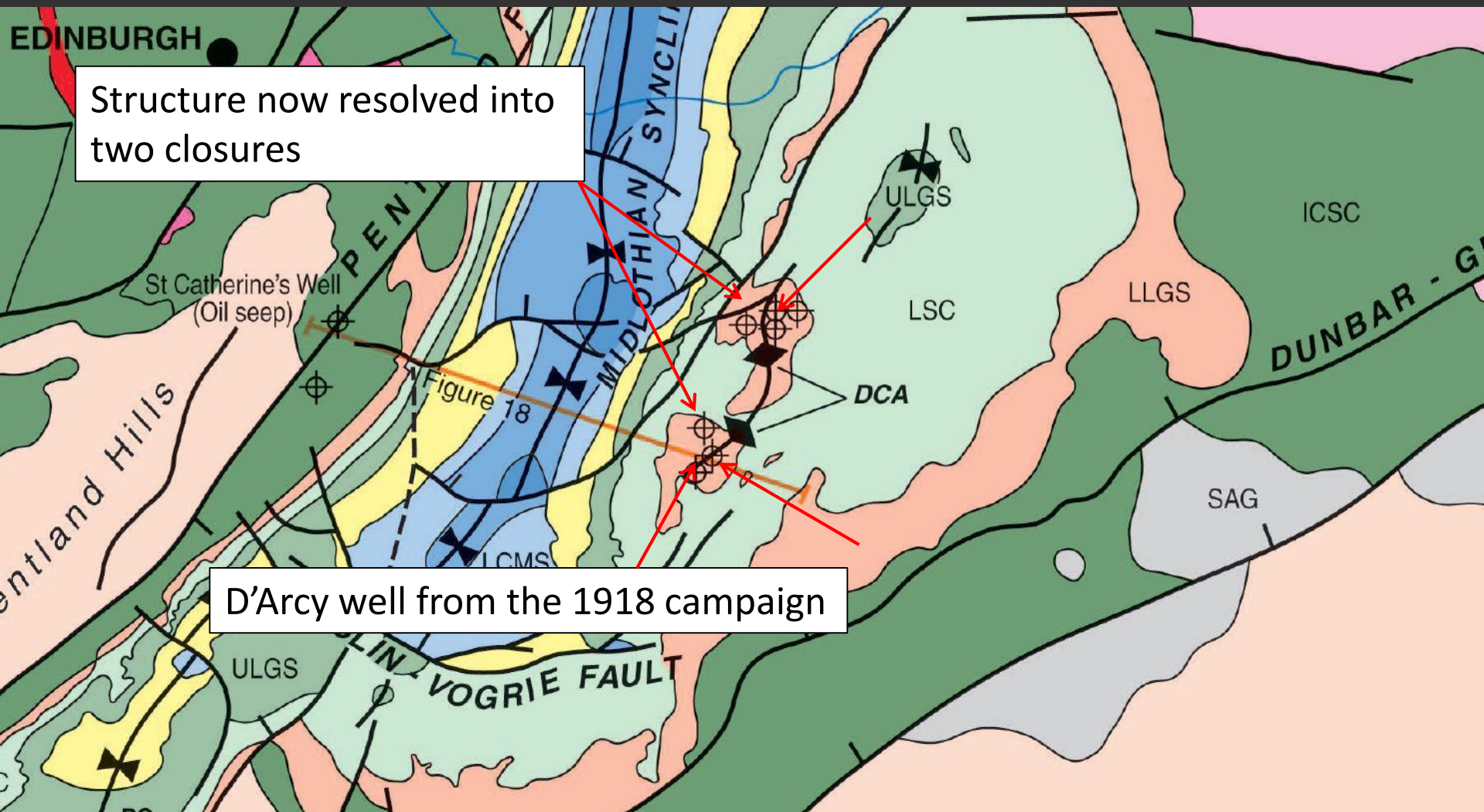


-Not developed by Shell

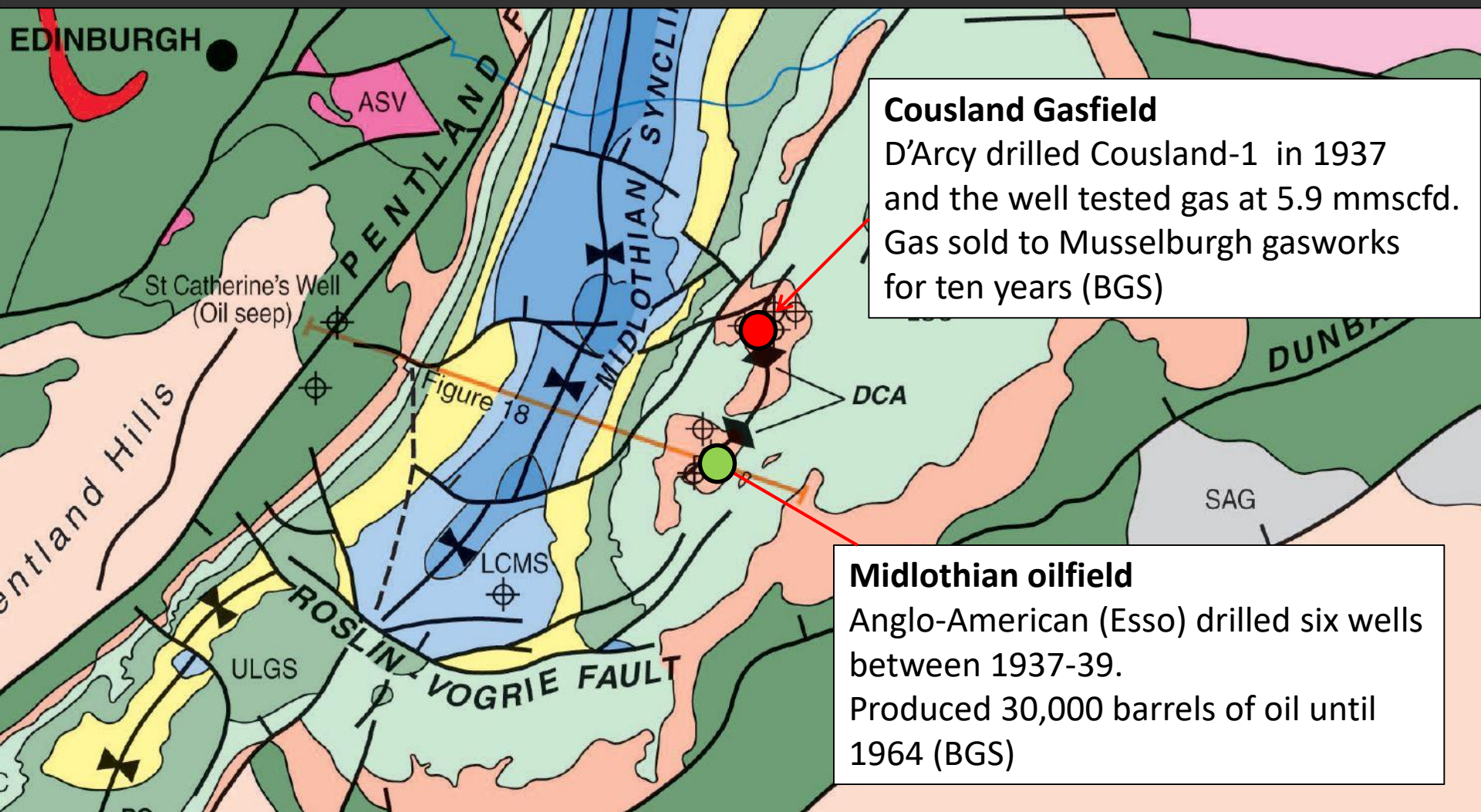
-Now operated by Alkane Energy who have plans to install an electricity generating station onsite

-1bcf recoverable

