Analysis of UKOG drilling results at Broadford Bridge

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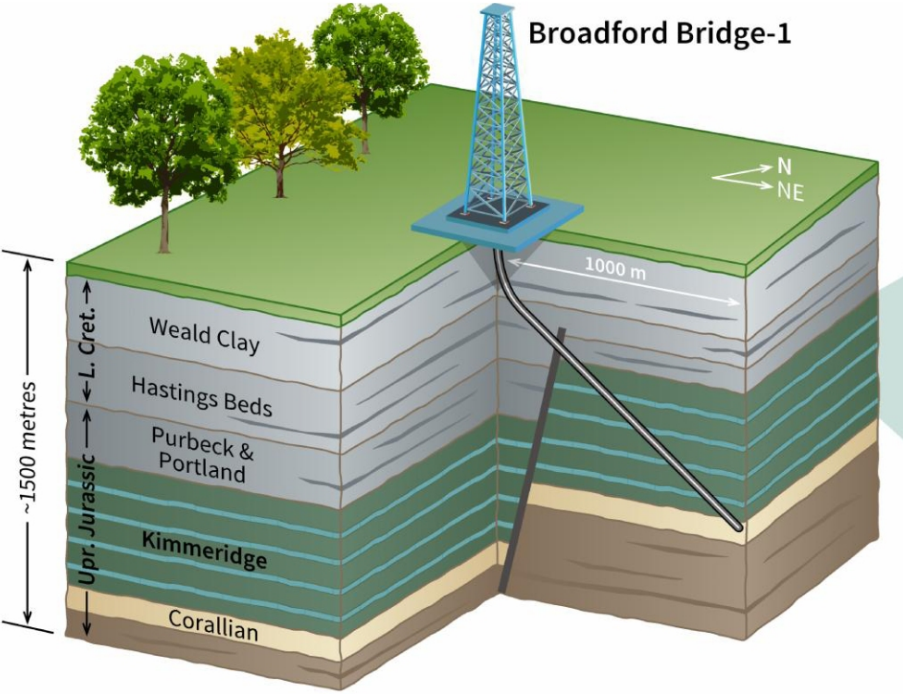
Posted on 11th December 2017 by Professor David Smythe

Yet more codswallop from UKOG

Recall UKOG's unique new hydrocarbon exploration definition, a Continuous Oil Deposit (COD), which, the company is claiming, underlies the entire Weald. Following UKOG's 'Gatwick Gusher' of 2015, the company has now followed it up by drilling at Broadford Bridge. It interpolates the results from the two wellpads, drilled some 27 km apart, to postulate its COD. Incidentally, no industrial or academic expert would use a word like 'deposit' to refer to oil, because oil infiltrates or permeates a medium. It is not laid down. The very phrase COD, with its 'deposit', smacks of amateurism, of mendacious promotion of a concept which does not exist in the real world of hydrocarbon exploration.

In response to several requests, I have tried to make sense of the drilling progress figures issued by UKOG's subsidiary, Kimmeridge Oil and Gas (KOGL), for the last few months at Broadford Bridge. They are very confusing and seemingly contradictory. I have on this occasion stuck to the imperial measure of feet used by KOGL instead of the scientifically preferable metric system, so that my figures can be checked directly against those in the AIM announcements by UKOG. There are two wells at Broadford Bridge, no. 1 (BB-1 for short), followed by a daughter or satellite 'sidetrack' well BB-1z, for which no. 1 is the 'donor' well.

Let us draw a veil over the fact that KOGL breached the terms of the permit by drilling at around 45° to the horizontal from the old Celtique Energie wellpad, to target the Kimmeridge Clay Formation (KCF), instead of drilling to Celtique's permitted target of Sherwood Sandstone – and shame on West Sussex County Councill planners for having let this happen. KOGL drilled obliquely in a north-easterly direction, as shown here in its corporate presentation from May 2017.



UKOG cartoon of BB-1 directional drilling (click to enlarge).

