The expertise of Professor Paul Younger – Part 3. Hydrogeology of fracking (Part B) (https://web.archive.org/web/20230601163515/http://www.davidsmythe.org/frackland/?p=312)

Posted on 3rd February 2017 (https://web.archive.org/web/20230601163515/http://www.davidsmythe.org/frackland/?p=312) by Professor David Smythe (https://web.archive.org/web/20230601163515/http://www.davidsmythe.org/frackland/?author=1)

Introduction

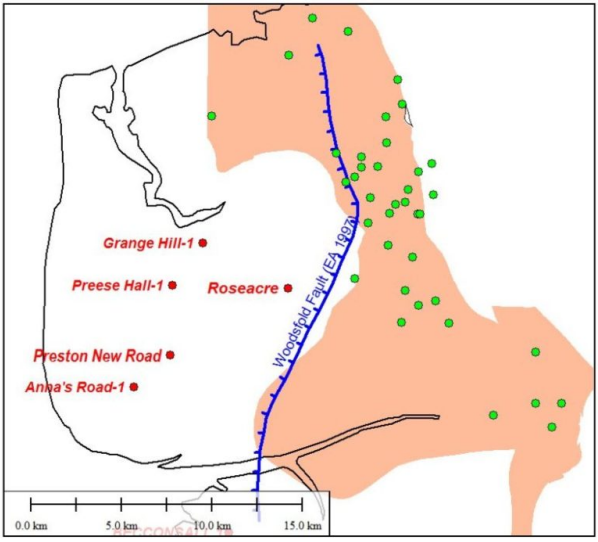
This post goes right to the heart of Professor Younger's supposed expertise in the hydrogeological aspects of fracking. The scientific issue here is whether or not the Sherwood Sandstone Group aquifer below the salt-bearing Mercia Mudstone Group in the Fylde west of the Woodsfold Fault (where Cuadrilla's drilling and fracking activities are focussed) is saline or not.

Citation of previous research

Professor Younger wrote:

> "*Smythe then proceeds to "examine the Fylde evidence" – though, breathtakingly, this examination does not engage with a single one of the many hydrogeological studies of the Fylde Aquifer published over the decades …*" [adverb emphasised]

He continues by citing nine papers which he asserts that I should have been aware of. References to previous work are an essential part of any research scientist's armoury of skills, so the implication behind his statement is not simply that I omitted to mention these papers, but that my competence is lacking.



(https://web.archive.org/web/20230601163515/http://www.davidsmythe.org/frackland/wp-content/uploads/2017/02/younger-3-fylde-fig-border.jpg)Fig. 1. Hydrogeology of the Fylde. The tan colour is the major Sherwood Sandstone aquifer at the surface. All the available hydrogeology studies concern the aquifer east of the major Woodsfold Fault (blue toothed line), where the water boreholes that were studied are situated (green dots). None of these studies have any bearing on the hydrogeology of the western Fylde, where Cuadrilla has drilled and proposes to drill (red dots).

But all nine of the citations that Professor Younger accuses me of neglecting are either irrelevant and/or outdated. None of the cited work has any bearing on the hydrogeology of the western Fylde, west of the Woodsfold Fault – the area of interest where Cuadrilla wishes to frack (Fig. 1). They all concern the major aquifer at outcrop (i.e. at the surface), some 10-20 km to the east. It would be misleading to cite works which have no relevance to the question at hand. So why has Professor Younger done this?

Perhaps the best way to explain the irrelevance of Professor Younger's citations is by analogy. Imagine that I had written a tourist guide to the attractions of Glasgow, and Professor Younger had then responded:

> "*Professor Smythe presents a tourist guide to Glasgow, though, breathtakingly, he fails to mention the many attractions of the city, including the Castle on its volcanic core, and the Royal Mile leading down to*

Holyrood Palace. He nowhere mentions the breathtaking views north from the Old Town, over the magnificent Georgian New Town, to the Kingdom of Fife across the Forth Estuary". [apologies to those who are not familiar with the cities of Glasgow and Edinburgh].