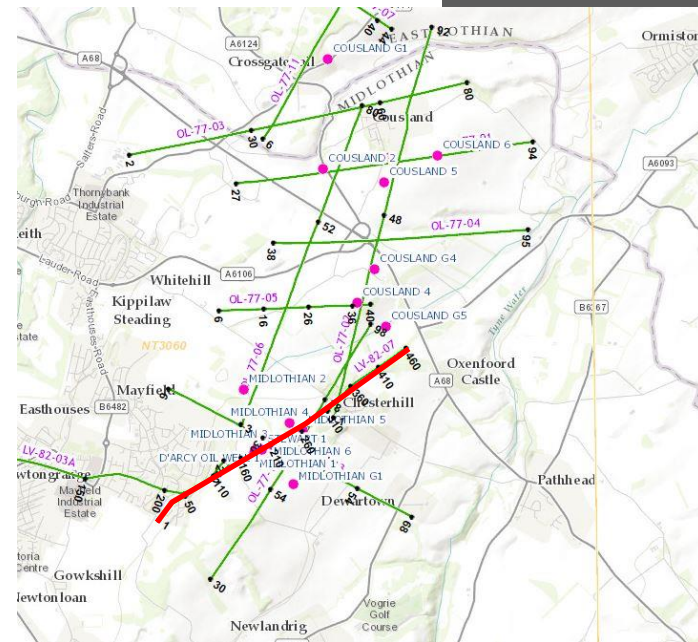
Midland Valley: re-drilling the D'Arcy structure

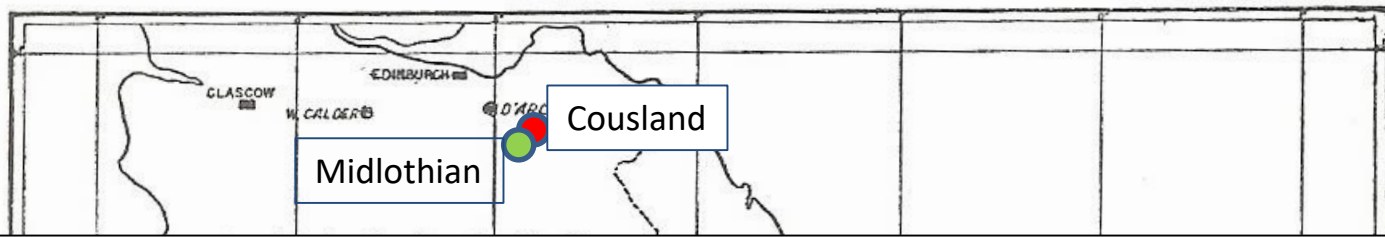


Midland Valley: re-drilling the D'Arcy structure



www.ukogl.org.uk





10 prospects drilled from 1918-1922:

Six fields

1 oilfield (Hardstoft) produced from 1919-1945

1 oilfield subsequently produced (Midlothian)

3 gas fields subsequently produced (Callow, Ironville and Cousland)

1 gas field with development plans (Nooks Farm)

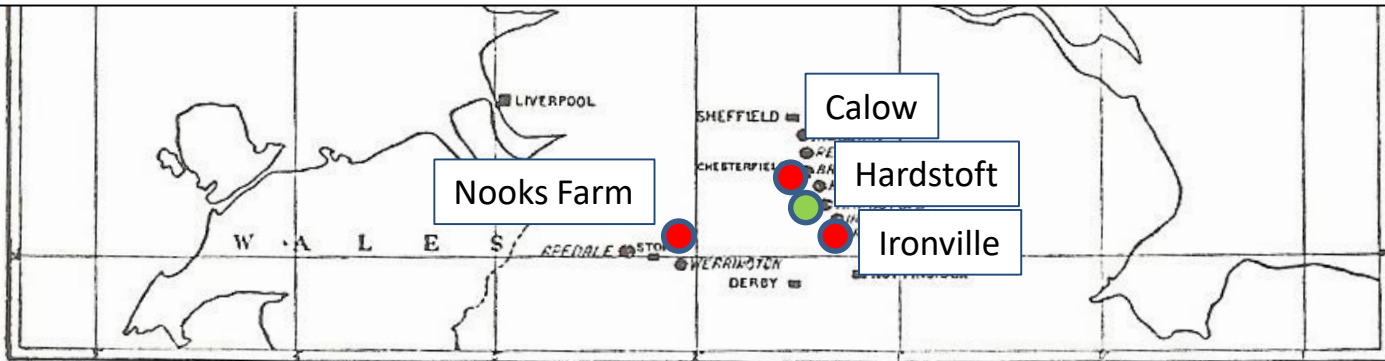


FIG. 1.—MAP SHOWING LOCATION OF OIL-WELLS.

Well post mortem

- Excellent selection of prospects.

Not so good with well locations-some wells were drilled off-structure.

The worst example being Werrington-1.

Probably due to the fact that this was the only target outside a worked coalfield.

Therefore, no structure maps

- incorrect assumption that the limestone was the main reservoir.

Oil in the limestone in Hardstoft turned out to be an anomaly.

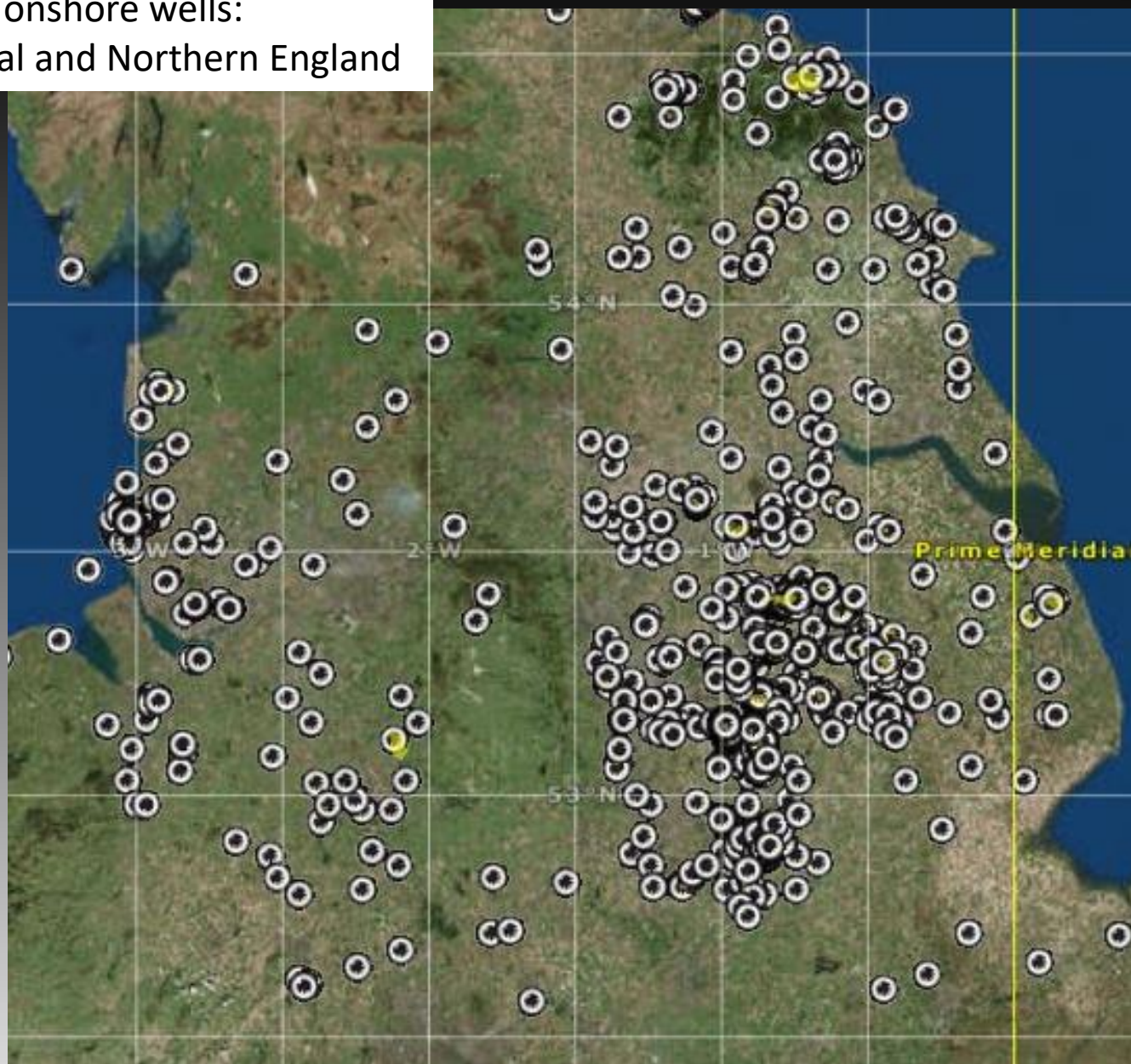
- D'Arcy subsequently had oil discoveries in Namurian and Lower Westphalian sandstones.

