Frackland

Critical comments on unconventional exploration by fracking in the UK and Europe

The expertise of Professor Paul Younger – Part 3. Hydrogeology of fracking (part A)

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Posted on 31st January 2017 by Professor David Smythe

Introduction

Two of my previous blog articles dealt with Professor Paul Younger's expertise in hydrocarbon exploration and in quantitative modelling of fluid flow, respectively. This third article on the subject of his expertise discusses his published views on several case histories involving hydrogeological flow through sedimentary layers and up faults, in the context of shale fracking. This topic is, or should be, well within his domain of expertise. I have split this article into two separate parts since the question of his expertise on groundwater below the Fylde, where Cuadrilla is about to start fracking, deserves its own blog. This will be issued as part 3B.

The technical versions of much of this debate may be found in the several comments by Professor Younger on the discussion paper I published in January 2016, together with my replies to these comments. These exchanges spanned several months up till mid May 2016.

Karst terrains

The issue here concerns two case histories of potential targets for fracking of shale in faulted karst and/or limestone terrains. Karst is the landscape caused by dissolution of the limestone by rainwater, which is slightly acidic.

The Languedoc example

This example is important because the eastern Languedoc region near Montpellier was formerly under licence to Total for unconventional shale exploitation. Professor Younger has evidently not actually read these cited works – and he gets the name of the principal author wrong.

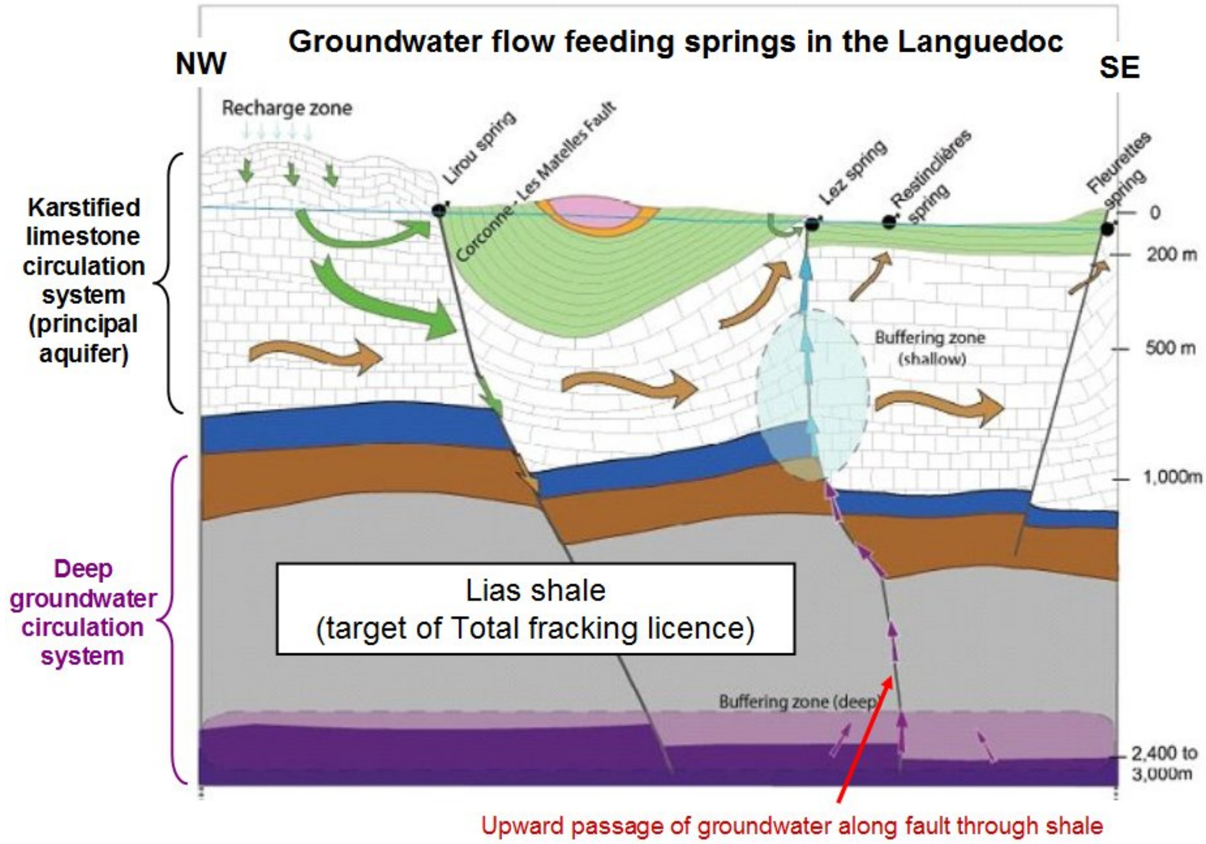

Figure 1. Groundwater circulation system of the Lez spring system near Montpellier, France (after Cristina Bicalho). Note the deep system where upward-flowing groundwater traverses the target shale via a fault.