(https://web.archive.org/web/20230601163515/http://www.davidsmythe.org/frackland/wp-content/uploads/2017/02/Edinburgh_Castle_wiki.jpg)Fig. 2. Fylde groundwater irrelevant citation analogy: imagine that in my Glasgow tourist guide, Professor Younger accused me, "breathtakingly" of failing to include this castle. Photo: Wikimedia Commons.

But this is exactly what he has done with his Fylde citations. It is also noteworthy that, despite his blunderbuss approach to citations, Professor Younger fails to cite himself the much more detailed recent studies commissioned by the Environment Agency (EA).

I have disputed the EA's claim that groundwater here is saline, and that it is therefore is not of concern if it were to be contaminated by fracking. My worries are dismissed by Professor Younger; however he does not offer a detailed rebuttal, because he apparently does not have time to deal with my *"unsubstantiated opinions"*.

Other areas in England claimed to be relevant to the Fylde

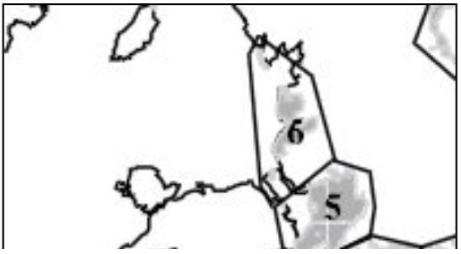
Professor Younger alludes to his wide and deep knowledge of the hydrogeology of UK geological basins, of which there are probably several dozen, depending upon how they are counted. He states, in particular:

> *"Smythe's claims about the possibility that fresh groundwater occurs in the Sherwood Sandstones beneath saline water in the Mercia Mudstones is* ***at odds with all known sites in the UK where this setting has been monitored*** *(e.g. in many English coalfields)."* [my emphasis].

I hesitate to take issue with this strong claim by one of the UK's leading hydrogeologists. So let us first be clear what is being said:

- The "*setting*" is my claim that there could be fresh groundwater in the Sherwood below saline water in the Mercia Mudstones (in the Fylde), and
- Such a setting does not exist anywhere in the UK.

There are just four other basins (cf. Younger's "*all known sites*"), apart from West Lancashire Basin within which the Fylde is situated, which have halite within the Mercia Mudstones. They are numbered 2 to 5 in Figure 3, West Lancashire being the sixth.

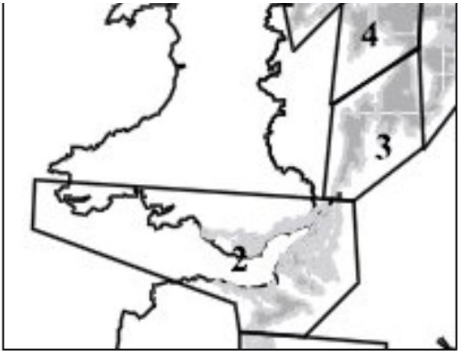


(https://web.archive.org/web/20230601163515/http://www.davidsmythe.org/frackland/wp-content/uploads/2017/02/hobbs-etal-MMG-basins-map-cropped-to-halite-bearing-basins-border.jpg)Fig. 3. The UK basins in which the Mercia Mudstones contains halite (rock salt) layers. These extend from West Lancashire (including the Fylde) in the north (no. 6) to Avon/Somerset/South Wales in the south (no. 2).

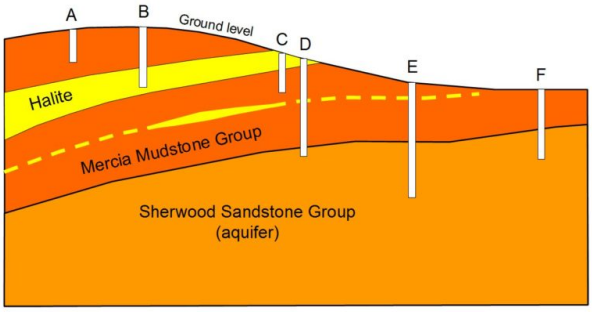
So Professor Younger claims that because the

setting occurs in four of the five halite-bearing basins it must necessarily be true of the fifth, in particular in the Fylde. Firstly, this is a *non sequitur*, and secondly, it is not even necessarily correct in the other basins, as I demonstrate below.