- incorrect assumption that the oil was derived from the limestone

The overlying Edale/Bowland shales are the source rock

- more gas than oil was discovered. **Why?**

DECC onshore wells: Central and Northern England



Two gas fields and one oil field west of the Pennines.
Conventional drilling clearly does not work in this area

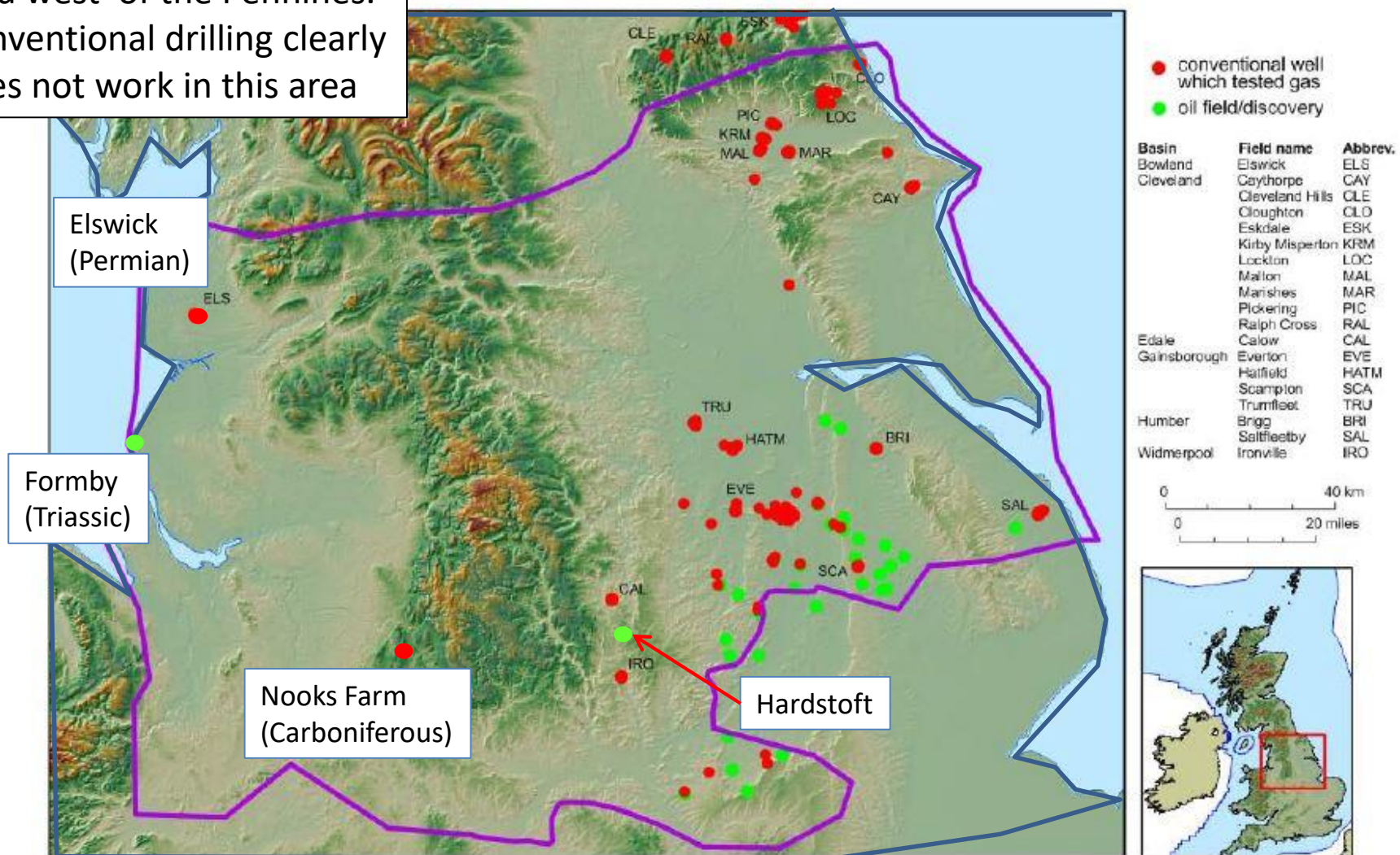


Figure 3. Distribution of wells (not including coal-related CBM or vent gas) which have tested gas and oil in central Britain (from DECC data).