Figure 1 shows Cristina Bicalho's diagram of the groundwater circulation system, with added labels. The deep circulation system, indicated in mauve, includes the upper target shale sequence of Lias age. Cristina Bicalho postulates that a small proportion of the Lez spring waters originates from deep Triassic evaporites (the mauve rock at the base of the diagram between 2400 and 3000 m depth). This water flows up along a fault, where it is buffered by the main aquifer system (light blue ellipse in Figure 3). The evidence for the deep origin comprises various hydrogeochemical signatures.

Professor Younger has criticised me for using this example from karstified limestones as an example of groundwater flow along faults. But he has only looked at the upper half of the diagram, and ignores the deep circulation system. This example is highly pertinent to UK shale exploration, because it shows thick shales, in grey, cut by faults. One of these faults provides the upward passageway for deep groundwater flow. This evidence refutes his claim that faults within thick shale sequences cannot be transmissive because of the phenomenon of fault gouge – the smearing out of crushed rock along the fault plane.

The Bath hot springs example

Professor Younger berates me for not citing sources in my mention of the Bath hot springs circulation system:

> *"Smythe does not bother to cite any of the many papers on the origin of the Bath hot springs; had he referred to the literature he might have discovered that, although the Carboniferous Limestone source and approximate minimum age of the waters (1,000 years) are now reasonably well constrained ..., the actual location of the recharge area has never been definitively established; while the Mendips is widely presumed ..., other karst hydrogeology specialists argue convincing* [sic] *for a South Wales source area ...".* [Ellipses indicate omitted citations]

It was hardly necessary to cite sources because the system is very well known. The reason I brought up the example was because, like the Languedoc, it is another area of sensitive groundwater supply which had been licensed for unconventional exploration – in this case for coal bed methane (CBM) extraction, rather than for shale gas/oil.

Professor Younger's attempt to revive an old controversy over the location of the recharge area is either mischievous, or else demonstrates once again his own failure to keep up with the literature on the topic. One of his own sources states: "*A different northern* [South Wales] *source was proposed …, but is convincingly dismissed ….*" [Ellipses indicate omitted citations]. Since then the defunct South Wales source idea has barely been mentioned.

So I stick with the consensus 'Mendips Model'. Figure 2 shows how recharge in the Mendips passes northwards and down along the Carboniferous Limestone (blue brick pattern) and emerges at Bath. The concept of the thrust fault enabling rapid upward flow of the hot water under Bath (and Bristol) has been firmed up by recent geophysical surveys.