Incidentally, his mention here of coal basins perplexed me (there is no coal below west Lancashire, for example. But he is probably confusing the halite layers lying above the Coal Measures of Yorkshire (see my previous post about his Selby Coalfield study) with those in the Mercia Mudstones. But these Yorkshire halites are of Permian age, i.e. older than, and lying beneath, the Triassic age Sherwood Sandstone and Mercia Mudstone.



I have looked at the water boreholes in the four basins which fit the 'setting' criteria discussed above. They are summarised in the schematic diagram of Figure 4.



(https://web.archive.org/web/20230601163515/http://www.davidsmythe.org/frackland/wp-content/uploads/2017/02/MMG-on-SSG-borehole-schematic.jpg)Fig. 4. Schematic setting, not to scale, of Mercia Mudstone covering Sherwood Sandstone in the five halite-bearing basins of England shown in Figure 3. Examples of water borehole penetration types are lettered A – F. Dashed yellow layer indicates either very thin halite (rock salt) layer, or where the salt has been dissolved away completely. Vertical scale is of the order of 500 – 1000 m.

The diagram shows the different rocks penetrated by water boreholes drilled on the Mercia Mudstones. This rock is an aquitard, of low permeability, so in practice there are few boreholes compared to the number drilled directly into the Sherwood (not shown here). Within the Mercia there are layers of halite (rock salt), sometimes very thick, and which have been extensively mined. The halite never crops out at the surface, because local groundwater has dissolved it away. There are also thin layers of halite, as well as relict layers where the mineral evidence reveals that there was once some halite. This is indicated diagrammatically by the dashed yellow layer.

The six borehole types, of which I have found examples, shown in Figure 4 as follows:

1. Boreholes which only penetrate the Mercia to shallow depth (say 60 m); above the thick halite; water used for farm and domestic purposes.
2. Boreholes drilled and encountering thick halite; some of these had the halite, not water as their target.
3. Water boreholes drilled on the halite to shallow depth; some appear to have been usable for farm or irrigation purposes despite being reported as slightly saline.
4. An attempt to find deep fresh water in the Sherwood, but drilled from the halite. Water was saline so the borehole, at a brewery, was apparently abandoned.
5. Boreholes drilled through the Mercia with relict halite into the Sherwood.
6. Boreholes drilled from a low level of Mercia, below the halite layers, into the Sherwood.

Here are some examples of types E and F, which are most relevant to the discussion.

Eaton Crewe Waterworks (type F)

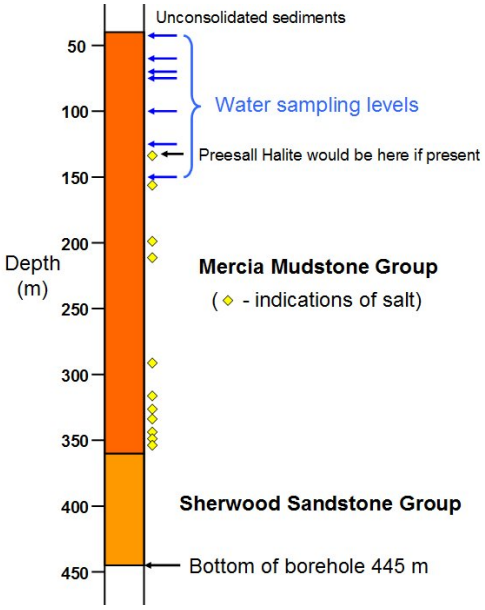
(https://web.archive.org/web/20230601163515/http://www.davidsmythe.org/frackland/wp-content/uploads/2017/02/eaton-works-streetview.jpg)Fig. 5. Eaton Crewe Waterworks, Tarporley, Cheshire. The two pilot boreholes, drilled in 1938 and 1966, respectively, are under the manhole covers in the foreground. Inside the building there are two 40″ (1 m) wide boreholes supplying water from the Sherwood. Google Earth Street View image, July 2011.