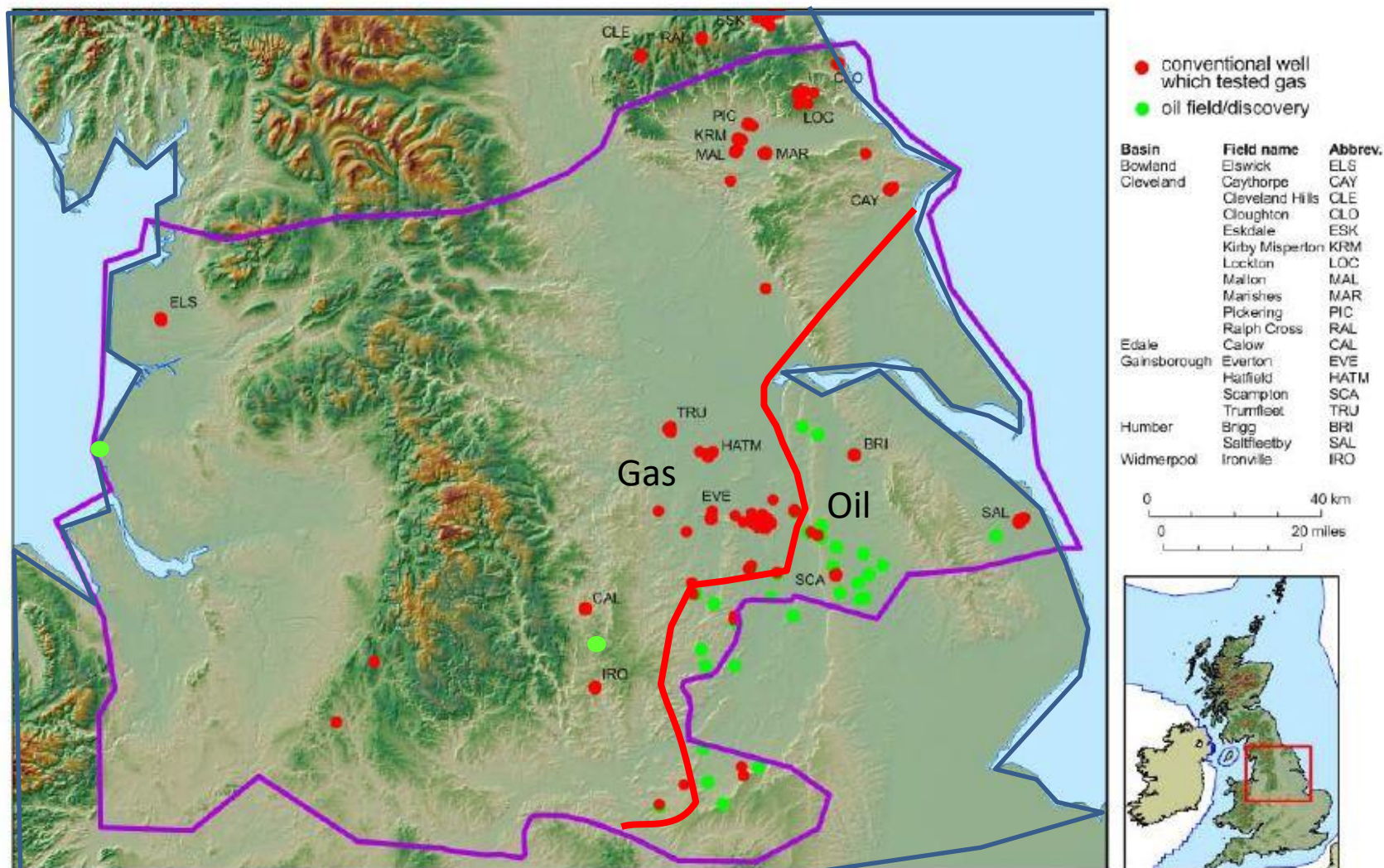
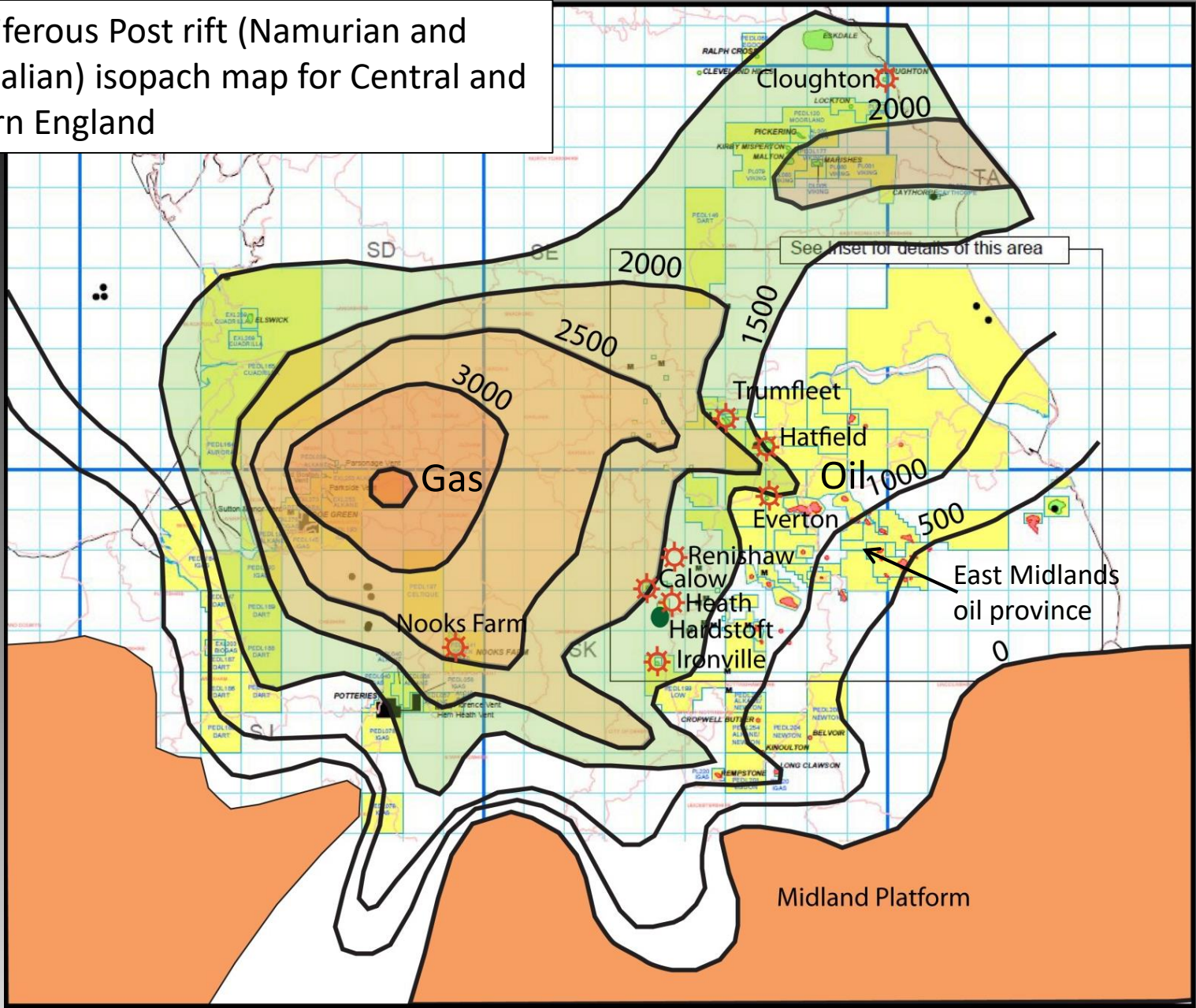