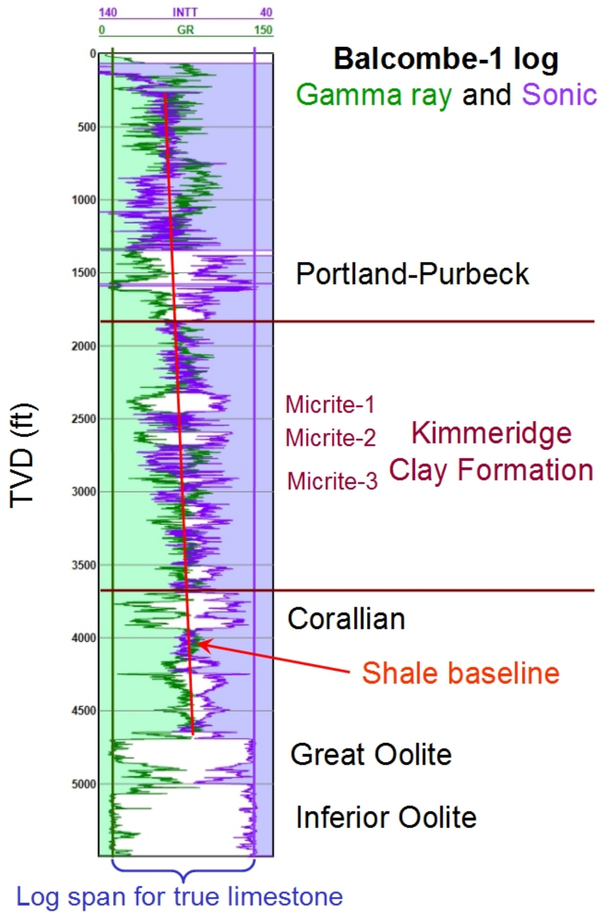
The original well Broadford Bridge-1 (BB-1) encountered problems when drilling through the Broadford Bridge Fault, shown diagrammatically above as the thick black line, where the fault cuts the Purbeck and Portland sequence of shales, sandstones and limestones. The fracturing around the fault (the so-called fault damage zone) may have made the Purbeck limestones, in particular, susceptible to borehole 'washout'. This is where the open borehole (before it is cased with a steel tube) becomes larger than the nominal 9-5/8 inch diameter of the drill bit. However, UKOG claims that the fracture problems also arose at greater depth, within the KCF:

> *"it became apparent that the duration and difficulty of coring such highly-fractured rocks in an inclined well led to potential plugging of some intensely fractured Kimmeridge zones likely jeopardising flow test performance. Sections of the overlying Purbeck also exhibited washout zones making both optimal casing-setting in the full 8.5-inch open hole section and resultant Kimmeridge well completion problematic."*

The 'plugging' referred to above means drilling mud getting into fractures and clogging them up, thereby reducing flow. This is, in my view, evidence of another cock-up by this cowboy company (see my analysis of Horse Hill-1 for an evidence-based conclusion on the incompetence of UKOG). Ironically, had UKOG followed the terms of the permit, as awarded to Celtique at Broadford Bridge, the washout problems would have been avoided because the geological layers in question would have been drilled vertically, to the south of the Broadford Bridge Fault, and would probably thereby have avoided the fault damage zone.

Two, and sometime three, micrites

The difference between the different numbers of micrite layers recognised within the KCF is partly one of interpretation. The Balcombe-1 log shown here illustrates the problem. Conoco drilled this well in 1986.



