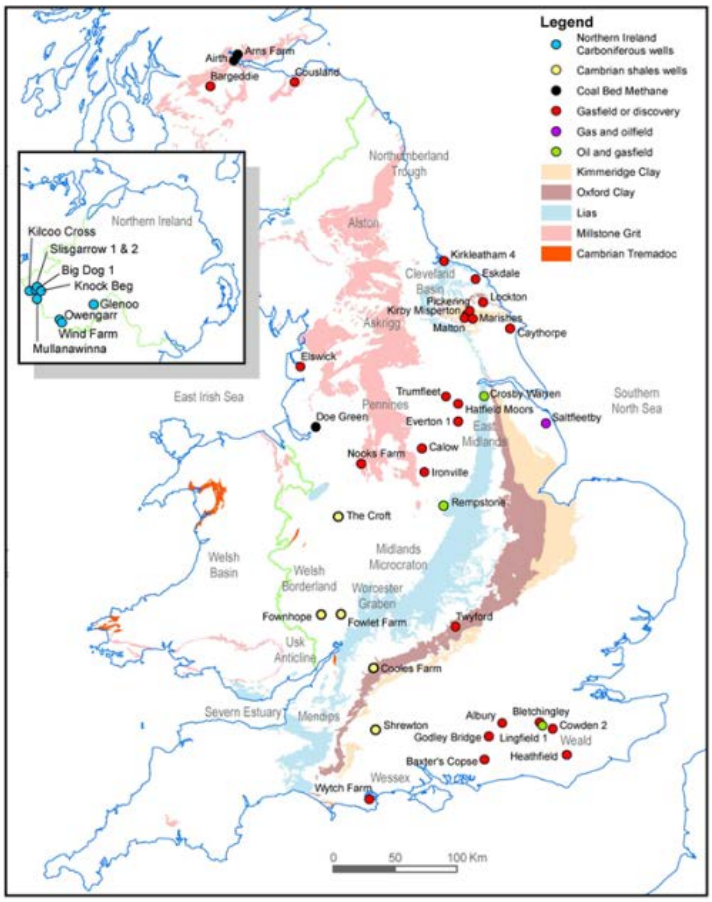
Physical resources

Fracking in the UK; will it happen? (*June 2014*)

Whether or not one has read the *Tractatus Logico-Philosophicus* of Ludwig Wittgenstein, there can be little doubt that one of his most famous quotations can be applied to much of the furore over hydraulic fracturing (fracking) of hydrocarbon-rich shale in south-eastern Britain: '*Whereof one cannot speak, one must remain silent*'. That sentiment was more pithily expressed by Mark Twain as '*Better to remain silent and be thought a fool than to speak and remove all doubt*'. A press release by the British Geological Survey in late May 2014 caused egg to appear on the shirts of both erstwhile 'frackmeister' David Cameron (British Prime Minister) and anti-fracking protestors in Sussex. While there are oil shales beneath the Weald, these Jurassic rocks have never reached temperatures sufficient to generate any significant gas reserves (see: Upfront, *New Scientist*, 31 May 2014 issue, p. 6). Yet BGS estimate the oil shales to contain a total of 4.4 billion barrels of oil. That might sound a lot, but the experience of shale fracking companies in the US is that, at best, only about 5% can be recovered and, in cases that are geologically similar to the Weald, as little as 1% might be expected. Between 44 and 220 million barrels is between two and six months' worth of British oil consumption; and that is only if the entire subcrop of Wealden shales is fracked.



Areas where petroleum-rich shales occur at the surface in Britain. (Credit: British Geological Survey)