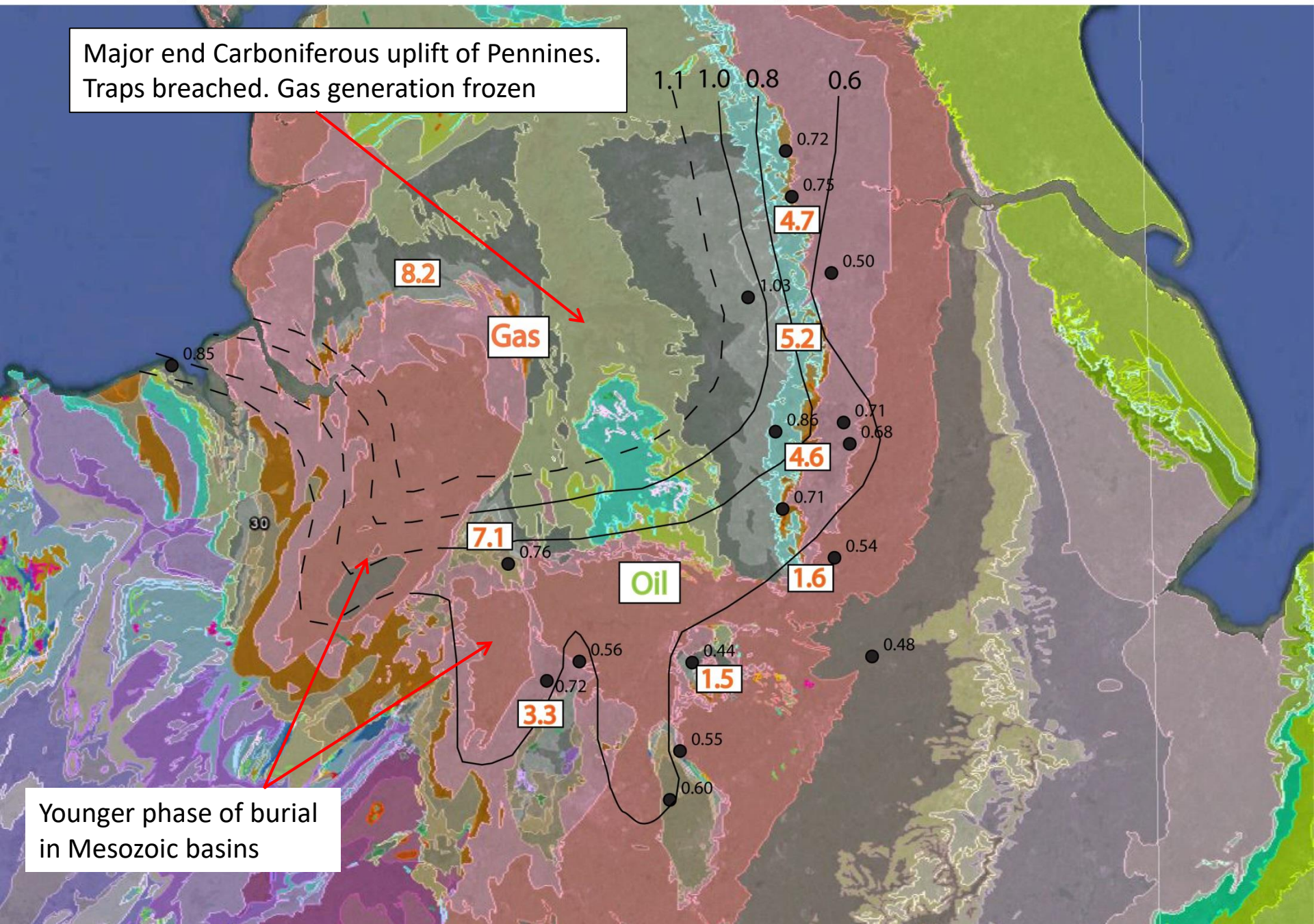
Figure 3. Distribution of wells (not including coal-related CBM or vent gas) which have tested gas and oil in central Britain (from DECC data).