The top of the Sherwood here is at 68 m. In the Cheshire Basin generally the high salinities in the Sherwood, at depths greater than 450 m, are due to halite dissolution. Clearly these waterworks disprove Professor Younger's thesis, unless he has some confidential information about the installation that he is not prepared to divulge.

The other three examples come from the western Fylde, in the critical area where fracking is taking place. These are discussed in the next section.

Western Fylde borehole evidence

Kirkham borehole (type E)



(https://web.archive.org/web/20230601163515/http://www.davidsmythe.org/frackland/wp-content/uploads/2017/02/kirkham-simple-log.jpg)Fig. 6. Simplified geological log of the Kirkham borehole, western Fylde. Groundwater sampling levels measured by the EA are shown by blue arrows. Evidence of halite is shown by yellow diamonds. If the Preesall Halite, found further NW, were present, it would be at the level shown by the black arrow.

This borehole was drilled in 1970 as a test for underground gas storage, but has since then been used as an observation borehole. It penetrated the Sherwood at 366 m and went on down to 445 m.

The only evidence that the EA seems to consider, in dismissing the groundwater potential of the entire western Fylde, is the hypersalinity of the water samples observed in this borehole. I pointed out that this evidence is invalid because two of the three hypersaline samples were taken from levels within the Mercia Mudstones, where the observed hypersalinity, some two or three times more salty than seawater, can be explained by perched (hydrogeologically isolated) relict halites known to exist within the Mercia Mudstones. This is indicated by the dashed yellow line in Figure 4 at borehole type E. The groundwater within the Sherwood was never sampled.

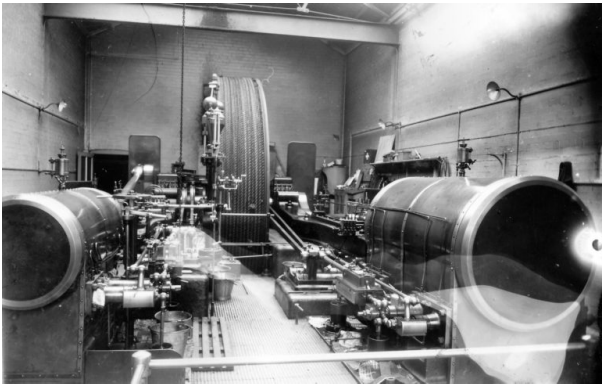
Rowe's Model Dairies, Inskip (type E)

(https://web.archive.org/web/20230601163515/http://www.davidsmythe.org/frackland/wp-content/uploads/2017/02/frith-inskip-cheese-factory.jpg)Fig. 7. Rowes Model Dairies, Inskip, c. 1950, where a 161 m deep borehole penetrated the Sherwood Sandstone aquifer at 124 m. Photo credit: Francis Frith Collection.

This borehole was drilled in 1940-41. It lies 6 km NNE of the Kirkham borehole, and, like it, is just west of the Woodsfold Fault. It is 2.7 km NE of Cuadrilla's Roseacre Wood site. It supplied a dairy and cheese factory untill the mid 1960s. Would Professor Younger have us believe that saline water was used here?

Phoenix Mill, Wesham (type E)

This borehole was drilled to a depth of 445 m in the nineteenth century. It lies 1.7 km west of the Kirkham borehole and 4.2 km east of Cuadrilla's Preston New Road site. No geological details are available, but this depth appears to be through the Mercia Mudstone Group and well into the Sherwood.