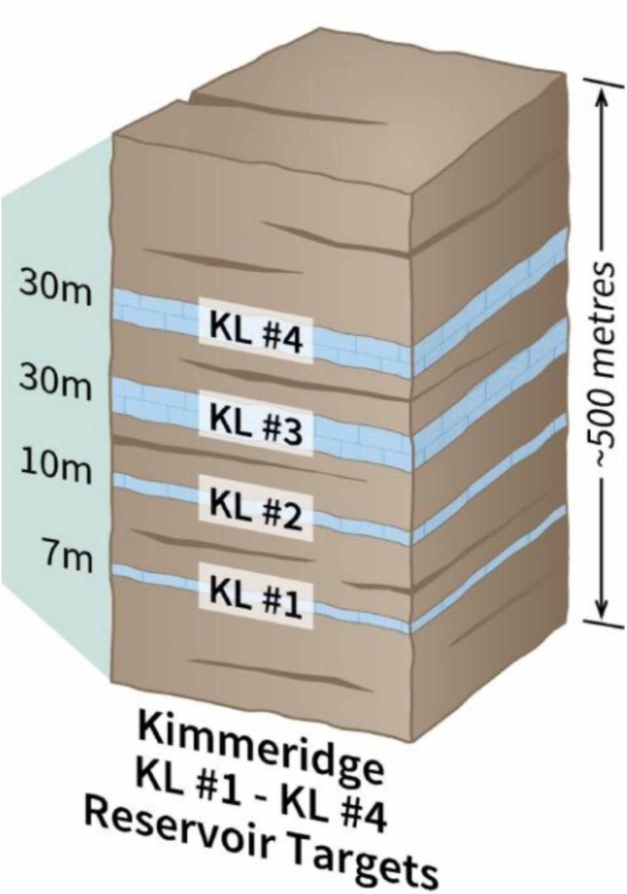
Gamma ray and sonic logs for Balcombe-1 showing Kimmeridgian micrites (impure limestones), contrasting with deeper Oolite limestones (click to enlarge).

The two log attributes are gamma ray (green) and sonic (purple). I have arranged the scales so that the logs coincide for shale, along the shale baseline marked in red. A shift leftwards of the green curve to low gamma ray readings, coinciding with high sonic velocity (shift of the blue curve to the right) opens up the gaps shown in white, aligned symmetrically on either side of the shale baseline. The gap for a true, pure limestone is illustrated by the Great and Inferior Oolites. I have put in two parallel vertical lines to highlight the span, or divergence, of the two logs when 100% limestone is present, such as is the case with the Oolites. The two main Kimmeridgian micrites, 1 and 2, recognised by Conoco at Balcombe-1, are clearly far from being pure limestone (calcium carbonate). They are calcareous mudstones or ‘dirty’ (impure) limestones, known informally in the hydrocarbon industry as micrites. Conoco did not recognise any deeper micrites, noting merely the presence of occasional groups of argillaceous limestone beds a few feet thick at most, below the second micrite. The BGS recognises a third micrite (labelled Micrite-3 in the log above) of about 50 ft (15 m) in thickness.

The Three Musketeers (plus d’Artagnan makes four)

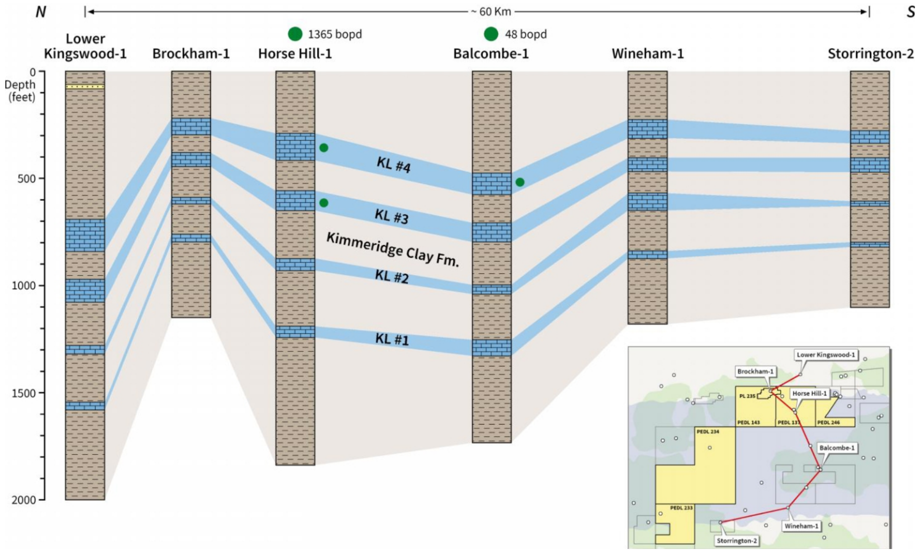
UKOG sees **four** micrites, not three, not only in the Balcombe-1 log, but also elsewhere, spanning the entire Weald. How far is one prepared to stretch the definition of micrite, a shale/limestone mix, especially when UKOG then proceeds to label them as limestone? In my view, UKOG’s over-enthusiastic application of the term limestone is misleading, designed to avoid mentioning the S-word.

