Shale resources in the south east of England – what lies beneath the surface?

The British Geological Society has published a report on the UK Jurassic shale of the Weald Basin: Geology Shale Oil and Shale Gas Resource Estimation. Here is a summary of the report that estimates that there is 2.2 billion and 8.6 billion barrels of oil in place.

Following the publication of shale gas resource estimates for the Carboniferous Bowland-Hodder shales (Andrews, 2013), this report is the second to address the potential distribution and in-place resources of unconventional oil and gas contained in shales beneath the UK.

No significant shale gas resource is recognised in the Jurassic of the Weald Basin. Marine shales were deposited in the Weald Basin at several intervals during the Jurassic (c.145-200 Ma). The basin is composed of several fault-controlled sub-basins, which form part of a wider basin that extended into northern France. It is geologically distinct from the Wessex Basin which lies to the south west, outside the study area.

Five units within the Jurassic of the Weald Basin contain organic-rich, marine shale: the Mid and Upper Lias Clays (Lower Jurassic) and the Oxford Clay, Corallian Clay and Kimmeridge Clay (Upper Jurassic). These attain gross shale thicknesses of up to 300 ft (90 m), 220 ft (67 m), 500 ft (150 m), 260 ft (80 m) and 1800 ft (550 m) respectively in the Weald Basin depocentre, and they contain varying amounts of organic matter. Conventional oil and gas fields in the basin attest to the capability of some of these units to produce hydrocarbons. It is possible that oil could have been generated from any or all of the five shales, but in the current model even the deepest Jurassic unit is not considered to have been sufficiently deeply buried to have generated significant amounts of gas. Some gas has been generated in association with oil and shallow biogenic gas may also be present.