(https://web.archive.org/web/20230601163515/http://www.davidsmythe.org/frackland/wp-content/uploads/2017/02/Deane-Shed-1.jpg)Fig. 8. Compound steam engine of the type used at Phoenix Mill in the nineteenth century. Consumption of water, which would necessarily have been fresh, was about 40,000 l per day, of which most could be recycled.

The water would have been required chiefly for the compound steam engine to run the weaving looms. The water would have re-used in a closed cycle, with a reservoir on-site. The existence of the reservoir has been confirmed from a 1911 map. Mr John Phillp of the Northern Mill Engine Society says that such an engine would require about 40,000 litres per day, but that most of this would be recycled. However, it is unlikely that a source of salty water would have been countenanced, because it would lead to precipitation and corrosion in the boiler, with resulting inefficiency.

Fylde discussion

The boreholes described above are part of a group which I examined, comprising some 39 relevant wells west of the Woodsfold Fault, of depth greater than 30 m, which are available on the BGS borehole mapper website. About five of these borehole records are confidential, and/or there is no information. In addition, I studied the water composition records of 56 boreholes, which I obtained from the EA.

I think it is reasonable to conclude that it is unlikely that hypersaline or even saline (undrinkable) water was used either for the cheesemaking at the dairy or for powering the looms at the mill.

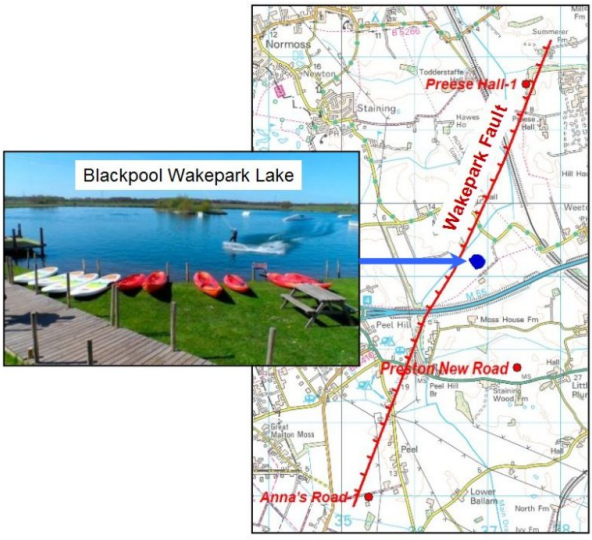
The EA believes, based on no solid evidence, that the flow across the Woodsfold Fault will be low. Next, it

assumes that there will be little or no vertical flow – but this assumption ignores the presence of faults cutting the Mercia Mudstones. These could be transmissive pathways, particularly when one considers the stress regime in the uppermost 300 m below ground level.

The EA cannot find a discharge for the flow, if present, but this again ignores the presence of faults. Lastly, since the Woodsfold Fault is *defined* as a no-flow boundary, the lack of westward flow in the model cannot be used as an argument to prove that there is no westward flow.

Since I published the paper in January 2016, and taken account the ensuing commentaries on it, I have done a little more research on the possible flow pattern of the groundwater under the western Fylde. I have obtained the 2D seismic data for the area shown in Figure 7, and mapped a newly-recognised fault, which I call the Wakepark Fault, running (coincidentally) from the Cuadrilla wells Preese Hall-1 to Anna's Road-1. In fact the fault has been previously recognised at depth, both independently by an oil company in 1994 and more recently by the BGS, but has not previously traced up through the Mercia Mudstones to the surface. It does not appear on the current BGS paper or digital geology maps.

(https://web.archive.org/web/20230601163515/http://www.davidsmythe.org/frackland/wp-content/uploads/2017/02/wakepark-fault-and-lake.jpg)Figure 9. Blackpool Wakepark recreational lake is fed by four pure freshwater springs. These could originate in the postglacial sandy deposits in the top 30 m of the subsurface (unlikely) or else could be fed by flow up the Wakepark Fault (red toothed line). Use of copyright OS digital data acknowledged. Photo credit: Ream Hills Holiday Park.