Carboniferous Post rift (Namurian and Westphalian) isopach map for Central and Northern England

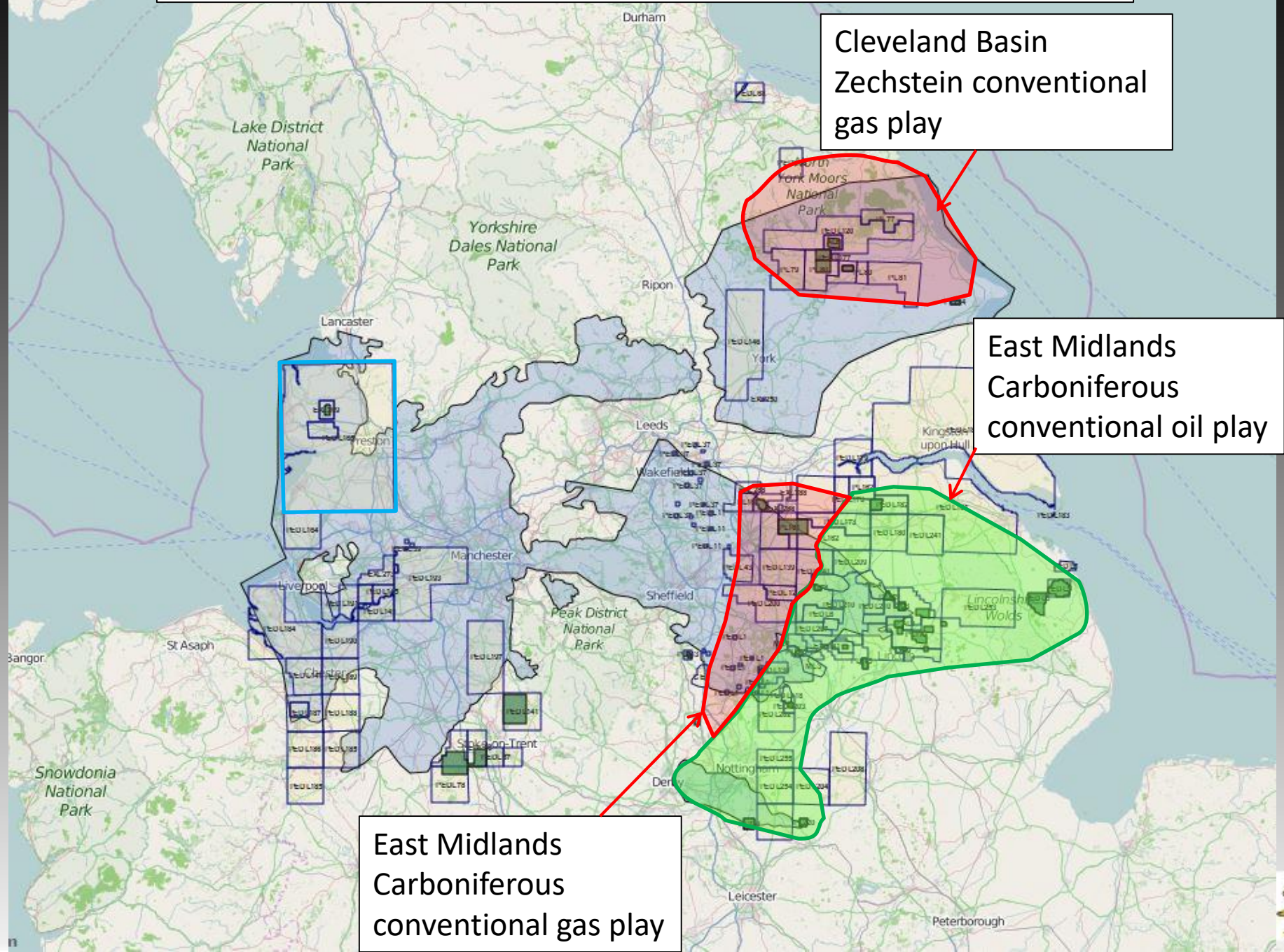


Westphalian Vitrinite reflectance (Black) and average coal gas content (red) in m³/ton