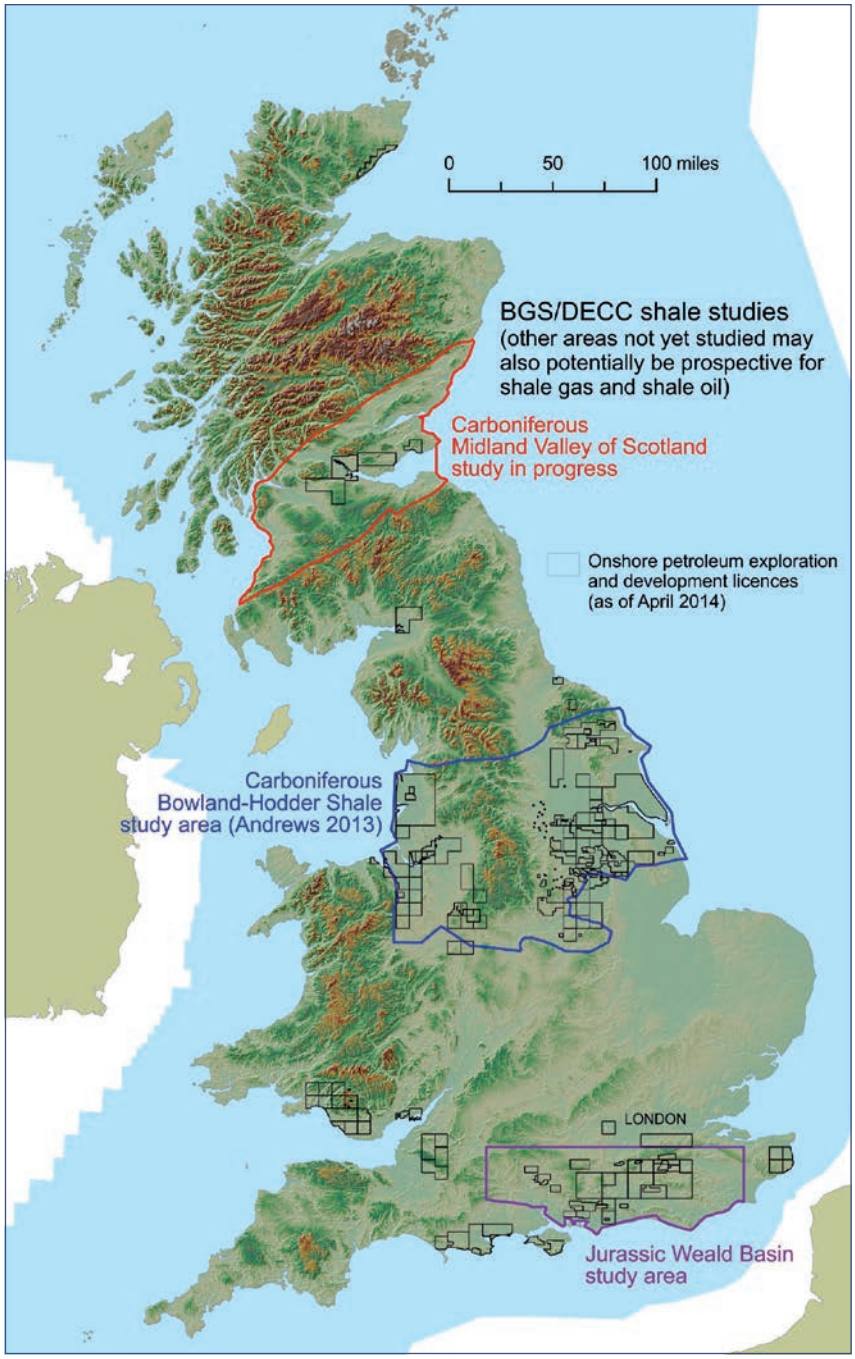

Figure 1 *Location of the BGS/DECC Weald study area in southern Britain, together with prospective areas for shale gas in northern Britain and currently licensed acreage. Other shale gas and shale oil plays may exist.*

Organic-rich shales occur at two levels in the Lias (Lower Jurassic) of the Weald; these have direct equivalents in the Paris Basin, although in the Weald they fail to reach the richness found in France.

In a third Lias unit, the Blue Lias (Lower Lias), total organic carbon (TOC) reaches 8% farther west in shales in the Wessex Basin, where it sources the Wytch Farm oilfield, but organic carbon contents are typically well below 2% in the equivalent limestones and shales of the study area. This contrast in organic content may result from differences in palaeogeography and organic input or preservation between the basins. The most significant organic-rich shales in the Weald Basin occur in the lowermost Oxford clay (TOC up to 7.8%) and middle Kimmeridge clay (TOC up to 21.3%) and these represent potential 'sweet-spots' worthy of further investigation.

None of the Jurassic shales analysed by Rock-Eval methodology in the Weald Basin has an 'oil saturation index' (S1*100/TOC) of greater than 50, i.e., much of the 'oil' may be physically associated with kerogen, rather than present in pore space. This is low in comparison to shale oil-producing areas in North America, so it may be that only limited amounts of shale within the Jurassic of the Weald Basin have any potential to produce oil in commercial quantities. However, after correcting for the evaporation of light hydrocarbons since the sample was taken, it may be that some horizons within the Mid and Upper Lias, lower Oxford clay and Kimmeridge clay exceed the 100 required for the oil to be producible. Also, the fact that oil has migrated into conventional reservoirs suggests that optimum conditions are reached at least locally within the basin. Interpreting the presence of producible oil in the organic-rich shales allows for an in-place resource volume to be calculated with a broad range of probabilities.

The maturity of the shales is a function of burial depth, heat flow and time. In this study, the Jurassic shales are considered mature for oil generation (vitrinite reflectance, Ro, values between 0.6% and 1.1%) at depths between approximately 7000-8000 ft (2130-2440 m) and 12000-13000 ft (3660-3960 m) (where there has been minimal uplift). However, southern Britain experienced a phase of significant uplift in Cenozoic times, due to basin inversion, that has raised the mature shales by up to 6750 ft (2060 m) to shallower present-day depths than would otherwise be expected. However, even the Lias shales are unlikely to have attained sufficient maturity to allow for significant gas generation.

Where they have been buried to a sufficient depth for the organic material to generate oil, all five prospective shales are considered to have some potential to form a shale oil resource analogous, but on a smaller scale, to the producing shale oil provinces of North America (e.g., Barnett, Woodford and Tuscaloosa).