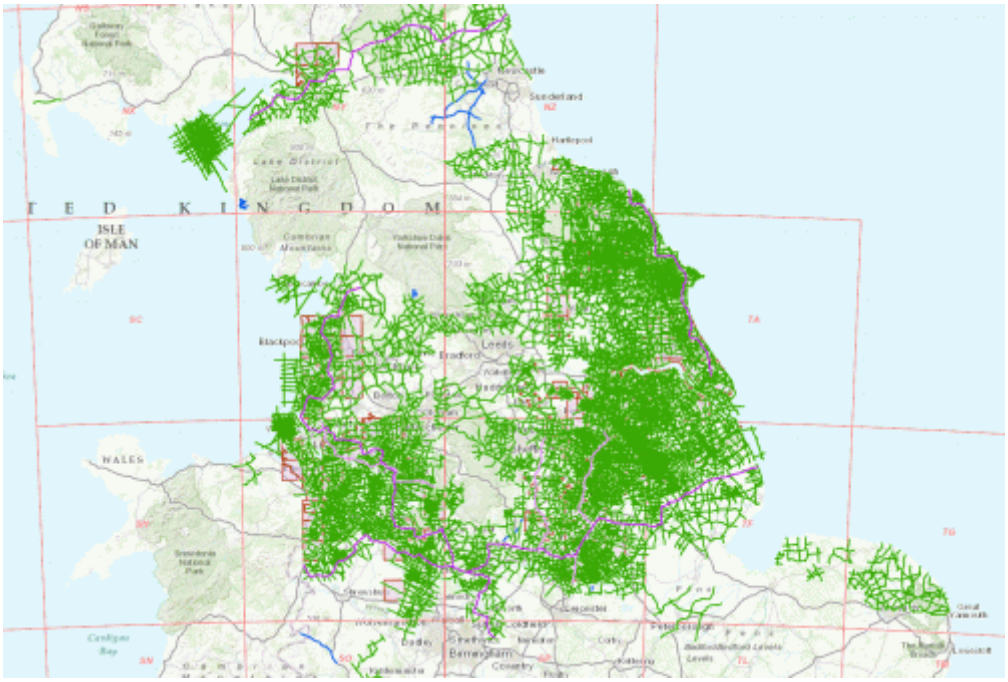
Why would any commercial exploration company, such as Cuadrilla, go to the trouble of drilling wells, even of an 'exploratory nature', for such meager potential returns? Well, when there is sufficient hype, and the British Government has gushed in this context for a few years, bigger fish tend to bite and cash flows improve. For instance, Centrica the owner of British Gas forked out $160 million to Cuadrilla in June 2013 for a quarter share in the well-publicised licence area near Blackpool in Lancashire; the grub stake to allow Cuadrilla to continue exploration in exchange for 25% of any profit should commercial quantities of shale-gas be produced.

Sedimentary rock sequences further north in Britain whose geological evolution buried oil shales more deeply are potential gas producers through fracking; an example is the Carboniferous Bowland Shale beneath the Elswick gasfield in west Lancashire, targeted by Cuadrilla. Far greater potential may be present in a large tract of the Pennine hills and lowlands that flank them where the Bowland Shale occurs at depth.

Few people realize just how much detail is known about what lies beneath their homes apart from maps of surface geology. That is partly thanks to BGS being the world's oldest geological survey (founded in 1835) and partly the sheer number of non-survey geologists who have prowled over Britain for 200 years or more and published their findings. Legally, any excavation, be it an underground mine, a borehole or even the footings for a building, must be reported to BGS along with whatever geological information came to light as a result. The sheer rarity of outcropping rock in Britain is obvious to everyone: a legacy of repeated glaciation that left a veneer of jumbled debris over much of the land below 500m that lies north of the northern outskirts of the London megalopolis. Only highland areas where glacial erosion shifted mullock to lower terrains does bare rock occupy more than 5% of the surface. Of all the data lodged with BGS by far the most important for assessing the rock type and structure at depth are seismic surveys, which use shock waves generated by vibrating plates deployed on specialized trucks. These and the cables that connected hundreds of detectors were seen along major and minor roads in many parts of Britain during the 1980s during several rounds of licenced onshore exploration for conventional petroleum resources. That the strange vehicles carried signs saying Highway Maintenance lulled most people, apart from professional geologists, as regards their actual purpose. Over 75 thousand kilometers of seismic sections that penetrated thousands of metres into the Earth now reside in the UK Onshore Geophysical Library. An interactive map at UKOGL allows you to see details of these surveys, current areas licenced for exploration and the locations of various petroleum wells by ticking the appropriate boxes.

Such is the detail of geological knowledge that estimates of any oil and gas, conventional or otherwise, residing beneath many areas of Britain are a lot more reliable than in other parts of the world that have not had a vibrant onshore petroleum industry. So you can take it that when the BGS says there is such and such a potential for oil or gas beneath this or that stretch of rural Britain they are pretty close to the truth. Yet it is their raw estimates that are most often publicized; that is, the estimated *total* volumes. Any caveats are often ignored in the hype that follows such an announcement. BGS recently announced that as much as 38 trillion cubic metres of gas may reside in British shales, much in the north of England. There followed a frenzy of optimism from Government sources that this 40 years' worth of shale gas would remove at a stroke Britain's exposure to the world market of natural gas,

currently dominated by Russia, and herald a rosy economic future to follow the present austerity similar to the successes of shale-gas in North America.



Seismic survey lines in northern England (green lines) from the interactive map at the UK Onshore Geophysical Library

Equally, there has been fear of all kinds of catastrophe from fracking on our 'tight little island' especially amongst those lucky enough not to live in urban wastelands. What was ignored by both tendencies was reality. In the US, fracking experience shows that only 10% at most of the gas in a fractured shale can be got out; even the mighty Marcellus Shale of the NE US underlying an area as big as Britain can only supply 6 years of total US gas demand. Britain's entire shale-gas endowment would serve only 4 years of British gas demand.