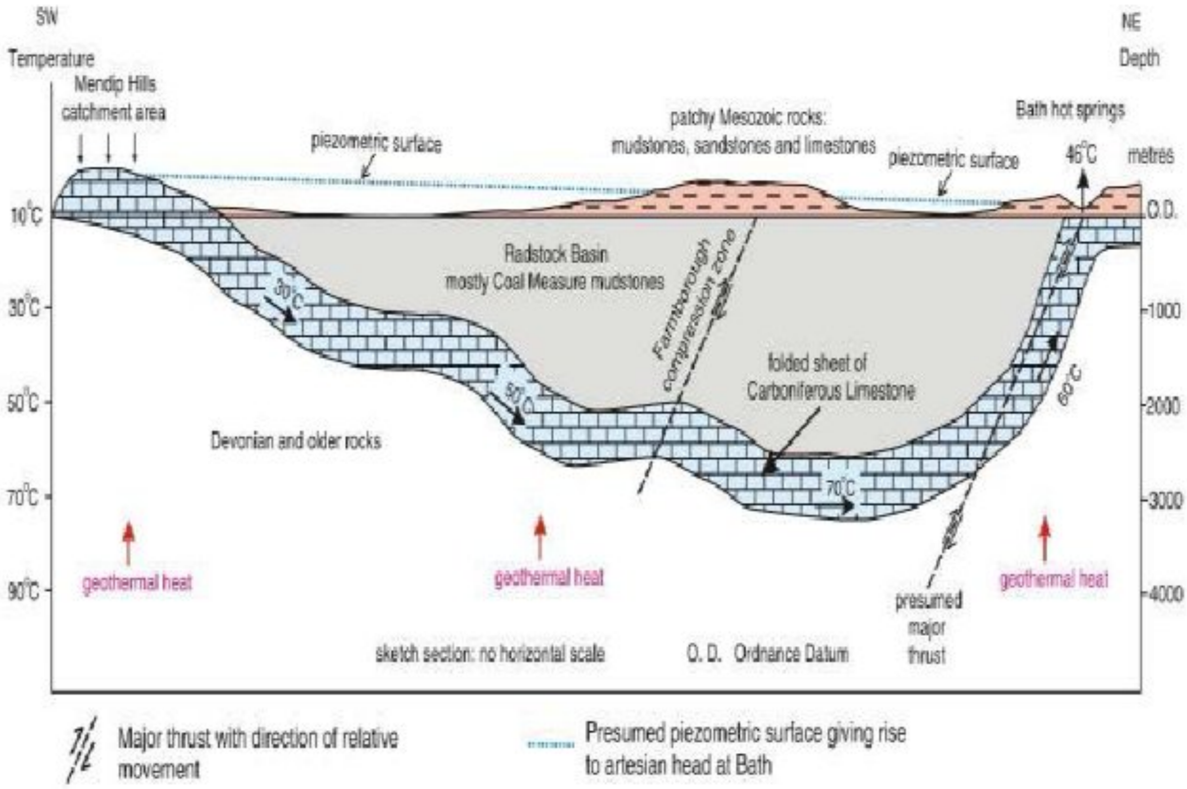

Figure 2. Cross-section showing the deep limestone aquifer system recharging in the Mendip Hills and emerging at 46.5°C at Bath, passing up a major thrust fault system (credit: R.W. Gallois).

There is another thrust fault system below the Coal Measures basin (grey in Figure 2) which might also be a potential passageway for Mendips water. That basin was until recently under threat of unconventional exploration and development.

The Selby Coalfield

Professor Younger published a review article last year with the tendentious title '*How can we be sure fracking will not pollute aquifers? Lessons from a major longwall coal mining analogue (Selby, Yorkshire, UK)*'. He stated that:

> *"the focus in this paper is on a very particular hydrogeological risk: that freshwater aquifers could be polluted by upward migration of contaminated fluids through* ***vertical fractures induced by the fracking process****."* [my emphasis].

Although this statement seems to make it clear that he will concentrate on fracking-induced fractures, he does later on introduce the topic of natural (pre-existing) geological faults.

He also repeats the old canard that fracking of onshore conventional oil wells has been carried on in the

UK for decades, despite admitting that only one unconventional shale gas well has been fracked to date. What he slides over here is the distinction between conventional fracking (including of geothermal and water wells) and unconventional high-volume fracking. They are as different as a bicycle is from a Lamborghini.

He then discusses the potential for pollution of water resources by mine waters (his own area of expertise as a hydrogeologist), and arrives at the Selby Coalfield, the case study alluded to in the title of the paper. The two maps he includes are little more than sketches. The schematic cross-section also depicted lacks faults, as do the maps. He provides a detailed account of the mine development and hydrogeological problems, and compares the damage done to the subsurface by coal extraction with the fracking process. He demonstrates, quite reasonably in my view, that the former is far more serious than the latter, and since there has been little or no evidence of groundwater pollution during or since the Selby mining activities, he then concludes that fracking is a safe procedure, and that the hydrogeological risks will be minimal.

The possibility of pre-existing faults acting as conduits is a completely separate issue from that of the hydraulically-induced fractures created by the fracking process. But Professor Younger's review of Selby appears to employ a sleight-of-hand regarding the extensive faulting in the coalfield. On the lessons to be learned from Selby, he states:

> "*at no point during the working of the mine did intersection of faults lead to significant increases in water ingress … the mere presence of faults does not mean that hydraulic continuity will be established; contrary to the claims made (e.g., Smythe 2014a, b, c) in recent shale gas and coalbed methane planning hearings in Scotland.*"

The clear implication is that extensive faulting at Selby did not create a problem, and, therefore, nor should it during unconventional hydrocarbon development.