Major end Carboniferous uplift of Pennines.
Traps breached. Gas generation frozen



Why the 14th onshore round was the unconventional round



Why the 14th onshore round was the unconventional round

Areas prospective for shale gas from
DECC/BGS report
Gas mature but conventional play has failed.
Bowland Shale P50 GIIP 1329 tcf (DECC 2013)
UK North Sea has produced 84 tcf as at end of 2011

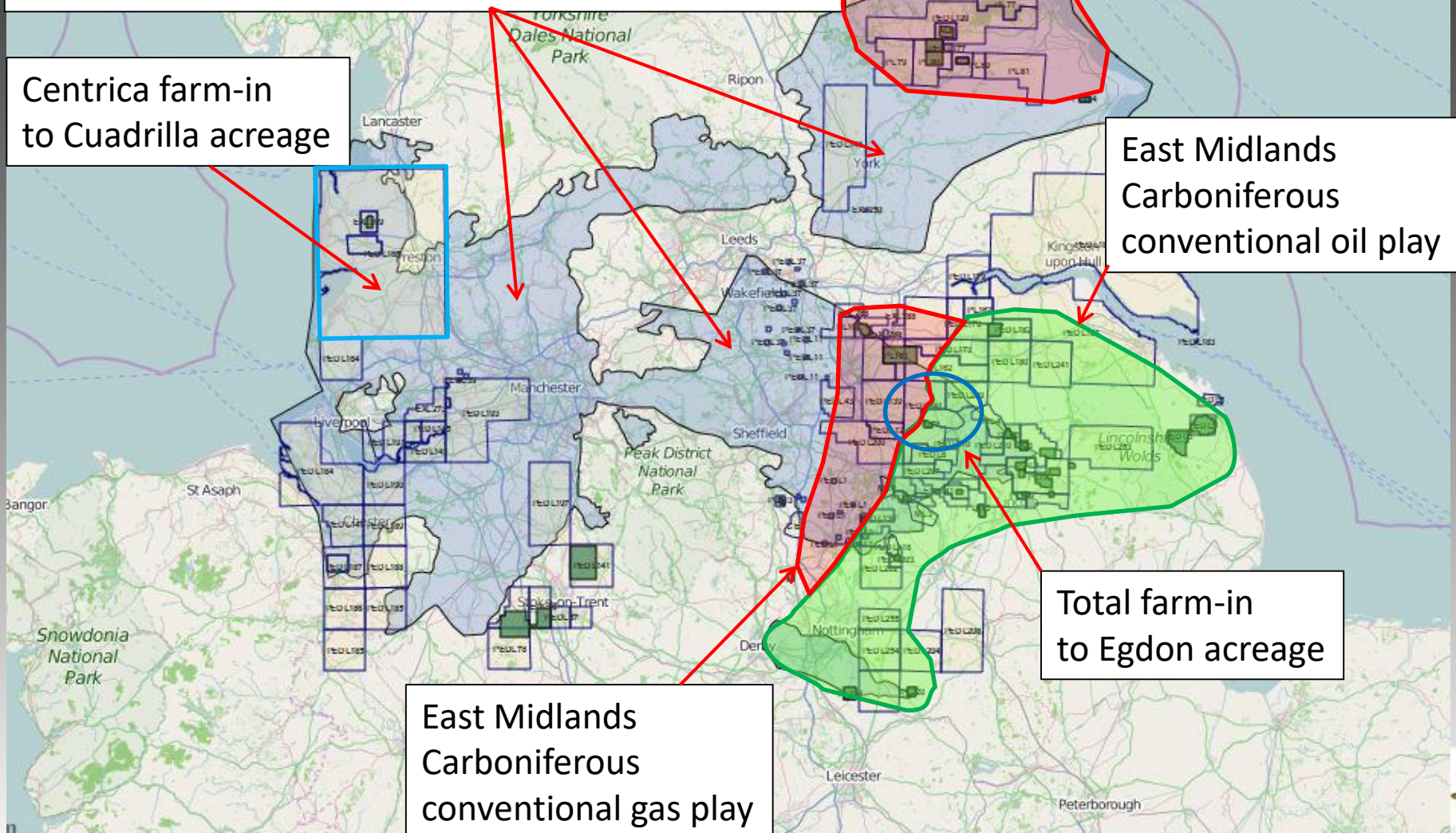
Cleveland Basin
Zechstein conventional
gas play

Centrica farm-in
to Cuadrilla acreage

East Midlands
Carboniferous
conventional oil play

East Midlands
Carboniferous
conventional gas play

Total farm-in
to Egdon acreage



Postscript: Hardstoft oilfield