The target of interest to UKOG is ostensibly the sequence of so-called limestones within the KCF, as shown by the sky-blue layers in UKOG’s diagram below. But the real target is the entire shale sequence of the KCF. The more calcareous beds within the KCF, being more brittle and fractured than the shale, are merely suitable layers for horizontal drilling and fracking because of their mechanical properties. This geology is like the (now-dying) Bakken shale oil play of North Dakota.



UKOG's micrites, labelled as Kimmeridge Limestone (click to enlarge).

The micrites are numbered KL-1 to KL-4, from the bottom up (KL being Kimmeridge Limestone), embedded in shale shown in pale brown. Further confusion arises in the numbering scheme because UKOG has previously identified the uppermost two micrites as KC Lst 1 and 2, respectively, counting from the top down. There exists (at least) one more scheme, in which the micrites are labelled by letter, I, J, K …, counting from the top down.



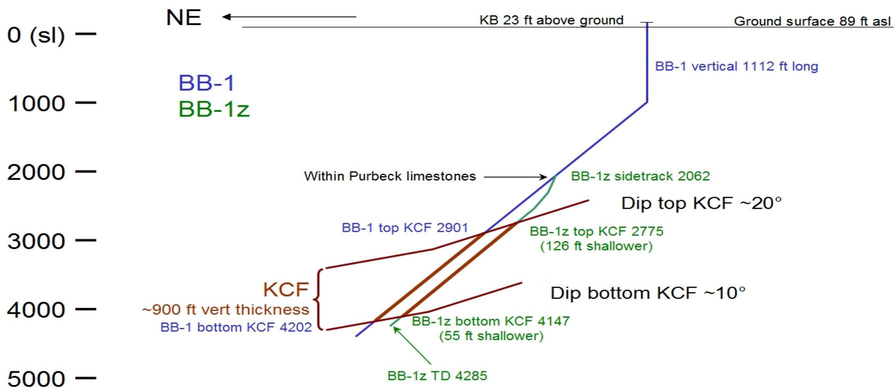
UKOG fence diagram across the Weald showing correlation of four micrites from well to well (click to enlarge).

This UKOG diagram of correlations between wells or boreholes, shown here, is called a fence diagram. It portrays just the KCF, with each well ‘hung’, as if from a washing line, from the same starting point or level, the top of the KCF. Of course this does not show the current depths of the layers, but it does give a good indication of the thickness variations within the Kimmeridgian. It shows that UKOG’s four discrete limestone layers are allegedly found within the KCF right across the Weald Basin from north to south.

The British Geological Survey (BGS) study of the Jurassic shales of the Weald Basin, dated May 2014, includes a much more comprehensive set of such fence diagrams, linking 63 wells hung along six separate fences. Each well is portrayed as a geological column (as in the UKOG fence diagram above) but with graphs of two logs, one on either side. This pair of logs (gamma ray and sonic) gives a good indication of the rock type, as shown above for Balcombe-1. In contrast to UKOG, the BGS recognises only two micrites over the whole basin (the thickest and uppermost two of UKOG’s four), with a lower third one present locally. Only one well out of the 63 (Stanmer-1, near Lewes) is portrayed with four micrite layers. The BGS also avoids colouring the micrites on the geological columns in light blue, the conventional colour used for limestones, and sensibly uses lime green instead.

The Famous Five

Not content with seeing four micrites over the entire Weald, UKOG has now identified a **fifth** so-called Kimmeridge Limestone at Broadford Bridge! The geology is now becoming as remote from reality as an Enid Blyton children’s adventure story. Nevertheless, I have tried to analyse what is actually going on, geologically speaking, as identified by BB-1 and its sidetrack BB-1z. Here is one possible interpretation, shown as a scaled cross-section containing the plane of the wellbore.