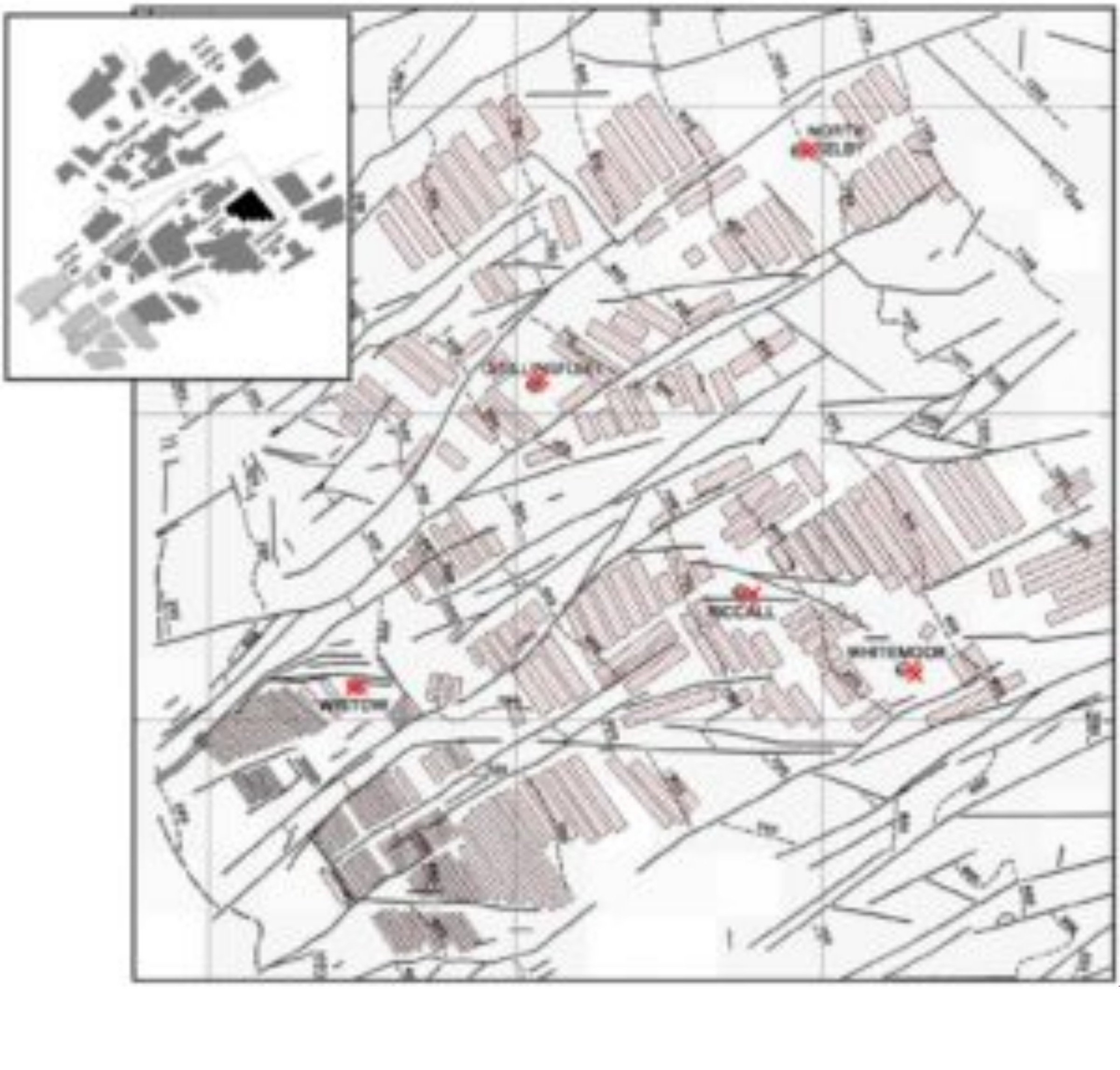

Figure 3.

Worked Barnsley seam coal panels at the Selby mine (red cross-hatching) superimposed on fault map (solid black lines). The entry shafts to the five mines are shown by pairs of red crosses. Note that the panels (where coal was removed) avoid all the faults. National grid at a 5 km interval is shown. The inset map shows Younger's version, in which each block depicts a group of several rectangular longwall panels, and the faults are omitted.

Figure 3 shows the extensive faulting of the Barnsley coal seam, with the coal working panels superimposed as red cross-hatched areas. It can be compared to the sketch provided by Professor Younger, shown in the inset, in which no faults are marked. The detailed fault map shows that all of the coalmine workings were laid out to avoid the faults, these having been mapped in detail prior to the exploitation of the coal. So the question of whether faults act as transmission pathways cannot be addressed by appeals to the Selby experience.

Professor Younger, by omitting all details of the faults, tries to give the impression that they never gave rise to any but local problems when they were – very rarely – intersected by undergound workings. He jumps to his general conclusion from Selby that "*there are no <u>prima</u> <u>facie</u> geomechanical, hydrogeological or geochemical reasons why unconventional gas resources in northern England and Scotland could not be developed without causing aquifer pollution.*"

In my view his conclusions are misleading. If he wishes to maintain his account he should provide considerably more details of which faults were indeed intersected, along with information on how high up the geological layering the offending faults penetrate. Did they, for example, cut the aquifers above the Coal Measures?