Hybrid conventional/shale oil plays with low-porosity and impermeable rocks juxtaposed against mature shales may also represent a favourable exploration target in the Weald Basin; these have also proven successful in the North America (e.g., the Bakken oil system). The oil resources potentially present in these plays are not included in the in-place oil volumes in this report.

The total volume of potentially productive shale in the Weald Basin was estimated using a 3D geological model generated using seismic mapping, integrated with borehole information. This gross volume was then reduced to a net mature organic-rich shale volume using a maximum, pre-uplift burial depth corresponding to a vitrinite reflectance cut-off of 0.6% (modelled at 7000 ft/2130 m, and 8000 ft/2440 m). This volume was further truncated upwards at two alternative levels – firstly, at a depth of c.3300 ft (1000 m) (as proposed by USEIA 2013) and secondly at a depth of c.5000 ft (1500 m) below land

	Total oil in-place estimates (billion bbl)		Total oil in-place estimates (million tonnes)	
	With top of oil window at 7000 ft (2130 m) maximum burial depth	With top of oil window at 8000 ft (2440 m) maximum burial depth	With top of oil window at 7000 ft (2130 m) maximum burial depth	With top of oil window at 8000 ft (2440 m) maximum burial depth
Kimmeridge Clay	0.41 – 2.03 – 4.77	0.11 – 0.61 – 1.44	55 – 270 – 636	15 – 81 – 192
Corallian Clay	0.20 – 0.52 – 1.04	0.11 – 0.30 – 0.61	27 – 69 – 139	15 – 40 – 81
Oxford Clay	0.59 – 1.39 – 2.46	0.41 – 0.96 – 1.70	79 – 185 – 328	55 – 128 – 227
Upper Lias Clay	0.28 – 0.63 – 1.05	0.22 – 0.52 – 0.85	37 – 84 – 140	29 – 69 – 113
Mid Lias Clay	0.33 – 0.79 – 1.43	0.27 – 0.64 – 1.15	44 – 105 – 191	36 – 85 – 153
All Jurassic clay units	**2.2 – 4.4 – 8.6**		**293 – 591 – 1143**	

Table 1 *Estimates of the total potential in-place shale oil resource in the Jurassic Weald study area. P90, P50 and P10 values are given for each unit, where P10 is the most optimistic scenario. This estimate only covers unconventional oil, and excludes volumes in potential tight conventional or hybrid play*

surface (as proposed by Charpentier & Cook, 2011 for shale gas). This is a regionally applied cut-off; the depth at which shale oil (or shale gas) productivity becomes an issue in terms of pressure and hydrogeology will need to be addressed locally.

The volumes of potentially productive shale and average oil yields were used as the input parameters for a statistical calculation (using a Monte Carlo simulation) of the in-place oil resource. Two scenarios were modelled for each shale unit (Table 1).

This study offers a range of total in-place oil resource estimates for the various Jurassic shales of the Weald Basin of 2.2 – 4.4 – 8.6 billion bbl (0.29 – 0.59 – 1.14 billion tonnes) (P90 – P50 – P10). In time, the drilling and testing of new wells will give an understanding of achievable, sustained production rates. These, combined with other non-geological factors such as oil price, operating costs and the scale of development agreed by the local planning system, will allow estimates of the UK's producible shale oil reserves to be made.

There is a high degree of uncertainty in these figures. Indeed, there is a chance that there may be little or no 'free oil', given that the 'oil saturation index' is considerably less than 100 (see Jarvie, 2012) and what oil there is could be located entirely within the kerogen particles and would thus require heating/retorting to extract it. In these circumstances, the resource could no longer be categorised in terms of 'shale oil'. The potential for hybrid plays in which oil might have migrated into tight reservoirs adjacent to mature shale is acknowledged, but the potential volumes of oil trapped in such plays is not addressed in this report.

Later in 2014 the Carboniferous shales of the Midland Valley of Scotland will be the subject of a further BGS/DECC report. To download the full report go to: www.bgs.ac.uk/shalegas/.

References

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