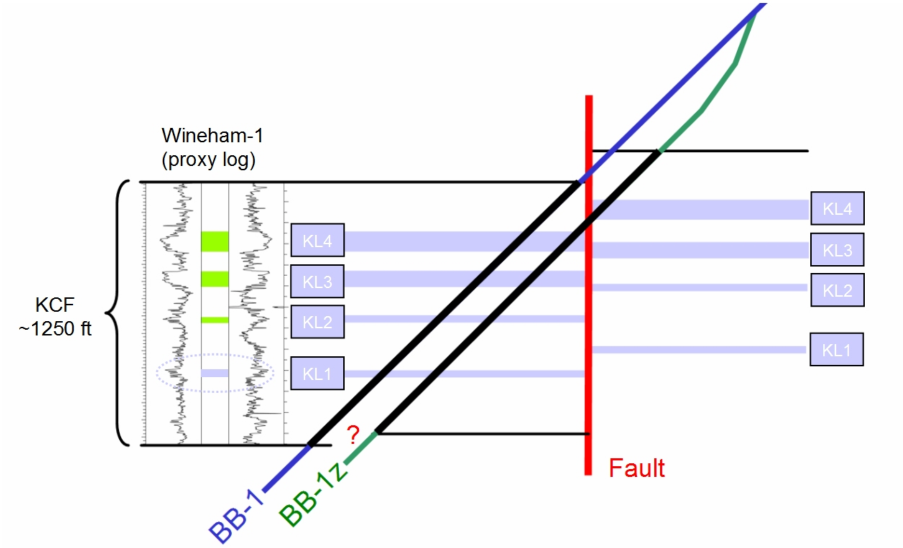


Scaled diagram of depths (feet) to the Kimmeridge Clay Formation in BB-1 and BB-1z wells (click to enlarge).

Depths shown are true vertical depths below sea level (TVDSS) in feet. Depths published by KOGL are measured depths (MD) along the wellbore from the kelly bushing (KB) on the drilling platform. To convert these to TVD I have assumed a vertical wellbore to 1000 ft, followed by drilling of both wells at 45° to the horizontal (the mean of two calculated values, 44° and 46°). The KB is 112 ft above sea level. BB-1z was drilled parallel to and about 200 ft south of BB-1. The assumption of a sharp elbow instead of a more realistic curved path for the deviated wellbore means that all my depths may be too shallow by a few feet. This is not critical, as we are more concerned with the relative differences between depths, rather than absolute depth below sea level.

The oblique thickness (along wellbores) of the KCF from the diagram above is 1900 ft (cf. KOGL quotes 1480 ft). KOGL claims a c.1400 ft vertical KCF thickness. The four depths for the top and bottom of the KCF in the two wells can be reconciled by assuming that the layer bends upwards to the SW, as shown by the two parallel brown lines. But this solution yields just 900 ft for the thickness of the KCF, and, furthermore, the nearest seismic line (shown below) shows that the Jurassic and younger layers are flat-lying. They do not dip at up to 20°. So, in conclusion, this picture is not convincing.

How can we reconcile the measured depths, to obtain a more credible view of the geology? In my view the answer lies in the claim by UKOG that there is a fifth micrite. The diagram below explains how.

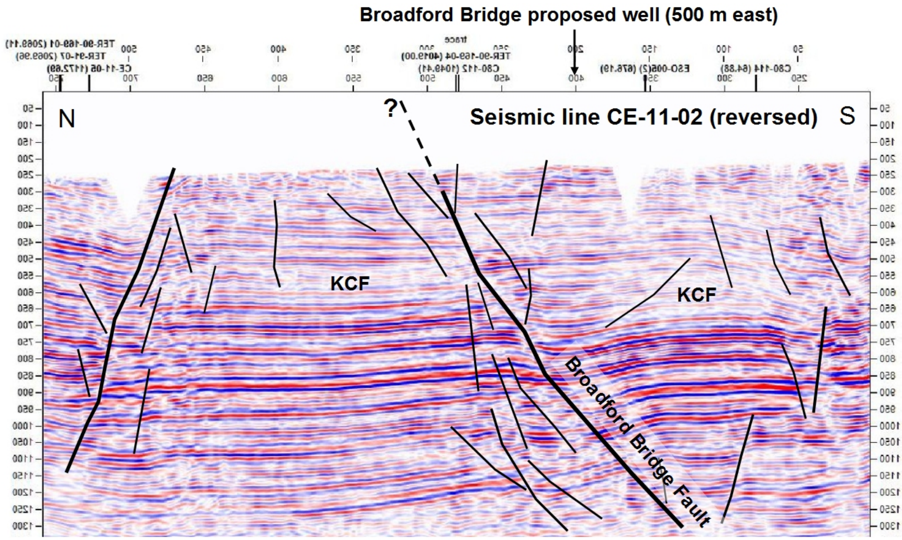


Alternative explanation for existence of five micrites as claimed by UKOG (click to enlarge).