The intrinsic risk of faults acting as pathways for fluid flow

I contend that there is an inherent risk of groundwater resource contamination *via* faulting during or after unconventional resource development. Professor Younger claims that this is an "*erroneous assumption*" on my part.

Professor Younger cites several hydrogeology textbooks to deny that faults 'inherently' act as pathways. Perhaps we are not talking the same language; to me, 'inherent' means built-in, innate, or intrinsic, qualifying adjectivally the noun 'risk', or chance, probability. The phrase 'inherent risk' does not imply that faults are *necessarily* permeable to flow, and I am of course aware that any particular fault may behave differently over different segments of its track, and over different geological periods. But there is a built-in risk, which needs to be assessed and, if possible, quantified.

Saline springs as an example of dilution

Professor Younger makes an analogy with saline springs to show that even if contaminating fluids did reach shallow groundwater resources, the contaminants would be "*diluted beyond detectability*". Even if such an analogy were appropriate, it evidently excludes gas (especially methane) migration. Such an argument is reminiscent of the days when it was thought acceptable for nuclear waste to be dumped in the oceans, justified by the so-called 'dilute and disperse' principle.

His dilution argument is invalid, not least because one of the fluid flow modelling studies I cited (and with which Professor Younger is evidently unfamiliar – see my previous post) mentions that contaminated fluid from the fracked shale reaches the near-surface *via* the specified pathway at 90% of its original concentration. Such packets of undiluted fluid are referred to in the engineering world as 'slugs'. The word (presumably from the German verb *schlucken*, to swallow) is also used in Scots vernacular, meaning a swallow or gulp.

Discussion

The Selby coalfield case history, which Professor Younger trumpets as a reason for us not to be concerned about shallow groundwater contamination, is irrelevant to the problem of UK shale development, because practically no faults were cut by the coal extraction activities.

He concluded in his lecture on the subject last year at the Geological Society:

> "*Opponents of shale gas developments should therefore focus attention on more realistic potential impacts, most of which are familiar from almost any planning application, such as increased truck traffic on minor roads*."

So, based on his inappropriate and misleading Selby case history, he dismisses all the well-founded science-based concerns about the possibility of groundwater contamination from fracking.

The purpose of my two limestone terrain examples is to show that deep groundwater circulation systems exist, and that the faults present act as flow pathways. Professor Younger has evidently not studied the Languedoc example, because otherwise he would have noted the the subsidiary lower system has nothing to do with karstified limestones. The second example, the Bath thermal water system, illustrates two overthrust fault zones, with possible and probable upward flow, respectively.

If the 'inherent risk' of faults acting as pathways in shale development is indeed very low, as Professor Younger seems to imply, then why have so many quantitative modelling papers been published about this very problem in the last few years? Why is the English summary of the extensive 2012 German study called 'Hydrofracking Risk Assessment'? That document concludes, regarding groundwater:

> *"Hydrofracking can entail considerable environmental risk, particularly when it comes to water resource conservation, which we strongly feel absolutely must take precedence over energy production."*

I have mentioned the modelling research in my post no. 2 about Professor Younger's expertise. In conclusion, it seems to be widely agreed that there is an 'inherent risk' in unconventional resource exploitation. His dilution argument for not worrying about upward migration of contamination is invalid because of the possibility that 'slugs' of essentially undiluted fracking origin can find their way to the shallow subsurface.

Conclusions

Professor Younger has again demonstrated (as with his lack of grasp of current research on groundwater modelling of faults) that he does not study the issues in adequate depth. He merely skims the surface of the problem. Karst terrain and limestone aquifers offer a special kind of hydrogeology, but their study is pertinent to unconventional exploitation (whether of coal bed methane or of shale gas), by demonstrating deep groundwater circulation controlled in part by faults.

Professor Younger's review of the Selby coalfield groundwater history misleads by implying that all is well, hydrogeologically speaking, even in such a highly faulted coal basin; but he glosses over the fact that practically all the faults in the coal seam being exploited were avoided by advance knowledge and planning. The case history is therefore irrelevant to the issue of faults as conduits for pollution.

Regarding the risk of faults acting as conduits, Professor Younger seems to go out of his way to deny that there is a risk. In addition, even when admitting that the possibility exists, as he does with his reference to saline springs, he complacently assumes that a contamination fluid migrating upwards will somehow get "*diluted beyond detectability*".

The precautionary principle suggests, in conclusion, that faults acting as conduits for contaminated groundwater and gas released by fracking need to be considered far more carefully than Professor Younger's litany of evidence denial and hyperbolic optimism would have us believe.

Categories: Frackademics, Paul Younger

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