The Blackpool Wakepark Lake is an artificial lake created from boggy ground (Figure 9), and replenished by four springs. Now, it is possible that the springs supplying this lake are recharged from the unconsolidated sandy post-glacial deposits in the top 30 m of the subsurface, but the volume of flow from such a source would seem to be far too small. The more likely alternative, in my view, is that they are fed by upflow along the Wakepark Fault from the Sherwood. This newly identified discharge is the missing link in the flow cycle, originating as recharge in the Bowland Fells, that the EA failed to find.

A spokesperson at the Ream Hills Holiday Park told me that the lake water is tested annually, and is of such good quality that it could be bottled and sold as spring water. So this is not a resource that should be lightly written off, as the EA and Professor Younger conclude.

Conclusions

My concern that the EA has written off a past and future potential groundwater resource in the Fylde is justified. Before any unconventional exploitation begins it would be prudent for the EA and/or the BGS to sample the water at SSG levels. But Professor Younger berates me for daring to criticise the work of the EA.

In his attempts to rebut my supposed lack of expertise in this area of hydrogeology, Professor Younger has erected a facade of emphatic assertions, buttressed by numerous citations; but when one examines his allegations they turn out to have no more substance than a cowboy township erected for the filming of a spaghetti western (Figure 8). He shoots from the hip, but the bullets are blanks, and there is nothing behind the township façades. He is no Clint Eastwood.

(https://web.archive.org

/web/20230601163515/http://www.davidsmythe.org/frackland/wp-content/uploads/2017/02/Vera-Mini-hollywood-western-town-almeria-grey.jpeg)Figure 10. Spaghetti western filmset exemplifies the flimsiness of Professor Younger's research on the hydrogeology of the Fylde. Photo credit: IHA Vacation Rentals.

Either Professor Younger is deliberately setting out to deceive the reader (including the editors of the journal *Solid Earth Discussions* to which he submitted his comments), or he is recycling half-remembered and mostly obsolete references from his youth; I leave you to judge for yourself, but, in my view it demonstrates his poor scholarship even within his own area of expertise.

Professor Younger seem to be incapable of grasping the point that the potability, or otherwise, of the groundwater in the confined aquifer west of the Woodsfold Fault is not well constrained. The historical evidence of deep boreholes abstracting from the confined Sherwood aquifer suggests that it may well be fresh.

Professor Younger reiterates his serious misunderstandings, combined with misquoting of the literature, including:

- His irrational belief that fluids migrate downwards in a fracked and faulted shale setting, in the face of six independent quantitative modelling studies which prove the opposite (see the second in my series of articles about his expertise),
- His assertion that the confined aquifer below the western Fylde can only be saline, based on false analogies with similar UK settings,
- His quotation of irrelevant previous work, presumably with the aim of browbeating the editors or other non-specialist readers that he has a superior grasp of the problem.

Professor Younger and his colleague Rob Westaway have been in regular contact with Cuadrilla since 2014, and in June 2015 two Cuadrilla staff flew to Glasgow for a meeting with them. The Glasgow pair had previously written a critique of my submissions to Lancashire County Council at the latter's request in December 2014. It is not clear why LCC asked this pair of researchers, out of the dozens of potentially able and willing experts, to undertake this review. It is possible that Cuadrilla put forward their names.

Perhaps Professor Younger's views have been coloured by the commercial research sponsorship that he seems keen on promoting at Glasgow University (but, ironically, with little success). In any case, he is not doing his domain of academic research in hydrogeology any favours by his slipshod work in fracking.

Categories: Cuadrilla (https://web.archive.org/web/20230601163515/http://www.davidsmythe.org/frackland/?cat=13), Frackademics (https://web.archive.org/web/20230601163515/http://www.davidsmythe.org/frackland/?cat=12), Paul Younger (https://web.archive.org/web/20230601163515/http://www.davidsmythe.org/frackland/?cat=11)