The cross-section is in the same plane as the previous one, but here I have assumed flat layering, and have inserted four micrite layers (sky blue) using the proportions taken from the nearby Wineham-1 well. This latter well has been scaled vertically to match the KCF thickness at Broadford Bridge (in fact the 1204 ft vertical thickness of the KCF at this well is already a close match to the 1250 ft, measured from the diagram above, for the Broadford Bridge thickness). The Wineham-1 image, from the BGS, shows three micrites in light green. The logs on either side are gamma ray and sonic, to the left and right, respectively. I have added to this well image the location of a lower fourth micrite (sky blue layer) based on the log divergence seen within the sky blue ellipse.

The appearance of a fifth micrite, as claimed by UKOG, can be explained by a fault repeating part of the geological layering through which the sidetrack drilled. The fault must be located just to the right (to the SW) of where BB-1 hits the top of the KCF. I have shown the fault as vertical, but it could just as well dip to the left (NE) as a normal fault, or alternatively to the right, in which case it would be a reverse fault. Following the BB-1z wellbore through the KCF from the top downwards, you can see that it goes through UKOG's KL-4 micrite twice. This accounts for the total of five micrites. If this picture is correct, the logs in the repeated micrite should be identical.

I reproduce below a seismic section I published more than six months ago; it is the nearest seismic line to what was then the proposed BB-1 well.



Nearest seismic section to BB wellpad, showing interpretation of faults. KCF = Kimmeridge Clay Formation (click to enlarge).

The diagram shows many small faults interpreted to be present on either side of the principal Broadford Bridge Fault. These show, in effect, the damage zone on either side. UKOG traversed the main fault at Purbeck-Portland level, and then penetrated a subsidiary fault, part of the damage zone, lying to the left (north side in the image above) at the top of the KCF. This much has been admitted indirectly in the statement from UKOG quoted above. Note that the calculated throw of the fault repeating the KL-4 micrite is 126 ft, or 38 m, barely above the resolution (detection level) of seismic data like that shown here, which as around 30 m.

The vertical offset of the bottom of the KCF may also be due to another fault, but I have just indicated this problem by a question mark in my earlier diagram. It may seem like special pleading, or unusual coincidence, for such faults to be positioned where they are; however, the diagram above does not preclude the presence of even more small faults.

Conclusion

There must be either folding or faulting to account for the depth figures to the top and base of the KCF quoted by UKOG for each of the two BB wells. However, if there are errors in these figures, or else if there exists an entirely different solution, then I look forward to learning of it.

I also look forward to the release of information on flow testing of the upper pair of micrites, KL-3 and KL-4, due later this month. The problem for UKOG is that if the results are reported as promising, they can only be honestly interpreted as due to having drilled through and/or adjacent to faults, just as they did at Horse Hill. The damage zone on either side of a major fault will considerably enhance local fracture permeability. But no inference should be drawn from such figures as to the likely flow potential of micrites across the Weald in general. A competent test of the true flow potential of the micrites can only be undertaken in a zone clear of all faulting, which is evidently not the case here at Broadford Bridge. So whatever the results, they will have to be taken with a large pinch of salt. The AIM investment market seems to be already adopting this view, if the share price (below, scale in pounds sterling) is any guide.

As at 10-Dec-2017 22:58:25 - All data delayed by at least 15 minutes.

Sliding UKOG share price as at 10 December 2017 (click to enlarge).

In conclusion, the COD of the Weald Basin is just more codswallop. UKOG continues to operate in a technically incompetent manner. Its operations at Broadford Bridge are turning into a fiasco.