To tap just the gas in the upper part of the Bowland basin would require 33 thousand fracking wells in northern Britain. Between 1902 and 2013 only 19 onshore petroleum wells were drilled here in an average year. To make any significant contribution to British energy markets would require 100 wells per annum at a minimum. Yet, in the US, the flow rate from fracked wells drops to a mere zephyr within 3 years. Fracking on a large scale may well never happen in Britain, such are the largely unstated caveats. But the current hype is fruitful for speculation that it will, and that can make a lot of cash sucked in by the prospect – without any production whatsoever.

Related articles: Carbon Briefing: the what, where, and how much of UK shale oil (carbonbrief.org); The cost of fracking Britain (bbc.co.uk)

Serious groundwater depletion in western US (*August 2014*)

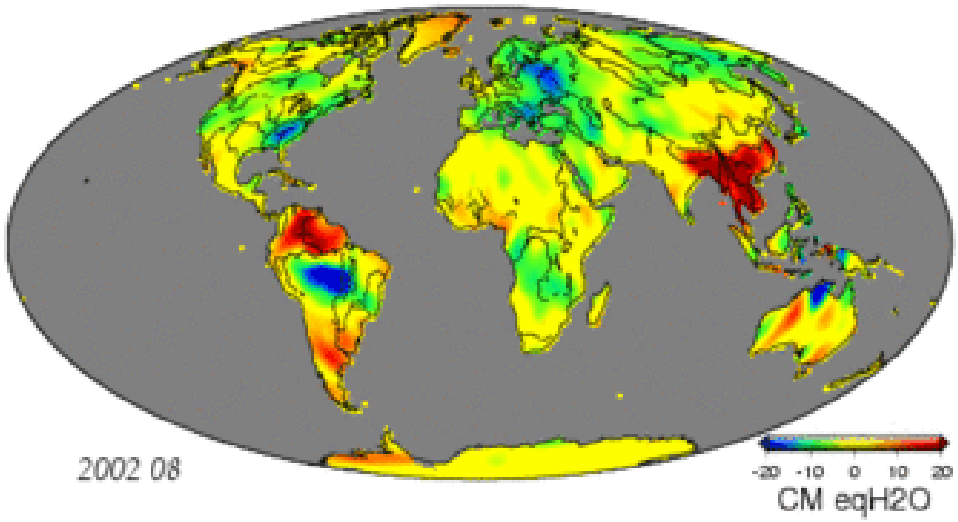
The 2300 km long Colorado River, whose catchment covers most of Arizona and parts of the states of Colorado, California, Nevada, Utah, New Mexico and Wyoming, is one of the world's most harvested surface water resources. So much so that barely a trickle now ends up in Baja California where the huge river once flowed into the sea. The lower reaches of

the river system cross arid lands and it is the water source for several major cities and areas of intensive agriculture, serving as many as 40 million people and 16 thousand km^2 of irrigated fields. It has been nicknamed the US Nile because of its economic importance, but Egypt's Nile has far less pressure put on it, although its exit flow to the Mediterranean is also hugely reduced from its former peak volume. The water crisis affecting the Colorado River and the areas that it serves has peaked during the 14-year drought over its lower reaches. To ease conditions in the former wet lands of Mexico near the river's outlet 2014 saw deliberate major releases from giant reservoirs higher in the Colorado's course.

The Colorado River Basin

Surface abstraction is not the only drain on water resources of the Colorado River basin: groundwater pumping from the sediments beneath has grown enormously for both irrigation and urban use. That it is possible to play golf at many courses in the desert and to see monstrous musical fountains in Las Vegas is down largely to groundwater exploitation. There have been concerns about depletion of underground reserves once abstraction outpaced natural recharge by infiltration of rainfall and snow melt. However, highlighting the magnitude of the problem required a rather dramatic discovery: so much water has been lost from aquifers that the missing mass has reduced the Earth's gravitational field over the south-west US (Castle, S.L. *et al*. 2014. Groundwater depletion during drought

threatens future water security of the Colorado River Basin. *Geophysical Research Letters*, doi: 10.1002/2014GL061055).



Data from GRACE showing changes in groundwater from 2003 to 2009

The evidence comes from the Gravity Recovery and Climate Experiment (GRACE), jointly funded by NASA and Germany's DLR and launched in March 2002. GRACE uses two satellites that follow the same orbit with a spacing of 220 km between them. Range finders on each measure their separation distance, and so their ups and downs as gravity varies, with far greater accuracy than any other method. Measuring the Earth's entire gravitational field at their orbital height takes about a month. Groundwater depletion beneath the Gangetic Plains of northern India, to the tune of 109 km^3, was detected in 2009 and the same approach has been applied to the Colorado Basin for nine years between 2004 and 2013. It shows that during this part of one of the longest droughts in the history of the south-west US 50 km^3 have been lost from beneath, as a rate of about 5.5 km^3 per year. Though the total is half the loss from beneath northern India, it should be remembered that more than ten times as many people depend on the Ganges Basin.