Categories: Uncategorised

Professor David Smythe

I am Emeritus Professor of Geophysics in the University of Glasgow (a courtesy title). I retired from the University in 1998 and live in France, where I continue my research in geology and geophysics.
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Response to Analysis of UKOG drilling results at Broadford Bridge

1. *Alan Burgess* [13th December 2017 at 4:38 pm]
[Reply ↓]

Hello David, I found your report technically convincing and quite witty. I am a geologist who worked briefly for Exlog and BP. Then did an MSc in Applied Geophysics. Mostly I have been a physics teacher. I am helping those opposing UKOG at Markwells Wood.
…
One of the objection lines we are considering is:"Does fracking trigger fault re-activation?" Do you think the line is plausible? Are we likely to find credible scientific evidence to support such a line? Look forward to your response.

2. *[Professor David Smythe]* *Post author* [14th December 2017 at 12:35 pm]
[Reply ↓]

Thank-you Alan for your comments. My blogs tend to be rather technical, so it is nice to hear from someone who evidently understands all the details.

In response to your question on fault re-activation; yes, fracking can and does trigger earthquakes, by re-activating faults. But to date such earthquakes have been generally of very small magnitude. The biggest one triggered in 2011 by Cuadrilla fracking at Preese Hall-1 was of local magnitude 2.3, which is hardly a problem. But in British Columbia there was a magnitude 4.6 triggered by fracking in 2015.

The Weald Basin, which I presume you are most interested in, is seismically quiet, and therefore suggests that the crust here is nowhere near to being critically stressed, in contrast to the Bowland Basin of Lancashire. But I could be wrong.

3. *Alan Burgess* [14th December 2017 at 2:34 pm]
[Reply ↓]

Thank you very much for your reply.

Research by Dr Ian West indicates some earthquake activity over the historical period:

"In southern England the Chichester and adjacent area is notable for the frequency of earthquakes. They are usually small events of 3 to 4 magnitude, but there are occasional more severe quakes up to very strong, intensity 7 (1750, Chichester and affecting Brighton to Bridport). There is even the possibility of an historic Chichester earthquake causing more than one fatality. Generally the earthquakes did little more than made a noise and shook the ground. Occasionally they probably broke chimneys and caused damaging to weakly-constructed buildings. There seems to be no record of a severe earthquake though in the 500 years or so of reports, except perhaps one in

1275, if the epicentre really was at Chichester. With the Dover region, it is one of the main earthquake localities on the south coast of England. The earthquakes have been attributed to minor re-activation on a deep north-south strike-slip fault, which is the eastern termination of the Isle of Wight type of structures, and may be linked southward to the Massif Central of France. This is reasonable but details are not yet clear, however. Damage from these relatively minor earthquakes at Chichester has not been severe. Of course, a rather larger earthquake here is not impossible. Chichester Cathedral has been present for a short while in geological terms, only about 1000 years, but its survival supports the view that major earthquakes are probably very rare here. .

[Further note re Chichester Earthquakes "In the autumn of 1833, a centre [earthquake centre] near Chichester, which had been in action from time to time for nearly two centuries, gave rise to a series of moderately strong earthquakes that continued for nearly two years. These earthquakes were studied by an unofficial committee in Chichester, of which Mr. J.P. Gruggen was secretary. The report which he drew up was communicated to the Royal Society, but only a very brief summary was published [Royal Society Proceedings, vol. 3, 1837. The original report is preserved in the Archives of the Royal Society, but there are extracts from it in Davison, 1924]. Of considerable value in itself, it is interesting as the first report of a committee instituted for the study of British earthquakes."]" (copy and paste from website….http://www.southampton.ac.uk/~imw/Earthquakes-South-England.htm)

4. *Alan Burgess* 14th December 2017 at 2:50 pm
Reply ↓

Sorry one other thing that may be relevant: I phoned Ian West, he thought the Chichester earthquakes may be related to crustal rotation centred on the Bay of Biscay. It would be interesting to firm up this idea. It would be useful to provide a coherent mechanism.

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  I am David Smythe, Emeritus Professor of Geophysics in the University of Glasgow. I retired from the university in 1998 and live in France, where I continue my earth science research. This blog aims to correct some of the errors, omissions and misleading propaganda published by expert scientists in support of fracking. It complements my web page davidsmythe.org/fracking, where more detailed documents may be found.

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